TECHNICAL CONDITIONS OF CONTRACT (TCC)

NAME OF WORK: PILE TEST AND PILING WORKS FOR 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2

BHARAT HEAVY ELECTRICALS LIMITED

TECHNICAL CONDITIONS OF CONTRACT (TCC)
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Volume-IA	**Part-II : Technical Specifications**		
1	SPECIFICATION NO **PE-TS-486-607-C001 (Section C)**		
2	SPECIFICATION NO **PE-TS-999-600-C002 (Sub-Section D2) & PE-TS-457-600-C021 (Sub-Section D21)**		

2X700MWe PHWR- GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA UNIT# 1&2

NPCIL has awarded the work for Design & Engineering, manufacture, Procurement, Erection/Construction, commissioning & testing, trial operation and handing over of Turbine Island for 2 nos. of 700MWe PHWR (Pressurised heavy water reactor) based nuclear power plants to be set up at Gorakhpur, Haryana.

Project Information is as follows:

	Title	Description
1	**Owner**	NUCLEAR POWER CORPORATION OF INDIA LTD. (NPCIL)
3	**Project Title**	2X700MWe PHWR- GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA UNIT# 1&2 – TG ISLAND PACKAGE
4	**Project Site Location**	Site is situated on the left bank of the Fatehabad Branch of Bhakra canal, in Fatehabad district of Haryana state. The nearest village to the site is Gorakhpur.
5	**Site Access**	Chandigarh, the State capital is about 250 km away from the site by road. National Highway No. 10 passes through Badopal village at a distance of 6 km from site. From Delhi the road to site via NH-10 passes through Rohtak, Hansi and Hisar.
6	**Nearest Railway Station**	The nearest railway station Uklana Mandi (Northern Railway) is about 23km away from the project site.
7	**Nearest Airport**	The nearest major airport is Delhi at about 208 km by road
8	**Nearest Highway**	NH10
9	**Ambient Air Temperatures**	a) Maximum dry bulb temperature : +48.4 deg C, b) Minimum dry bulb temperature: -0.1 deg C, c) Design temperature for electrical equipment /devices: +50 deg
10	**Relative Humidity**	a) Maximum during monsoon : 100% b) Minimum (design) : 5%
11	**Air Quality**	Air quality is clean and free from chemical pollutants.
12	**Rainfall**	a) Annual Average : 512 mm b) Highest annual rainfall : 787 mm in 1997 c) Lowest annual rainfall : 171.1mm in 2000 d) Period : Year 1969-2007

13	**Wind Pressures**	a) Height above mean ground level - @10M Design Wind Speed m/sec - 62.81 b) Height above mean ground level - @100M Design Wind Speed m/sec – 76.14 The assessment of wind loads based on the above basic wind speed shall be done as specified in IS: 875.
14	**Wind Direction**	Predominantly W,SW,NW & SE with respect to true North
15	**Seismology**	Zone III as per IS 1893-2002 part I

Note: - The bidder is advised to visit and examine the site and its surroundings and obtain for himself on his own responsibility all information that may be necessary for preparing the bid and entering into the CONTRACT. All costs for and associated with site visits shall be borne by the bidder.

INSTRUCTIONS TO TENDERERS

The Tenderer are advised to physically visit the site and fully acquaint themselves with site conditions, transportation routes, various distances and the fact that other contractors would be working in this area and their structures are to be protected. The material brought and stacked for construction should not make hindrance to other contractors. **Necessary precaution and arrangements including sprinkling of water during work as acceptable to BHEL for safety & security for the above have to be made by the contractor. No claim will be entertained by BHEL on ground of lack of knowledge and the contractor's rates shall be deemed to have taken this into account.**

The contractor, in the event of this work awarded to him, shall establish an office at site and keep posted an authorized, responsible officer with valid Power of Attorney for the purpose of the contract. Any order or instructions of the `Engineer' or his duly authorized representative, communicated to the contractor's representative at site office will be deemed to have been communicated to the contractor at his legal address.

2.0	**GENERAL SCOPE OF WORK**
2.1	**Scope of this tender covers works for "Pile Test and Piling Works for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2" AT GORAKHPRUR, HARYANA.**
2.2	The brief scope of work is as follows: The bidder's scope shall include dewatering, filling, backfilling, disposal of surplus earth and rock, Pile boring, Installation of Test Piles & Job Piles, Toe Grouting, Conducting Initial load test, Routine load test, low strain Integrity test, High strain dynamic testing, Integrity testing by sonic coring/ sonic logging, reinforcement cage making and placing, breaking of pile up to cut-off level and other miscellaneous work related to Piling and site clearance before handing over to Owner / BHEL and other auxiliary items of work, etc. all complete including supply of all materials (except those specified in BHEL scope), consumables, labor, Tools and plants, transportation and storage, sample testing etc. all complete as per BOQ, specifications and drawings for proper and successful execution of the job for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2.
2.2.1	The scope of work is indicative but not limited to the given below. ➢ Installation of all piles in the mentioned areas, including testing as mentioned in the BOQ: The work will involve Installation of Bored cast-in-situ RCC vertical pile as per IS 2911 (Part 1 Sec 2) with diameter and length as specified in BOQ (length to be measured from pile cut-off level to the bottom of pile) using cement concrete grade M35 conforming to IS:456 with 20 mm nominal size stone aggregates with a minimum cement content of 400Kg per cum of concrete including providing all materials, boring/drilling in all types of soil including improved soil cement mix layer, providing bentonite slurry for stabilization of pile bore, flushing of pile bore, cleaning, providing plasticizer, admixtures wherever required, breaking pile head to cut off level and exposing pile reinforcement for embedment in pile cap etc including empty boring from ground level to pile cutoff level etc. all complete as per specification, drawing and as directed by the engineer-in-charge. The concrete placement temperature shall be maintained as not to exceed 38 degree centigrade as per specification. ➢ The scope will cover all works connected with installations and Testing of bored Cast-in-situ piles including mobilizations of specified rigs and other

	equipment their erection / dismantling / transportation / assembling and shifting from one area to another, preparation of firm ground as required for supporting the pile rigs, supply of materials, sampling and testing of materials consumables, labor, transportation etc. all complete as required for the proper and satisfactory completion of the job. ➢ The area of work shall be cleared of all vegetation, rubbish and other objectionable matter and materials including dismantling, removing and disposing off the existing underground structures / facilities etc. (if found), shall be disposed of as directed by the Engineer-in-Charge. No separate payment for these operations shall be made. The cost of all these operations shall be deemed to have been included in the unit rates rendered for the different items under bill of quantities. ➢ All the works areas shall be adequately flood lighted to the satisfaction of the Engineer-in-Charge when the work is in progress during the night shifts. ➢ The unit rates shall include all material equipment, fixtures, labor construction plant, temporary works and everything whether of permanent or temporary nature necessary for the completion of job in all respects ➢ The unit rates quoted for various items of B.O.Q shall include all the stipulations mentioned in Section C and technical specifications under Section D and nothing extra over B.O.Q rates shall be payable ➢ Drawings showing enough details for the construction as per the specification shall be furnished to the contractor in a phased manner as far as possible. ➢ The bidder should fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, local conditions, soil strata and site specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may have not been specifically brought out in the specifications
2.2.2	**<u>Cement, Ready Mix Concrete (RMC) and Steel Supply:</u>** Cement, Ready Mix Concrete of desired mix and Reinforcement Steel (as per BOQ cum Rates Schedule) required for the tender scope shall be procured by BHEL and issued to contractor free of cost (As FOC Item).
2.2.3	The working area shall be separated from the existing plant area (if required) by cordoning off the area by providing MS / GI sheets of suitable heights with appropriate frame work as approved by BHEL/ Customer. No extra payment shall be paid to contractor for this work.
2.2.4	The Customer NPCIL may depute their representative for checking and supervision of important / various different stages of work. The contractor shall be required to provide all facilities for inspection of works at no extra cost to

	BHEL. Any defect in quality of work or deviations from drawings / specifications pointed out during such inspection shall be made good by the contractor in the same way as if pointed out by the BHEL Engineer, without any cost implication to BHEL.
2.2.5	The work under this contract shall be carried out as per BOQ Cum Rate Schedule. In case the description / specifications as per BOQ are found to be incomplete, Indian standard specifications shall be followed. Quantities mentioned in the BOQ cum Rate schedules are approximate only and liable for variation due to change of scope of work / variation in schedule of quantities, changes in design etc. The tenderers shall undertake to execute actual quantities as per advice of BHEL Engineer and accordingly the final contract price shall be worked out on the basis of quantities actually executed at site and payments will also be regulated for the same. The quantities indicated against each item may vary to any extent and no compensation will be payable in variation of Individual quantity.
2.2.6	The complete works shall be carried out as per BOQ cum Rate schedule. If any work covered in the scope of contract cannot be executed using items available in BOQ, additional / extra items shall be made and rates for such items shall be worked out as per GCC clause 2.15.7. However contractor shall be bound to execute all the works under the scope of the contract and decision whether an extra item is applicable or not, shall be taken by BHEL Engineer which will be binding on the contractor.
2.2.7	Any activity which is necessarily required for satisfactory execution of any item of BOQ in line with technical specifications shall be deemed to be included in BOQ item even if it is not described in the item description and no extra payment shall be made against such activity.
2.3	**The technical requirements for work to be executed under this specification shall be as per PE-TS-486-607-C001 (Section C) & PE-TS-999-600-C002 (Section-D, Sub-Section D2) & PE-TS-457-600-C021 (Section-D, Sub-Section D21) enclosed with this tender document. (Part - II)**
2.4	Contractor's scope also includes following:
2.4.1	Furnishing all labor, materials (except those specified in BHEL scope), supervision, construction plans, equipment, supplies, transport to and from the site, materials handling, fuel, electricity, compressed air, water, transit and storage insurance and all other incidental items and temporary works not shown or specified but reasonably implied or necessary for the proper completion, maintenance and handing over the works, in accordance with the stipulations laid

	down in the contract documents and additional stipulations as may be provided by BHEL Engineer during the course of works.
2.4.2	Furnishing samples of all materials required by the engineers for testing / inspection and approval for use in the works. The samples may be retained by the engineer for final incorporation in the works. Furnishing test reports for the products used or intended to be used, if called for the specifications or if so desired by the engineer.
2.4.3	Giving all notices, paying all fees, taxes etc., in accordance with the general conditions of contract, that are required for all works including temporary works.
2.4.4	Arranging manufacturer's supervision for items of work done as per manufacturer's specifications when so specified.
2.4.5	The scope of work will also include such other related works although they may not be specifically mentioned in the above paragraph and all such incidental items not specified but reasonably implied and necessary for completion of the job as a whole all as desired and as directed by the engineer.
2.4.6	The scope of work covered above is not a comprehensive list of items of work involved. The detail scope of work may vary considerably depending on the actual construction requirements.
2.4.7	The work covered under this specification is of highly sophisticated nature requiring the best quality of workmanship, engineering and construction management. The contractor should ensure timely completion of the work. The contractor must have the adequate quantity of tools, construction aids, equipments, etc., in this possession. He must also on his rolls adequate trained, qualified and experienced supervisory staff and skilled personnel.
2.4.8	Where ever the Supply & Erection together is covered in the scope of bidder necessary approvals from BHEL / NPCIL shall be taken by bidder for the design, inspection procedure & vendor. List of items for which such approvals required will be frozen during execution of the contract. **NOTE: 1. Contractor shall procure and supply the items to project site as per the BOQ from BHEL / NPCIL approved vendors, meeting the specification, Drawings and instructions of the Engineer.**
2.4.9	Bidder has to tie-up with the vendor who has a prior experience of Toe-Grouting at any other site. Specialized manpower and resources are required for Toe Grouting. Bidder has to ensure the deployment of specialized agency for this BOQ item and in accordance with the stipulations laid down in the contract documents & additional stipulations as may be provided by BHEL Engineer during the course of works, so as to achieve the desired results. Necessary approvals from BHEL/NPCIL shall be taken by the bidder for the design, inspection procedure &

	vendor for Toe Grouting work.
2.4.10	Bidder has to tie-up with the vendor who has a prior experience of Integrity testing of pile using Sonic coring/ Sonic logging at any other site. Specialized manpower and resources are required for this work. Bidder has to ensure the deployment of specialized agency for this BOQ item and in accordance with the stipulations laid down in the contract documents & additional stipulations as may be provided by BHEL Engineer during the course of works, so as to achieve the desired results. Necessary approvals from BHEL/NPCIL shall be taken by the bidder for the design, inspection procedure & vendor for Integrity testing of pile using Sonic coring/ Sonic logging.

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.1.0	**ESTABLISHMENT**			
3.1.1	**FOR CONSTRUCTION PURPOSE:**			
A	Open space for office	Yes		BHEL may provide free of charge limited open space for office and store as and where made available by its customer. Also refer clause no. 3.8.1
B	Open space for storage	Yes		
C	Construction of bidder's office, canteen and storage building including supply of materials and other services		Yes	
D	Bidder's all office equipment, office / store / canteen consumables		Yes	
E	Canteen facilities for the bidder's staff, supervisors and engineers etc.		Yes	
F	Firefighting equipment like buckets, extinguishers etc.		Yes	

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
G	Fencing of storage area, office, canteen etc. of the bidder		Yes	
3.1.2	**FOR LIVING PURPOSES OF THE BIDDER**			
A	Open space		Yes	

B	Living accommodation		Yes	Bidder to arrange land outside the plant boundary for their labor accommodation. Basic sanitation and cleanliness of labour colony is to be maintained by bidder at no extra cost to BHEL. NPCIL (customer)/ BHEL shall have regular visit at labour colony for inspection of cleanliness and sanitation, if any penalty is given to BHEL by NPCIL towards the labour colony sanitation or for any other reasons, same shall be deducted from the bidder from their due payments because scope of establishing labor colony as per the statutory requirements and

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
				NPCIL requirement, is in the scope of bidder only.
3.2.0	**ELECTRICITY**			
3.2.1	Electricity For construction purposes **(To be specified whether chargeable or free)**		**Yes**	Construction Power can be provided at single point source on **chargeable basis** as and when made available by Owner, however bidder has to deploy DG Sets at no extra cost to BHEL.
3.2.1.1	Single Point source	**Yes**		
3.2.1.2	Further distribution for the work to be done which include supply of materials and execution		Yes	
3.2.2	Electricity for the office, stores, canteen etc. of the bidder which include:		Yes	
3.2.2.1	Distribution from single point including supply of materials and service		Yes	

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.2.2.2	Supply, installation and connection of material of energy meter including operation and maintenance		Yes	
3.2.2.3	Duties and deposits including statutory clearances for the above		Yes	
3.2.2.4	Living facilities for office use including charges		Yes	
3.2.2.5	Demobilization of the facilities after completion of works		Yes	
3.2.3	Electricity for living accommodation of the bidder's staff, engineers, supervisors etc. on the above lines**.**		Yes	
3.3.0	**WATER SUPPLY**			
3.3.1	**For construction purposes:**			
3.3.1.1	Making the water available at single point		Yes	Construction Water can be provided at single point source on **chargeable basis** as and when made

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.3.1.2	Further distribution as per the requirement of work including supply of materials and execution		Yes	available by Owner. However, bidder has to make an arrangement for construction water at his own cost by resorting to the methods like water tankers, etc.
3.3.2	**Water supply for bidder's office, stores, canteen etc.**			

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.3.2.1	Making the water available at single point		Yes	Construction Water can be provided at single point source on **chargeable basis** as and when made available by Owner. However, bidder has to make an arrangement for construction water at his own cost by resorting to the methods like water tankers, etc.
3.3.2.2	Further distribution as per the requirement of work including supply of materials and execution		Yes	
3.4.0	**LIGHTING**			
3.4.1	For construction work (supply of all the necessary materials) 1. At office storage area 2. At the preassembly area 3. At the construction site /area		Yes	

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.4.2	For construction work (execution of the lighting work/ arrangements) 1. At office storage area 2. At the preassembly area 3. At the construction site /area		Yes	
3.4.3	Providing the necessary consumables like bulbs, switches, etc. during the course of construction		Yes	
3.4.4	Lighting for the living purposes of the bidder at the colony / quarters		Yes	
3.5.0	**COMMUNICATION FACILITIES FOR SITE OPERATIONS OF THE BIDDER**			
3.5.1	Téléphone, internet, intranet, e-mail etc.		Yes	
3.6.0	**COMPRESSED AIR SUPPLY**			
3.6.1	Supply of Compressor and all other equipment required for compressor and compressed air system including pipes, valves, storage systems etc.		Yes	
3.6.2	Installation of the above system and operation and maintenance of the same.		Yes	

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.6.3	Supply of the all the consumables for the above system during the contract period		Yes	
3.7	**CONSTRUCTION FACILITIES**			
3.7.0	Engineering works for construction:			
3.7.1	Providing the construction drawings for all the works covered under this scope	Yes		
3.7.2	Drawings for construction methods and detailed shop drawings	Yes	Yes	In consultation with BHEL. Detailed shop drawings shall be prepared by the Contractor as specified in the BOQ
3.7.3	As-built drawings – where ever deviations observed and executed and also based on the decisions taken at site– routing of small bore pipes		Yes	In consultation with BHEL
3.7.4	Shipping lists etc. for reference and planning the activities	Yes	Yes	”
3.7.5	Preparation of site construction schedules and other input requirements		Yes	”

Sl. No.	Description	Scope / to be taken care by		Remarks
		BHEL	**Bidder**	
3.7.6	Review of performance and revision of site construction schedules in order to achieve the end dates and other commitments	Yes	Yes	”
3.7.7	Weekly construction schedules		Yes	”
3.7.8	Daily construction / work plan		Yes	”
3.7.9	Periodic visit of the senior official of the bidder to site to review the progress so that works are completed as per schedule. It is suggested this review by the senior official of the bidder should be done once in every two months.		Yes	
3.7.10	Preparation of preassembly bay		Yes	
3.8	**Other important Conditions regarding facilities to be provided by BHEL / Contractor:**			
3.8.1	BHEL may provide free of charge limited open space, for office & storage shed, as and where made available by Customer (NPCIL). It is the responsibility of the contractor to construct sheds, provide all utilities and dismantle and clear the site after completion of work or as and when required, as a part of his scope of work.			
3.8.2	Contractor shall be responsible for providing all necessary facilities like residential accommodation, transport, electricity, water, medical facilities etc. as required under various labour laws and statutory rules and regulations framed there under to the personnel employed by him.			

3.8.3	Provision of distribution lines of power and water from the central points to the required place with proper distribution boards observing the safety rules laid down by the authorities of the state shall be done by the contractor, supplying all the materials like cables, distribution board, switch boards, TPN, CBS, ELCBS/ MCCBS / Copper / Brass clamps, copper conductor, change over switches, pipes etc. at his own cost. If any failure is caused in supply of the power and water, it is the responsibility of the contractor to make alternate arrangements at his cost. The contractor shall adjust his working shift / hours accordingly and deploy additional manpower if necessary so as to achieve the targets.
3.8.4	In case of power cuts / load shedding no compensation for idle labor or extension of time for completion of work will be given to contractor.
3.8.5	Adequate lighting facilities such as flood lamps, hand lamps and area lighting shall be arranged by the contractor at the site of construction, contractor's material storage area etc. within finally accepted rates.
3.8.6	No claim for damages will be entertained by the Company on account of interruptions of water supply or limitation of quantity of water as aforesaid or on account of the water so taken being not fit for construction purposes or on any other account in connection with such water supply.
3.8.7	Contractor to satisfy himself that the water drawn by him is fit for construction / consumption and adequately treat such water at his cost when it is not found fit for the said purposes.
3.8.8	The Contractor should make arrangements for storage of sufficient quantity of water required for work.
3.8.9	The Contractor shall during the progress of the work, provide, erect and maintain at his own expenses all necessary temporary workshops, stores, consumables, offices, etc. required for the proper and efficient execution of the work. The planning, setting and erection of these buildings shall have the approval of the Engineer and the Contractor shall at all times keep them tidy and in a clean and sanitary condition to the entire satisfaction of the Engineer.
3.8.10	On completion of work or as and when required by BHEL, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and leveled and debris shall be removed as per instruction of BHEL by the contractor at his cost. In the event of his failure to do so, same will be got done by the Engineer and expenses

	incurred shall be recovered from the contractor along with prevailing overhead. The decision of BHEL Engineer in this regard shall be final.

(A) - LIST OF T & Ps TO BE ARRANGED BY THE CONTRACTOR AT HIS OWN COST:

Sl No.	EQUIPMENT	INDICATIVE QUANTITY
1	TRANSIT MIXER (6M3 CAPACITY) WITH MATCHING DUMPERS	3 Nos.
2	CONCRETE PUMPS (20CUM/Hr. min capacity) (Static)	APR*
3	SUBMERSIBLE PUMP (DIESEL / ELEC)	3 Nos.
4	HYDRA CRANE 14 T	2 Nos.
5	**ROTARY HYDRAULIC PILING RIGS CRAWLER MOUNTED**	**Total = 4 Nos.** **Deployment Plan :** **1. 01 no. Rig within 15 days from date of LOA.** **2. Another 03 Rigs 15 days in advance of start of Job piling. BHEL engineer shall inform the date of start of Job piling in advance.**
6	PLC OPERATED BATCHING PLANT WITH PRINTING FACILITY (MIN 10 **CUM** PER HOUR).	APR*
7	CRAWLER CRANE 40/50 MT	2 Nos.
8	15/20 MT TRAILORS WITH PULLING UNIT / TRACTOR – TRAILORS	2 Nos.
9	SLUDGE / SLURRY PUMP (DIESEL / ELEC)	2 Nos.
10	REINFORCEMET CUTTING / BENDING MACHINE	3 Nos.
11	PORTABLE LIGHTING MAST / LIGHTING SYSTEM	6 Nos.
12	CEMENT STORAGE SHED	APR*
13	DE WATERING PUMP – 5HP/10HP/20HP	1 No. EACH
14	PORTABLE CONCRETE MIXTURE M/C	APR*

15	ARC WELDING MACHINES	APR*
16	PLATE COMPACTOR	APR*
17	PNEUMATIC JACK HAMMER	APR*
18	MECHANIZED MODULAR UNITS OF SCAFFOLDING	APR*
19	PLY SHUTTERING BOARD/ STEEL SHUTTERING WITH ADEQUATE SUPPORTING STRUCTURE	APR*
20	HYDRAULIC EXCAVATOR/POCLAINS	APR*
21	JCB	APR*
22	DUMPERS	APR*
23	DOZERS	APR*
24	AIR COMPRESSOR	APR*
25	DG SET 62.5 kVA	APR*
26	WATER TANKER WITH SPRINKLER	APR*
27	PILE LOAD TEST ARRANGEMENTS	2 Nos.
28	VIBROMAX/EARTH COMPACTOR	APR*
29	WATER TANKER-4000 LTR. CAPACITY	APR*
30	FIRE EXTINGUISHER'S	APR*
31	CONCRETE VIBRATOR WITH ADEQUATE NEEDLE	APR*
32	DRINKING WATER TANK-2000 LT.	APR*
33	TREMIE PIPE	APR*
34	TREMIE HOPPER	APR*
35	GROUTING PUMP	2 Nos./Additional as per requirement

36	ARRANGEMENT FOR INTEGRITY TESTING USING SONIC CORING/SONIC LOGGING	APR*
37	ARRANGEMENT FOR LOW STRAIN PILE INTEGRITY TEST AND HIGH STRAIN DYNAMIC TESTING OF PILES	APR*

APR*: As per Requirement

NOTEs:

1. The above list – (A) is only indicative and these T&Ps may not be required for entire contract period but contractor will ensure that these T & Ps are provided as per the work requirement. **T&P Deployment schedule will be finalized at site based on the work fronts and in consultation with BHEL Engineer. Contractor have to mobilize / maintain the T& P as per the schedule notified time to time by BHEL Engineer.**

2. If any one of T&P mentioned above is not needed for proper execution of scope of work, provided contractor has not utilized BHEL free issued T&P for completing such work, no recovery from contractor shall be applicable.

3. Any additional item required in addition to above mentioned T&P for proper execution of scope of work, contractor has to arrange such T&P within quoted rate on the instruction of BHEL in writing in a reasonable period within two weeks from the written instruction from BHEL.
4. In case deployment of T&P w.r.t requirement, is delayed or deployed for a shorter period or abnormal down time of T&P or in case T&P w.r.t requirement was not deployed by the contractor as per instruction of BHEL and BHEL had to deploy either its own T&P or from outside, the recovery shall be done from the contractor as under:

    a. In case BHEL had to deploy its own T&P, hire charges of T&P applicable for outside agencies as per extant guidelines for "Hire Charges on issue of Capital Tools & Plants" shall be recovered.

    b. In case BHEL had to deploy the T&P from outside, actual hiring cost plus applicable overheads shall be recovered.

5. All the tools and tackles/measuring instruments shall be duly tested/calibrated and valid certificate to that effect should be submitted to BHEL site in-charge before the start of work.

6. Other terms and conditions regarding above items please also refer clause for T&P/IMTEs in SCC.
7. All the tools and plants required for this scope of work, except the Tools & Plants provided by BHEL are to be arranged by the contractor within the quoted rates. The list is suggestive in nature. **Any additional T & P required to meet BHEL commitments/schedule shall be arranged without any extra cost by the contractor.**
8. All the T&Ps/ measuring instruments required for the scope of work shall not be more than 3 years old and in good working condition.
9. **If the work related to T & Ps mentioned above list - (A) is completed then, Engineer I / C can release the T & P during contract period / extended period if any. However, written permission shall be taken by contractor from BHEL construction Manager before releasing T&P.**

B- LIST OF IMTEs/MMEs REQUIRED:

SL NO	EQUIPMENT
1	TOTAL STATION
2	AUTO LEVEL AND STAFF
3	COMPRESSION STRENGTH TESTING EQUIPMENT
4	CONSTRUCTION MATERIAL TEST EQUIPMENT
5	CONCRETE CUBE MOULDS (150 X 150 X 150) mm
6	CONCRETE SLUMP CONE
7	COARSE AGGREGATE SIEVES & SAND SIEVER
8	SIEVES AND SIEVE SHAKER
9	AGGREGATE IMPACT TEST MACHINE
10	PHYSICAL BALANCE FOR LAB WORK
11	RAPID MOISTURE METER
12	VICAT APPARATUS WITH PLUNGERS FOR CEMENT TESTING
13	THEODOLITE ONE STAND ACCURACY
14	DUMPY LEVEL UP TO 350 MM
15	CORE CUTTER TEST APPARATUS
16	CUBE MOULDS (70MM SIZE)

17	ELECTRIC OVEN

NOTES:

1. The above list is only indicative and these IMTEs/MMEs may not be required for entire contract period and will be provided as per need. Contractor will assess actual quantity and period of requirement based on his experience
2. Other terms and conditions regarding above items please also refer clause for T&P/MMEs.
3. All the IMTEs /MMEs required for this scope of work, except the IMTEs / MMEs provided by BHEL, are to be arranged by the contractor within the quoted rates. **The list is suggestive in nature. Any additional IMTEs / MMEs required to be arranged by the contractor.**

NOT APPLICABLE

6.0	**TIME SCHEDULE (MOBILIZATION, TIME SCHEDULE, CONTRACT PERIOD)**
6.1	**INITIAL MOBILIZATION** After receipt of LOA, Contractor shall discuss with Project Manager / Construction Manager regarding initial mobilization. Contractor shall mobilize necessary resources within 2 weeks of issue of LOA or as per the directive of Project Manager / Construction Manager. Such resources shall be progressively augmented to match the schedule of milestones as directed by BHEL Engineer.
6.2	**START DATE / ZERO DATE** The schedule date of start of work shall be the date after 2 weeks of issue of LOA; The Actual Date of Start of Contract Period (Zero Date) shall be date of handing over of site to contractor for work and shall be certified by the BHEL Engineer**.**
6.3	**COMPLETION PERIOD:** Entire work as detailed in tender specification **shall be completed within 10 (Ten) months from the actual date of start of work** as per the programs / milestones indicated by BHEL**.** Contractor has to mobilize adequate resources to meet BHEL's commitments to their customer as indicated from time to time. **In the event the contractor fails to respond to these requirements, BHEL shall take appropriate actions to meet customer's commitments in line with the provisions of General Conditions of Contract.**
6.4	In case due to reasons not attributable to the contractor, the work gets delayed and scheduled completion gets extended, time extension will be granted by BHEL as per clause no. 2.11 of GCC.
6.5	The work under the scope of this contract is deemed to be completed in all respects, only when all the works are carried out as per satisfaction of BHEL. The decision of BHEL on completion date shall be final and binding on the contractor.
6.6	In order to meet above schedule in general, and any other intermediate targets set, to meet customer/ project schedule requirements, contractor shall arrange & augment all necessary resources from time to time on the instructions of BHEL without any extra cost to BHEL.
6.7	**CONTRACT PERIOD:** The contract period for completion of entire work under scope of this contract shall be **10 (Ten) Months** from the actual / zero date of start of work.
6.8	**The Milestones are as under:**

Mile Stone	**Schedule**

	Start of Test Piling	Within 2nd week from Zero date	
	Pile Testing Completion	Within 8th Week from Zero date	
	Start of Job Piling	Within 8th Week from Zero date	
	Completion of Job Piling	Within 09th Month from Zero date	
	Completion in all respect including pile breaking and its testing	Within 10th Month from Zero date	
6.10	**CONSEQUENCE OF DELAY** It may be noted that in the event, delay in completion is attributable to the contractor; BHEL will impose LD on the contractor as per clause no. 2.7.9 of GCC.		

7.0	**TERMS OF PAYMENT**
7.1	The 'Engineer' will certify regarding the actual work executed in the measurement books and bills, which shall be accepted by the contractor in measurement book.
7.2	**The Contractor shall be paid monthly running bill as per chapter – X of SCC and Clause Nos. 2.22 & 2.23 of GCC.** The format for billing shall be approved by BHEL before raising invoices.
7.3	The contractor on certification of the engineer at site is entitled for payments of his running bills which shall be subject to any deduction/retention specifically under clauses 2.22 of GCC and 10.0 of SCC.
7.4	BHEL will release the payment through Electronic Fund Transfer (EFT)/RTGS
7.5	Final bill shall be submitted after completion of works and upon material reconciliation along with all prescribed formats.

8.0	**TAXES & DUTIES**
8.1	The contractor shall pay all (save the specific exclusions as enumerated in this clause) taxes, fees, license, charges, deposits, duties, tools, royalty, commissions, other charges, etc. which may be levied on the input goods & services consumed and output goods & services delivered in course of his operations in executing the contract. In case BHEL is forced to pay any of such taxes/duties, BHEL shall have the right to recover the same from his bills or otherwise as deemed fit. However, provisions regarding **GST** on output supply (goods/service) and TDS/TCS as per Income Tax Act shall be as per following clauses.
8.2	**GST (Goods and Services Tax)**
8.2.1	GST as applicable on output supply (goods/services) are excluded from contractor's scope; therefore, contractor's price/rates shall be **exclusive** of GST. Reimbursement of GST is subject to compliance of following terms and conditions. BHEL shall have the right to deny payment of GST and to recover any loss to BHEL on account of tax, interest, penalty etc. for non-compliance of any of the following condition.
8.2.2	The admissibility of GST, taxes and duties referred in this chapter or elsewhere in the contract shall be limited to direct transactions between BHEL & its Contractor. BHEL shall not consider GST on any transaction other than the direct transaction between BHEL & its Contractor.
8.2.3	Contractor shall obtain prior written consent of BHEL before billing the amount towards such taxes. Where the GST laws permit more than one option or methodology for discharging the liability of tax/levy/duty, BHEL shall have the right to adopt the appropriate one considering the amount of tax liability on BHEL/Client as well as procedural simplicity with regard to assessment of the liability. The option chosen by BHEL shall be binding on the Contractor for discharging the obligation of BHEL in respect of the tax liability to the Contractor.
8.2.4	Contractor has to submit GST registration certificate of the concerned state. Contractor also needs to ensure that the submitted GST registration certificate should be in active status during the entire contract period.
8.2.5	Contractor/Vendor has to issue invoice indicating HSN/SAC code, Description, Value, Rate, applicable tax and other particulars in compliance with the provisions of relevant GST Act and Rules made thereunder.

8.2.6	Vendor has to submit GST compliant invoice within seven days from the due date of invoice as per GST Law. In case of delay, BHEL reserves the right of denial of GST payment if there occurs any hardship to BHEL in claiming the input thereof. In case of goods, vendor has to provide scan copy of invoice & GR/LR/RR to BHEL before movement of goods starts. Special care should be taken in case of month end transactions.
8.2.7	Vendor has to ensure that invoice in respect of such services which have been provided/completed on or before end of the month should not bear the date later than last working day of the month in which services are performed.
8.2.8	Subject to other provisions of the contract, GST amount claimed in the invoice shall be released on fulfilment of all the following conditions by the Contractor: - a. Supply of goods and/or services have been received by BHEL. b. Original Tax Invoice has been submitted to BHEL. c. Contractor/ Vendor has submitted all the documents required for processing of bill as per contract/ purchase order/ work order. d. In cases where e-invoicing provision is applicable, vendor/contractor is required to submit invoice in compliance with e-invoicing provisions of GST Act and Rules made thereunder. e. Contractor has filed all the relevant GST return (e.g. GSTR-1, GSTR-3B, etc.) pertaining to the invoice submitted and submit the proof of such return along with immediate subsequent invoice. In case of final invoice/ bill, contractor has to submit proof of such return within fifteen days from the due date of relevant return. f. Respective invoice has appeared in BHEL's GSTR - 2A for the month corresponding to the month of invoice. Alternatively, BG of appropriate value may be furnished which shall be valid at least one month beyond the due date of confirmation of relevant payment of GST on GSTN portal or sufficient security is available to adjust the financial impact in case of any default by the contractor. g. Contractor has to submit an undertaking confirming the payment of all due GST in respect of invoices pertaining to BHEL.
8.2.9	Any financial loss arises to BHEL on account of failure or delay in submission of any document as per contract/purchase order/work order at the time of submission of Tax invoice to BHEL, shall be deducted from contractor's bill or otherwise as deemed fit.

8.2.10	TDS as applicable under GST law shall be deducted from contractor's bill.
8.2.11	Contractor shall comply with the provisions of e-way bill wherever applicable. Further wherever provisions of GST Act permits, all the e-way bills , road permits etc. required for transportation of goods needs to be arranged by the contractor.
8.2.12	Contractor shall be solely responsible for discharging his GST liability according to the provisions of GST Law and BHEL will not entertain any claim of GST/interest/penalty or any other liability on account of failure of contractor in complying the provisions of GST Law or discharging the GST liability in a manner laid down thereunder.
8.2.13	In case declaration of any invoice is delayed by the vendor in his GST return or any invoice is subsequently amended/altered/deleted on GSTN portal which results in any adverse financial implication on BHEL, the financial impact thereof including interest/penalty shall be recovered from the Contactor's due payment.
8.2.14	Any denial of input credit to BHEL or arising of any tax liability on BHEL due to non-compliance of GST Law by the Contractor in any manner, will be recovered along with liability on account of interest and penalty (if any) from the payments due to the Contactor.
8.2.15	In the event of any ambiguity in GST law with respect to availability of input credit of GST charged on the invoice raised by the contractor or with respect to any other matter having impact on BHEL, BHEL's decision shall be final and binding on the contractor.
8.2.16	**Variation in Taxes & Duties:** Any upward variation in GST shall be considered for reimbursement provided supply of goods and services are made within schedule date stipulated in the contract or approved extended schedule for the reason solely attributable to BHEL. However downward variation shall be subject to adjustment as per actual GST applicability. In case the Government imposes any new levy/tax on the output service/goods after price bid opening, the same shall be reimbursed by BHEL at actual. The reimbursement under this clause is restricted to the direct transaction between BHEL and its contactor only and within the contractual delivery period only.

	In case any new tax/levy/duty etc. becomes applicable after the date of Bidder's offer but before opening of the price Bid, the Bidder/Contractor must convey its impact on his price duly substantiated by documentary evidence in support of the same before opening of price bid. Claim for any such impact after opening the price bid will not be considered by BHEL for reimbursement of tax or reassessment of offer.
8.3	**Income Tax:** **TDS/TCS** as applicable under Income Tax Act, 1961 or rules made thereunder shall be deducted/collected from contractor's bill.

8.4	**BUILDING & OTHER CONSTRUCTION WORKERS (REGULATION OF EMPLOYMENT AND CONDITIONS OF SERVICE) ACT, 1996 (BOCW ACT) AND RULES OF 1998 READ WITH BUILDING & OTHER CONSTRUCTION WORKERS CESS Act, 1996 & CESS RULES, 1998.**
	In case any portion of work involves execution through building or construction workers, then compliance to the above titled Acts shall be ensured by the contractor and contractor shall obtain license and deposit the cess under the Act. In the circumstances it may be ensured as under:-
8.4.1	It shall be the sole responsibility of the contractor in the capacity of employer to forthwith (within a period of 15 days from the award of work) apply for a license to the Competent Authority under the BOCW Act and obtain proper certificate thereof by specifying the scope of its work. It shall also be responsibility of the contractor to furnish a copy of such certificate of license / permission to BHEL within a period of one month from the date of award of contract.
8.4.2	It shall be the sole responsibility of the contractor as employer to ensure compliance of all the statutory obligations under these act and rules including that of payment / deposit of 1% cess on gross payment made for value of work involving building or construction workers engaged by the contractor within a period of one month from the receipt of payment.
8.4.3	It shall be the responsibility of the sub-contractor to furnish the receipts /challans towards deposit of the cess together with the number, name and other details of beneficiaries (building workers) engaged by the sub-contractor during the preceding month.
8.4.4	It shall be the absolute responsibility of the sub-contractor to make payment of all statutory payments & compensations to its workers including that is provided under the Workmen's Compensation Act, 1923.
8.4.5	The contractor shall, however ensure before deposit of any BOCW Cess, that customer is not depositing the same in order to avoid excess deposit of cess.
8.4.6	The contractor shall bear cost of BOCW cess either by way of deposit or through recovery by BHEL in case the same is deposited by the customer.
8.4.7	In case of failure in above mentioned compliances, BOCW Cess @ 1% as well as applicable penalty as specified in BOCW Act/Rules shall be deducted from the contractor.

NOTE:

1	The Gross amount is to be construed as cost of construction in line with the provisions of the BOCW of the BOCW Cess act and in case of compliance by customer by way of deduction at source in line with clause No 3(2) of the act an equitable adjustment to the relatable cost of construction attributable to the bidder shall be

	made in terms of clause no 8.2 of TCC
2	In case compliance by customer by way of deduction at source in line with clause no 3(2) is not resorted to, the compliance of BOCW Cess act shall be ensured by the bidder in line with the provisions of BOCW Cess act in terms of clause no 8.2.2b of TCC
3	The bidder may consider the cost of construction for levy of BOCW Cess inclusive of GST, however, due to whatsoever reason if the GST does not form the cost of construction for levy of aforesaid Cess an equitable adjustment thereof shall be made to the contract price.

9.0	**MATERIALS**
9.1	The contractor shall at his own expenses provide all materials including paints, welding electrodes etc. required for the work. However for permanent works **cement, ready mix concrete & reinforcement steel will be issued free of cost** as per terms & conditions specified in clause No. 9.14 from BHEL / Customer stores or at a point instructed by BHEL.
9.2	All materials to be provided by the Contractor shall be of the best kind in conformity with the specifications laid down in the contract or as per relevant Indian standard and the Contractor shall, if requested by the BHEL Engineer, furnish proof to the satisfaction of BHEL Engineer that the materials so comply.
9.3	The Contractor shall, at his own expense and without delay, supply to the BHEL Engineer, samples of materials proposed to be used in the works. The BHEL Engineer shall within seven days of supply of samples or within such further period as he may require will intimate to the Contractor in writing, whether samples are approved by him or not. If samples are not approved, the Contractor shall forthwith arrange to supply to the BHEL Engineer for his approval fresh samples complying with the specifications laid down in the Contract. Any delay in approval of samples (original or fresh ones) shall not make the contractor eligible for any compensation.
9.4	The BHEL Engineer shall have full powers for removal of any or all of the materials brought to site by the Contractor which are not in accordance with the Contract specifications or do not conform in character or quality to samples approved by him. In case of default on the part of the Contractor in removing rejected materials, the BHEL Engineer shall be at liberty to have them removed by other means. The BHEL Engineer shall have full powers to procure other proper material to be substituted for rejected materials and in the event of the Contractor refusing to comply; he may cause the same to be supplied by other means. All costs, which may attend upon such removal and / or substitution, shall be borne by the Contractor.
9.5	The Contractor shall indemnify BHEL, its representatives or employees against any action, claim or proceeding relating to infringement or use of any patent or design or any alleged patent or design rights and shall pay any royalties or other charges which may be payable in respect of any article or material or part thereof included in the Contract. In the event of any claim being made or action being brought against BHEL or any agent, servant or employee of BHEL in respect of any such matters as aforesaid, the Contractor shall immediately be notified thereof, provided that such indemnity shall not apply when such infringement has taken place in complying with

	the specific directions issued by BHEL but the Contractor shall pay any royalties or other charges payable in respect of any such use, the amount so paid being reimbursed to the Contractor only if the use was the result of any drawings / specifications issued after submission of the tender.
9.6	The BHEL Engineer shall be entitled to have tests carried out as specified in the Contract for any materials supplied by the Contractor other than those for which, as stated above, satisfactory proof has already been furnished, at the cost of the Contractor and the Contractor shall provide at his expense all facilities which the Engineer may require for the purpose. If no tests are specified in the Contract, and such tests are required by the Engineer, the Contractor shall provide all facilities required for the purpose and the charges for these tests shall be borne by the Contractor only. The cost of materials consumed in tests shall be borne by the Contractor in all cases except when otherwise provided.
9.7	In addition, the Contractor shall perform / submit at his own cost such tests / samples as may be required by the BHEL Engineer out of the materials used by the company except for the costs of materials used in such tests/ samples.
9.8	After acceptance of the Contract, if Contractor desires BHEL to supply any other materials, such material may be supplied by BHEL, if available, at rates to be fixed by the BHEL Engineer along with prevailing departmental charges. BHEL reserve the right not to issue any material. The non-issue of such material will not entitle the Contractor for any compensation whatsoever either in time or in cost.
9.9	Material required for the works, whether brought by the Contractor or supplied by BHEL, shall be stored by the Contractor only at places approved by the Engineer. Storage and safe custody of material shall be the responsibility of the contractor.
9.10	BHEL's officials concerned with the Contract shall be entitled at any time to inspect and examine any materials intended to be used in or on the works, either on the Site or at factory or workshop or other place(s) where such materials are assembled, fabricated, manufactured or at any place (s) where these are lying or from which these are being obtained and the Contractor shall give such facilities as may be required for such inspection and examination.
9.11	All materials brought to the Site shall become and remain the property of BHEL and shall not be removed off the Site without the prior written approval of the BHEL Engineer. But whenever the Works are finally completed and advance, if any, in respect of any such material is fully recovered, the Contractor shall at his own expense forthwith remove from the Site all surplus material originally supplied by him

	and upon such removal, the same shall re-vest in and become the property of the Contractor.
9.12	It shall be the responsibility of the contractor to obtain prior approval of BHEL, regarding suppliers, type of electrodes etc. before procurement of welding electrodes / TIG wires. On receipt of electrodes at site these shall be subjected to inspection and approval by BHEL. The contractor shall inform BHEL details regarding type of electrodes, batch No. date of expiry etc. and produce test certificate for each lot / batch with correlation of batch / lot no. with respective test certificate. No electrode will be allowed to be used without valid test certificate.
9.13	All charges on account of Octroi, terminal or sales tax and other duties on material obtained for the works from any source shall be borne by the contractor.
9.14	**ISSUE AND ACCOUNTING OF CEMENT, RMC AND REINFORCEMENT STEEL.**
9.14.1	**Cement, Ready Mix Concrete and Reinforcement steel will be issued as free issue materials from BHEL site stores or other issuing points as specified by the Engineer.** Such issues would be only for permanent works. Conveying and Placement/Pouring of Concrete in piles/any other structure is in the scope of RMC supplier. However for any unforeseen conditions, bidder may maintain the suitable facility for taking the RMC from installed batching plant and further pouring in piles/any other structure. Necessary indents shall be raised by the contractor as per procedure laid down by the Engineer-in-Charge in advance of the actual requirement for incorporation in the works.
9.14.2	Materials will be issued only for permanent works and not for making templates, other temporary works, enabling works etc. and the same shall not be taken into account for purpose of material reconciliation. **Quarterly requirement of steel** must be positively submitted by the contractor at the last month of the previous quarter. The contractor shall submit to the engineer, a statement indicating estimated quantity of **cement & RMC required at least two months in advance.** In addition, the contractor shall also furnish the estimated requirement of cement and steel during a month by the third week of the previous month indicating his requirement.
9.14.3	The contractor shall bear all other costs including the lifting, carting from issue points to works site / contractor's stores, custody and handling etc. and return of surplus /

	serviceable materials to Owner's stores to be designated by the Engineer-in- charge and all expenditure will be made by the contractor.
9.14.4	All steel shall be issued in available lengths / shapes and no claims for extra payment on account of issue of non-standard lengths / shapes will be entertained. For the purpose of billing and accounting only linear measurement will be taken and weight will be calculated as per the IS Co-efficient. The different in unit weight as per IS and actual as issued, if any shall be to the contractor's account and contractor shall quote the rates for corresponding item to take care of such difference.
9.14.5	Cement, as received from the Manufacturer / Stockiest will be issued to the contractor. The theoretical weight of each bag of cement for issue purpose will be considered as 50Kgs. Per Bag. Any type of cement and in any container as received from Manufacturer / Stockiest shall be issued to the contractor No claim whatsoever shall be entertained on this. Cement bags weighing up to 4% less will be accepted by the contractor and accounted for as 50Kg per bag.
9.14.6	The Contractor shall maintain good stores for storing the cement issued to him. The flooring of the storage house, the clearance of cement bags from the side walls etc., shall be as per the instructions of the Engineer-in-charge.
9.14.7	The cement stores shall be open for supervision and verification by the Engineer-in-charge or his authorized representative by any time when the Engineer-in-charge feels the need to do so.
9.14.8	In the case of steel materials, the same shall be issued generally on the basis of linear measurement and the corresponding weight will be calculated as per Indian Standard. For the purpose of billing & accounting, only linear measurement will be taken and any difference in weight based on linear measurement & actual weight shall be to contractor's account. Quoted price shall be deemed to include the above & the permissible wastage mentioned. No claim whatsoever shall be entertained on account of wastage & difference in weight as referred to above.
9.14.9	Issue of stores material is subject to availability and the contractor shall not be entitled to any claim or compensation for non-supply or delay in the supply under any circumstances. The material will be issued generally during the working hours.
9.14.10	The Contractor will have to submit their design mix for different grades of Concrete keeping in view the requirements stipulated in IS:456, specifically regarding slump and Water Cement ratio and Specific Gravity of Materials brought to site as analyzed in the laboratories. The design shall be used upon absolute volume method and theoretical consumption of Cement shall be worked out on this basis. For other than

<table>
<tr><td></td><td>above designated mix Concrete items, the coefficients for consumption of cement shall be adopted as per CPWD practice. The theoretical consumption of cement thus worked out shall be binding upon the Contractor for reconciliation of Cement issued by the Owner. For any excess /under consumption based on these coefficients, the Contractor shall be penalized as per contract provisions. Though, permissible wastage specified shall be considered, while effecting penal recovery, no other allowance whatsoever shall be taken for reconciliation purposes.</td></tr>
<tr><td>9.14.11</td><td>The theoretical consumption of cement, reinforcement steel and ready mix concrete required for the work will be calculated on the basis of approved drawings / joint measurements. In the case of cement, the theoretical consumption shall be decided by the Engineer as mentioned above and his decision in this regard shall be final and binding on the Contractor. Ready Mix Concrete shall be measured on the basis of approved drawings and joint measurements by the BHEL Engineer and his decision in this regard shall be final and binding on the contractor. Reinforcement steel shall be measured by weight in tones. The weight will be arrived at by multiplying the used length by the sectional weight. The sectional weight will be same as were applied at the time of issue. Standard hooks, cranks, bends and authorized laps, chairs, separator pieces etc. specified in drawing or instructed by engineer as required shall be measured and paid for. No payment shall be made for binding wires, spacer block etc. required for keeping the steel in position unless otherwise specified in the contract. No extra payment will be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.</td></tr>
<tr><td>9.14.12</td><td>The contractor shall submit proper account of material / material reconciliation statement for the material drawn by him from stores once in every three months. Failing compliance of this requirement further issue of steel to the contractor may be suspended and no claim of compensation for delay in execution on this account shall be entertained.</td></tr>
<tr><td>9.14.13</td><td>All the cement, ready mix concrete & reinforcement steel thus issued shall be properly accounted for as per the following permissible wastage over the theoretical quantity / consumption incorporated in the works.
<table>
<tr><td>Item</td><td>Area</td><td>Permissible Variation / Wastage</td></tr>
<tr><td>Cement and Ready Mix Concrete</td><td>For All works</td><td>1.5%</td></tr>
<tr><td>Reinforcement Bars & MS Earthing Rods</td><td>For All works</td><td>3%</td></tr>
</table></td></tr>
</table>

9.14.14	Any unused / serviceable quantity of cement, reinforcement steel & ready mix concrete not returned in good condition & wastages / loss / consumption beyond specified / agreed limits shall be charged at penal rate of **Rs 7000 per MT for cement, Rs 80,000 per MT for reinforcement steel & 105% of BHEL Purchase cost of Ready Mix Concrete** at the time of preparing final bill, during finalization of the contract. The decision of Engineer-in-charge with regard to applicability of penal rates shall be final & binding upon the contractor.
9.14.15	For the materials i.e. Reinforcement (TMT) being issued free of cost, the scrap generated shall belong to BHEL.
9.14.16	Empty cement bags shall be the property of contractor and recovery @ 01/- (Rs. One only) per empty cement bag shall be made from their RA bills.
9.14.17	**SCRAP & SERVICEABLE MATERIALS:** All reinforcement steel of length above 2 M shall be considered as serviceable materials provided the materials is in good and acceptable condition. Reinforcement steel in length less than 2 M shall be treated as scrap.

10.1	**EXECUTION OF WORK**
10.1.1	The work shall be executed in a workman like manner and to the entire satisfaction of the Engineer and as per technical specification issued with tender, IS codes, technical specifications as applicable. In case of conflict, the decision of the Engineer I/c shall be final & binding.
10.1.2	The Engineer I/c will communicate or confirm his instructions to the Contractor in respect of the execution of the work in a "Work Site Order Book" maintained at his office and the Contractor shall visit this office daily and shall confirm receipt of such instructions by signing the relevant entries in this book or through e-mail. Such entries / e-mails will rank as order or notices in writing within the intent and meaning of these conditions.
10.1.3	Only BHEL approved make of electrodes will be used. All electrodes shall be heated and dried in the electric electrode drying oven to the required temperature for the period specified by the Engineer before these are used in erection work. All welders shall have electrodes drying portable oven at the work spot. The electrodes brought to site will have valid manufacturing test certificate. The test certificate will have co-relation with the lot no. / batch no. given on electrode packets. No electrodes will be allowed to be used in the absence of above requirement. The thermostat and thermometer of electrode drying oven will be also calibrated and test certificate from Govt. approved / accredited test house traceable to National / International standards) will be submitted to BHEL before putting the oven in use. Periodical calibration for the same shall also be arranged by the contractor within the finally accepted rates.
10.2	**SETTING OUT**
10.2.1	All the works shall be set out to the true lines, grades and elevation indicated on the drawing. The contractor shall be responsible to locate and set out the works. Only one grid reference line and bench mark all be made available for setting out the works under the contract. This reference lines shall be used as datum for the works under the contract and the contractor has to establish for his work area at available points horizontal and vertical control points. The contractor shall inform BHEL well in advance of the times & places at which he wishes to do work in the area allotted to him so that suitable datum points established by him are checked by BHEL / Customer to enable the contractor to proceed with the works. Any work done without being properly located may be removed and / or dismantled by BHEL / Customer at contractor's expense.
10.2.2	The contractor shall at his own expense take all proper and responsible precautions to preserve and maintain these datum marks to its true position. In

	the event of these marks being disturbed or obliterated by accident or due to any other cause whatsoever, the same may be deemed necessary placed by BHEL / Customer at contractor's expenses.
10.3	**SITE DRAINAGE**
10.3.1	All water including sub-soil water which may accumulate on the Site during the progress of the works or in trenches and excavations, including monsoon period shall be removed by the contractor from the Site to the satisfaction of the Engineer. It will also be responsibility of the contractor to de-water all the foundation pits, trenches with suitable de-watering methods like, pumping out, well point system etc. considering the depth of water table at plant site. All such expenditure on de-watering shall be deemed to be included in quoted rates.
10.4	**INSPECTION AND STAGE APPROVAL OF THE WORK**
10.4.1	The owner or his duly authorized representative shall have at all reasonable times access to the contractor's premises or works and shall have the power to inspect drawings or any portion of the work, examine the materials and workmanship and shall have the authority to reject any work. This would be implemented through joint inspection by the representative of the owner and BHEL and in the form of joint protocols without any extra claims and loss of time and amount.
10.4.2	All work embracing more than one process shall be subject to examination and approval at each stage thereof and the Contractor shall give due notice in writing to the Engineer when each stage is ready. In default of such notice being received, the Engineer shall be entitled to approve the quality and extent thereof at any time he may choose and in the event of any dispute, the decision of the Engineer thereon shall be final and conclusive.
10.5	**UNCOVERING AND MAKING GOOD**
10.5.1	The Contractor shall uncover any part of the Works and/or make openings in or through the same as the Engineer may from time to time direct for his verification and shall reinstate and make good such part to the satisfaction of the Engineer. If any such part has been covered up or put out of view after being approved by the Engineer and is subsequently found on uncovering to be executed in accordance with the Contract, the expenses of uncovering and / or making opening in or through, reinstating and making good the same shall be

	borne by BHEL. In any other case all such expenses shall be borne by the Contractor.
10.6	**DISCREPANCIES AND ADJUSTMENT OF ERRORS**
10.6.1	The several documents forming the Contract are to be taken as mutually explanatory of one another, detailed drawings being followed in preference to small-scale drawings and figures dimensions in preference to scale and special conditions in preference to general conditions.
10.6.2	In case of discrepancies between schedules of quantities, the specification and / or the drawings, the following order of preference shall be observed. (a) Description in schedule of quantities. (b) Technical Conditions of Contract. (c) Drawings. (d) Technical Specifications (e) Special Conditions of Contract (f) General conditions of contract
10.6.3	If there are varying or conflicting provisions made in any one document forming part of the contract, the Engineer shall be the deciding authority with regard to the document.
10.6.4	Any error in description, quantity in schedule of quantities or any omission there from shall not vitiate the contract or release the contractor from the execution of the whole or any part of the works comprised therein according to the drawings and specifications or from any of his obligations under the contract.
10.7	**MATERIAL OBTAINED FROM EXCAVATION**
10.7.1	Valuable Materials / Archeologically important materials of any kind obtained from excavation on the Site shall remain the property of BHEL / its client and shall be disposed of as the Engineer may direct, at no extra cost.
10.8	**SAFETY CODE**
10.8.0	**The contractor shall comply with following towards Safety and Social Accountability.**

10.8.1	Besides provision with regard to SAFETY under Clause 9.0 of SCC, the contractor will be responsible for Health, Safety & Environment management at site for the construction activities to be carried out by them. The contractor shall continuously take special care to ensure the safety and prevention of human and equipment accidents and maintain good sanitary conditions in and around the site. All the construction work and plant operation must be carried out in the safest possible manner. The Engineer reserves the right to stop any process which, in the Engineer's opinion, is being performed dangerously. In this case the contractor must immediately adhere the requisite safety precautions and any delays attributed to the work stoppage on this account shall not affect the agreed contractual finishing dates.
10.8.2	HSE plan for site operation by Sub Contractor (Doc No. HSEP 13 Rev 00 attached) shall be followed.
10.9	**NUISANCE**
10.9.1	The Contractor shall not at any time do, cause or permit any NUISANCE on Site or do anything which shall cause unnecessary disturbance or inconvenience to owners, tenants or occupiers of other properties near the Site and to the public generally.
10.10	**TREASURE , TROVE , FOSSILS etc.**
10.10.1	All fossils, coins, articles of value or antiquity and structures and other remains or things of geological or archaeological interest discovered on the site shall be the absolute property of BHEL / BHEL's client and the Contractor shall take reasonable precautions to prevent his workmen or any other person from removing or damaging any such article or thing, shall immediately upon discovery thereof and before removal acquaint the Engineer with such discovery and carryout the Engineer's directions as to the disposal of the same.
10.11	**PROTECTION OF WORKS**
10.11.1	Trees designated by the Engineer shall be protected from damage during the course of the Works and earth level within 1 meter of each such tree shall not be charged. Where necessary, such trees shall be protected by providing temporary fencing.
10.11.2	The contractor shall provide and maintain at his own expense all lights, guards, fencing and watching when and where necessary or required by the Engineer for the protection of the Works or for the safety and convenience of those employed on the Works or the public.

10.11.3	The contractor shall have total responsibility for protecting his works till it is finally taken over by the Engineer. No claim will be entertained by the Engineer for any damage or loss to the contractor's works and the contractor shall be responsible for the complete restoration of the damaged works to its original condition to comply with the specifications and drawings. Should any such damage to the contractor's works occur because of other party not under his supervision or control, the contractor shall make his claim directly with the party concerned. The contractor shall not cause any delay in the repair of such damaged works because of any delay in the resolution of such disputes. The contractor shall proceed to repair the work immediately and no cause thereof will be assigned pending resolution of such disputes.
10.12	**RECORD FOR MATERIALS CONSUMED**
10.12.1	The contractor shall maintain and furnish to the Engineer the RECORD OF MATERIALS consumed in the works for each activity. The statement showing the theoretical vis-à-vis actual consumption of specified materials, such as ~~structural~~ /reinforcement steel, ~~cement~~ RMC, bitumen, lead, paint etc., shall be enclosed along with the running bills submitted by the contractor. Contractor has to also furnish the test results of the materials used in the work as per IS specifications.
10.13	**PROTECTION OF EMBEDMENTS, BOLTS ETC.**
10.13.1	The contractor shall ensure proper protection to the satisfaction of the Engineer, of all bolts, inserts, embedment etc. from weather etc./ by greasing, rapping them with gunny bags or canvas or by any other means as directed by Engineer. Cost of such protections shall be deemed to be included in the rates quoted for the item.
10.14	**COMPLETION OF WORK AND COMMENCEMENT OF GURANNTEE PERIOD**
10.14.1	The works shall be completed to the entire satisfaction of the Engineer and in accordance with the completion schedule as specified in the Contract, and all unused stores and materials, tools, plant, equipment, temporary buildings, site office, labor hutments and other things shall be removed and the site and work cleared of rubbish and all waste materials and delivered up clean and tidy to the satisfaction of the Engineer at the Contractor's expenses.
10.14.2	BHEL shall have power to take over from the Contractor from time to time such sections of the work as have been completed to the satisfaction of the Engineer.

	Such work however shall not be treated as have been completed until the extra / pending works are executed to the satisfaction of Engineer.
10.14.3	The Engineer shall certify to the contractor the date on which the work is completed and the date thereof for commencement of Guarantee Period. Guarantee Period shall be as given in GCC.
10.15	**CLEARANCE OF SITE AND REPAIRS.**
10.15.1	Contractor has to clear the site / area where mechanical and electrical erection work is to be commenced / or in progress. The contractor shall remove construction materials and equipment lying in the vicinity and causing obstruction in the erection work within 24 hrs. notice. In case, he fails to clear the site, this will be done at his risk & cost by BHEL.
10.16	**QUALITY ASSURANCE**
10.16.1	The contractor has to establish / arrange at site the field testing facilities for testing of civil construction materials and concrete cubes for ensuring the proper quality, grade and strength of the materials used in the construction in line with approved field quality check list of BHEL/ its client. Contractor has to submit detailed report for testing of all material used etc. All testing shall be done as per IS code specifications/ BHEL's quality plan. If further test is required by the engineer to be carried from outside laboratory, the cost of the same shall be borne by the contractor.
10.17	**AMBULANCE & EMERGENCY VEHICLE:** Contractor shall arrange / tie-up with nearest Hospital / Nursing Home to deal with any emergency situation including arrangement of ambulance as and when needed. The availability of the ambulance has to be in accordance with the site working schedule. As the project is having a very tight timeline, round the clock working is envisaged for achieving and meeting the targets.
10.18	**METHOD OF MEASUREMENT**
10.18.1	Method of measurements shall be as per standard specifications included in the tender. For other items measurements shall be as per relevant IS Codes.
10.19	**DEVIATION**
10.19.1	The Contractor shall not make any alteration in, addition to or omission from the work as described in the tender documents except in pursuance of the written instructions of the Engineer. No such deviation from the work described in the tender documents shall be valid unless the same has been specifically

	confirmed and accepted by the Engineer in writing and incorporated in the Contract.
10.19.2	The Engineer may deviate, either by way of addition or deduction, from the work so described, provided that the Contract sum be not thereby varied on the whole by more than the percentage set out in the tender documents. The value of all additions and deductions shall be added to or deducted from the Contract sum. (Whenever the Engineer intends to exercise such a right his intentions shall specify the deviations which are to be made, the lump-sum assessment or the proposed basis of payment, the extra time allowed, if any, and the date for completion of the entire contract). Any objection by the contractor to any matter concerning the order shall be notified by him in writing to the Engineer within seven days from the date of such order, but under no circumstances shall the work be stopped (unless so ordered by the Engineer) owing to differences or controversy that may arise from such an objection. In the absence of such a notification of objection by the Contractor, he will be deemed to have accepted the order and the conditions stated therein.
10.19.3	Valuation of Deviations shall be as per Clause 2.15 & 2.16 of GCC.
10.20	**COMPLIANCE TO REGULATIONS AND BYELAWS**
10.20.1	The Contractor shall conform to the provisions of any statute relating to the work and regulations and bylaws of any local authority and of any water and lighting Companies or Undertaking with whose system the work is proposed to be connected. He shall, before making any variation from the drawings or the specifications that may be necessitated for such connections give the Engineer, notice specifying the variation proposed to be made and the reasons therefore and shall not carry out any such variation until he has received instructions from the Engineer in respect thereof. The Contractor shall be bound to give all notices required by statute, regulations or bye-laws as aforesaid and to pay all fees and taxes payable to any authority in respect thereof.
10.20.2	**In order to give phillip to Pradhan Mantri Kaushal Vlkas Yojna:** "The contractor shall, at all stages of work deploy skilled/semi-skilled tradesmen who are qualified and possess certificate in particular trade from CPWD Training Institute/ Industrial Training Institute/ National Institute of Construction Management and Research (NICMAR), National Academy of Construction, CIDC or any similar reputed and recognized Institute managed/ certified by State/ Central Government. The number of such qualified tradesmen shall not be less than 20% of total skilled/ semi-skilled workers

	required in each trade at any stage of work. The contractor shall submit number of man days required in respect of each trade, its scheduling and the list of qualified tradesmen along with requisite certificate from recognized Institute to Engineer-in-Charge for approval. Notwithstanding such approval, if the tradesmen are found to have inadequate skill to execute the work of respective trade, the contractor shall substitute such tradesmen within two days of written notice from Engineer-in-Charge. Failure on the part of contractor to obtain approval of Engineer-in-Charge or failure to deploy qualified tradesmen will attract a compensation to be paid by contractor at the rate of Rs. 100 per such tradesman per day. Decision of Engineer-in-Charge as to whether particular tradesman possesses requisite skill and amount of compensation in case of default shall be final and binding.
10.21	**PROGRESS REPORTING :**
10.21.1	Contractor is required to draw mutually agreed monthly programme in consultation with BHEL well in advance. Contractor shall ensure achievement of agreed programme and shall also timely arrange additional resources considered necessary at no extra cost to BHEL.
10.21.2	Weekly progress review meetings will be held at site during which actual progress during the week vis-a-vis scheduled programme shall be discussed for actions to be taken for achieving targets. The programme for subsequent week shall also be presented by contractor for discussions. The contractor shall constantly update / revise his work programme to meet the overall requirement. All quality problems shall be discussed during above review meetings. Necessary preventive and corrective action, shall be discussed and decided upon in such review meetings and shall be implemented by the contractor in time bound manner so as to eliminate the cause of non-conformities.
10.21.3	The contractor shall submit weekly and monthly progress reports, materials reports, consumables (gases / electrodes) report and other reports as per proforma considered necessary by the Engineer.
10.21.4	The progress report shall indicate the progress achieved against planned , with reasons indicating delays , if any, and shall give the remedial actions which the contractor intends to take to make good the slippage or lost time , so that further works again proceed as per the original programme and the slippages do not accumulate and effect the overall programme.

10.21.5	The daily manpower reports shall clearly indicate the manpower deployed, category wise specifying also the activities in which they are engaged.
10.22	**DRAWING AND DOCUMENTS**
10.22.1	The detailed drawings, specifications available with BHEL engineers will form part of this tender specification. These documents will be made available to the contractor during execution of work at site. The contractor will also ensure availability of all drawings / documents at work place.
10.22.2	Necessary drawings / documents by BHEL to carry out the construction work will be furnished to the contractor by BHEL (except those proposed to be prepared by contractor, as mentioned in this contract) on loan which shall be returned to BHEL Engineer at site after completion of work. Contractor shall ensure safe storage and quick retrieval of these documents.
10.22.3	The contractor shall maintain a record of all drawings and documents available with him in a register as per format given by BHEL Engineer. Contractor shall ensure use of pertinent drawings / data / documents and removal of obsolete ones from work place and return to BHEL.
10.22.4	The data furnished in various annexures enclosed with this tender specification are only approximate and for guidance. However, the change in the design and in the quantity may occur as is usual in any such large scale of work.
10.22.5	Should any error or ambiguity be discovered in the specification or information the contractor shall forthwith bring the same to the notice of BHEL before commencement of work. BHEL's interpretation in such cases shall be final and binding on the contractor.
10.22.6	Deviation from design dimensions should not exceed permissible limit. The contractor shall not correct or alter any dimension / details, without specific approval of BHEL**.**

Annexure-I: BOQ cum Rate Schedule for the Work of **"Pile Test and Piling Works for 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2"**

Annexure II: NPCIL SAEFTY GUIDELINES

a) Contract Conditions for Industrial Safety
b) AERB Safety Guidelines (Control of Works)

UN-PRICE SCHEDULE

ITEM NO.	DESCRIPTION OF WORK	TOTAL VALUE IN INR
1.0	TOTAL PRICE ('A') FOR THE TOTAL WORK AS PER TENDER SPECIFICATION FOR **"PILE TEST AND PILING WORKS FOR 2X700 MWE GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2" AT GORAKHPRUR, HARYANA.**	

Notes:

a. **The rate of individual item for the entire scope of work shall be arrived as per BOQ CUM RATE SCHEDULE (Annexure - I) of TCC of tender.**

b. **The derived item rate will remain firm throughout the contract period.**

Notes:

i. Bidder's quoted price above shall be complete in all respect for the full scope defined in specification and in accordance with all terms & conditions of tender.
ii. Contractor shall fully understand description and specifications of items mentioned in BOQ.
iii. Conditional price bids with any deviation/ clarification etc. are liable to be rejected. No cutting/ erasing/ over writing shall be done.
iv. Quantities mentioned in rate schedules are approximate only and liable for variation on either side depending upon site/ design requirement.
v. Taxes (GST) shall be payable extra as per relevant clauses of Technical Conditions of Contract.

						ANNEXURE I
	BOQ-CUM-RATE SCHEDULE					
SCOPE OF WORKS : "PILE TEST AND PILING WORKS FOR 2x700 MWe GORAKHPUR HARYANA ANU VIDYUT PARIYOJNA- UNIT NO. 1&2" AT GORAKHPRUR, HARYANA.						
ST NO	**Item Description**	**Unit**	**Quantity**	**FACTOR**	**RATE= FACTOR (F) *AMOUNT(A)/100000 (ROUNDED OFF UPTO TWO PLACE OF DECIMAL)**	**AMOUNT (RS.) = RATE * QUANTITY**
100	**EARTH WORK: Earth work In excavation, backfilling, disposal, dewatering, ground improvement including all labour, equipments, preparation of work procedure & inspection, testing, submission of reports and getting approval etc. complete as per specification, drawing and as directed by engineer- in-charge for the following.**					
A101	Earth work in excavation in **COMPACTED SOIL-CEMENT MIX** strata which can be excavated by any means including setting out, levelling, dewatering (but excluding special type of dewatering viz. well point method), shoring & strutting (wherever required), dressing the sides & bottom, all lifts, ramming/compacting the excavated bottom, stacking, disposal of surplus excavated materials within a lead upto 1 km, spreading/levelling of disposed materials etc all complete for following depths below ground level.					
a	Depth from **existing** ground level but not exceeding 2 m	CUM	**10000**	**0.07051**		
b	Depth exceeding 2 m but not exceeding 4 m	CUM	**2000**	**0.09294**		
c	Depth exceeding 4 m but not exceeding 6 m	CUM	**500**	**0.14422**		
A107	Earthwork in Back filling upto any depth below ground level around foundations, plinths, trenches, drains etc to proper grade and level in layers not exceeding 200 mm thickness using/with selected **materials from compulsorily excavated** earth available within a lead upto 1 Km and compacted as specified including re-excavation of stacked earth, watering, ramming/compaction by manual/mechanical means, dressing etc all complete.for the following.					
a	Each layer compacted so as to achieve at least 95% maximum dry density as per IS-2720 (Part-VII)	CUM	**500**	**0.03134**		

A108	Earthwork in filling upto any depth below ground level around foundations, plinths, trenches, drains etc to proper grade and level in layers not exceeding 200 mm thickness using/with selected **materials from compulsorily excavated soil cement mix** available within a lead upto 1 Km and compacted as specified including re-excavation of stacked earth, watering, ramming/compaction by manual/mechanical means, dressing etc all complete.for the following.					
a	Each layer compacted so as to achieve at least 95% maximum dry density as per IS-2720 (Part-VII)	CUM	**1200**	**0.06410**		
A109	Extra over ST No. A101, A107 and A108 for carriage of material/earth for every 500 m or part thereof beyond an initial lead of 1 km.	CUM	**10000**	**0.01987**		
A112	Supply and filling upto any depth below ground level around foundations, plinths, trenches, drains etc by using **compacted soil-cement mix** (cement content 5% by weight of dry soil) as per technical specifications and drawings. For the above purpose, selected earth free from pabbles and vegetation after recovering from the stacks of excavated soil shall be dried in drying beds before use so as to bring moisture content below/ equal to Optimum Moisture Content (OMC). The soil and cement in specified quantity shall be uniformly mixed in automated weigh batching and mixing plant(s). Suitable quantity of water shall then be added to this mix in batching and mixing plant so as to achieve desired OMC at site. This mix shall be transported to the placement locations and laid in layers not exceeding 200 mm each (compacted thickness) and compacting each layer at optimum moisture content using vibro rollers to achieve at least 95% Modified Procter Density which shall be verified after completion of compaction through field and laboratory tests as per technical specifications. Quoted rate shall include cost of transportation of soil from stock pile and drying beds, bringing moisture content of soil-cement to required level, uniform mixing of soil-cement in automated weigh batching and mixing plant(s), transporting soil-cement mix to placement locations, spreading in layers, compaction, curing, protecting and performing required tests as per specifications, including maintaing and submitting all the records. Quoted rate shall also include provision of all equipment, tools & plants, manpower, consumables, enabling works required for carrying out ground improvement, necessary arrangements for testing and conducting trials and offering the same for inspection to NPCIL. **Supply of cement for soil-cement mix is in the scope of bidder.**	CUM	**4800**	**0.52558**		
				0.00000		

200	**CONCRETE WORK: ~~Providing~~ ~~and~~ placing concrete work including cost of labour, materials, (unless otherwise specified in BOQ/contract specification) and equipment for handling, ~~transportation,~~ ~~batching,~~ ~~mixing,~~ placing, vibrating, compacting and curing (excluding cost of centering, shuttering and reinforcement) with mechanised equipments ~~like~~ ~~batching~~ ~~plant,~~ transit mixer, concrete pump etc. complete as per drawing, relevant codes, specifications and as per direction of engineer in charge for the following.** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodolog & work procedure, inspection and testing plan, source qualification of construction material, construction completion certificate, transfer docket containing necessary documents like test certificate, pour cards, inspection reports etc. and obtaining approval from BHEL/NPCIL as per specification and as directed by engineer - in - charge)** **Ready Mix Concrete will be supplied by BHEL and issued as Free of Cost (FOC) Item)**			0.00000		
201	Concrete of grade M7.5 (1 part cement, 4 part sand, 8 parts of 40 mm graded aggregate by volume) as mass filling course, lean concrete, levelling course, mud mat under and around foundations/floors, at any depth below finished floor level etc. **Ready Mix Concrete will be supplied by BHEL and issued as Free of Cost (FOC) Item)**	CUM	**2400**	**0.33187**		
A204	Concrete under floors, paving, lean concrete, levelling course, mud mat under and around foundations/floors, plinth protection, pipe encasing, roads, drain etc. with coarse sand and graded hard stone aggregate of 20mm nominal size at any depth below/above finished ground floor level for the following grades. **Ready Mix Concrete will be supplied by BHEL and issued as Free of Cost (FOC) Item)**			**0.00000**		
a	M15 Grade	CUM	**1400**	**0.33187**		
				0.00000		
300	**FORMWORK: Providing, fixing and removing formwork at all elevations for all structures, as per specifications and including all labour, material, scaffoldings, centereing etc. complete as per drawing, specifications and as per direction of engineer in charge for the following.**			0.00000		

301	Fairface form work with good quality water proof ply wood of minimum 12mm thickness and smooth surface below finished ground floor level for foundations, footings, base of columns, walls, columns, pilasters, beams, mass concrete, trenches etc.including chamfering of edges as per drawing, specification and instruction of engineer in charge.	SQM	**400**	**0.15526**		
				0.00000		
400	**REINFORCEMENT WORK : Reinforcement work including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling etc at all level as per specification, drawings and as directed by engineer - in - charge for the following:** **(All the items are inclusive of sampling and testing of construction material, preparation of construction methodology & work procedure, testing, inspection reports etc. and obtaining approval from BHEL/NPCIL as per specification and as directed by engineer - in - charge)**			**0.00000**		
A402	~~Providing,~~ straightening, cutting, bending, placing in position at all level, binding in position of steel reinforcements of HYSD TMT steel of grade Fe-500 confirming to IS:1786/NPCIL specifications including cost of ~~reinforcement steel~~, tying with 1.6 mm dia soft annealed binding wire, labour, scaffolding, cover blocks, protection of exposed ends of reinforcement bars with adequate coat of cement wash and plastic tape, transportation to & from stores, test, test report etc complete all as per specifications, drawings and as directed by Engineer. **(Reinforcement Steel will be supplied by BHEL and issued as Free of Cost (FOC) Item)**	**MT**	**1340**	**3.06457**		
2500	**PILING**			**0.00000**		
	PILING WORK: Piling works including all labour, material (unless otherwise specified in BOQ/contract specification), equipment etc. as per specification, drawings and as directed by engineer - in - charge for the following: (All the items are inclusive of sampling and testing of construction material, preparation of construction methodology, safety manual, job hazard analysis, work procedure etc and approval from BHEL/NPCIL. Submission, obtaining BHEL/NPCIL approval on construction completion certificate, transfer docket containing necessary documents like test certificate, pour cards, as built drawings, inspection reports etc as directed by engineer - in - charge)			**0.00000**		
2501	Mobilisation of hydraulic rotary piling rigs and accessories capable of pile boring/drilling in all types of strata including compacted soil cement mix/ash etc., installing various size of bored cast in situ RCC piles to project site and demobilisation of the same after completion of piling works etc all complete.	EACH	**4**	**249.96788**		

A2504	Installation of Bored cast-in-situ RCC vertical pile as per IS 2911 (Part 1 Sec 2) with diameter and length as specified (length to be measured from pile cut-off level to the bottom of pile) using cement concrete **grade M35** conforming to IS:456 with 20 mm nominal size stone aggregates with a minimum cement content of 400Kg per cum of concrete including providing all materials (but excluding reinforcement steel for which measurement/payment shall be made separately), boring/drilling in all types of soil inlcuding improved soil cement mix layer, providing bentonite slurry/polymer and/or casing for stabilization of pile bore, flushing of pile bore, cleaning, muck disposal within the plant boundary, providing plasticizer, admixtures wherever required, chipping of concrete & breaking pile head to pile cut off level,disposal of debris and exposing pile reinforcement for embedment in pile cap etc including empty boring from ground level to pile cutoff level etc. all complete as per specification, drawing and as directed by the engineer-in-charge. The concrete placement temperature shall be maintained as not to exceed 38 degree centigrade as per specification. **(Ready Mix Concrete will be supplied by BHEL and issued as Free of Cost (FOC) Item)**			**0.00000**		
e)	Pile with 760 mm diameter and **20** m length below cut off level	EACH	**1309**	**12.99947**		
A2505	Extra over ST. No.A2504 for pile length more than the specified length below cut off level for the following.			**0.00000**		
e)	For 760 mm diameter pile	RM	**1309**	**0.88251**		
A2506	Rebate on ST.No. A2504 for pile length less than the specified length below cut off level for the following.			**0.00000**		
e)	For 760 mm diameter pile	RM	**1309**	**-0.71017**		
2511	Conducting initial load test upto a maximum test load of 2.5 **times the safe load capacity** on single pile as specified in accordance with IS 2911 Part-4 including preparation of pile head for testing, necessary excavation including suitable dewatering (if/as required), all arrangements of loading, unloading, test equipments/ accessories, jacks, recording of results, labour, submission of test report but excluding the cost of installation of pile (installation of pile shall be paid separately) etc. all complete as per specification, drawing and as directed by engineer in -charge for the following:					
a	For vertical compression test by cyclic load method					
iv	760 mm diameter pile	EACH	**3**	**88.25333**		
b	For lateral load test					
iv	760 mm diameter pile	EACH	**3**	**14.79867**		

c	For tension/uplift test					
iv	760 mm diameter pile	EACH	**3**	**19.52257**		
A2512	Conducting routine load test on single job pile as specified in accordance with IS 2911 (Part-4) including preparation of pile head for testing, necessary excavation, providing all arrangements of loading, unloading, test equipments/accessories, jacks, recording of results, labour, submission of test report etc but excuding the cost of installation of job pile complete as per specification, drawing and as directed by the engineer-in-charge for the following.					
a	For vertical compression test by maintained load method					
iv	760 mm diameter pile	EACH	**7**	**36.40473**		
b	For lateral load test					
iv	760 mm diameter pile	EACH	**7**	**14.79867**		
c	For Pull out test					
iv	760 mm diameter pile	EACH	**7**	**51.27547**		

A2513	Conducting low strain pile integrity test as per ASTM D5882 on bored cast-in-situ RCC pile having 760mm diameter including all arrangements for test, equipments/accessories, materials, submission of test report etc but excluding the cost of installation of pile all complete as per specification and as directed by the engineer-in-charge.	EACH	**1309**	**0.93436**		
A2517	Conducting high strain dynamic testing of piles as per ASTM D4945 on bored cast-in-situ RCC pile having 760mm diameter including all arrangements for test, equipments/accessories, materials, submission of test report etc but excluding the cost of installation of pile all complete as per specification and as directed by the engineer-in-charge.	EACH	**14**	**51.27547**		
A2518	Integrity testing of pile by using sonic coring/sonic logging method in accordance with ASTM 6760 on bored cast-in-situ RCC pile having 760mm diameter including surface preparation of pile top by removing soil, mud, dust & chipping lean concrete lumps etc., deployment of testing equipment, computerised equipment etc. and high skill trained personnel for conducting the test & submission of test reports etc but excluding the cost of installation of pile all complete as per specification, drawings and as directed by the engineer-in-charge. **(Supply of 50mm dia and 1mm thick sonic logging mild steel tubes shall be paid saperately in BOQ item no. A2522)**	EACH	**650**	**5.12755**		
A2519	Conducting dynamic pile load tests, preparation of pile top by removing soil, mud, dust & chipping lean concrete lumps etc., deployment of testing equipment, computerised equipment etc. as per IS 9716 / ASTM and high skill trained personnel for conducting the test & submission of test reports, all complete as per specification and direction of Engineer. (Cost of installation of test piles shall be paid under relevant items)					
a)	Free Lateral Vibration test					
	760 mm diameter pile	EACH	**1**	**192.28298**		
b)	Forced Lateral Vibration test					
	760 mm diameter pile	EACH	**1**	**166.64525**		
c)	Free vertical Vibration test					
	760 mm diameter pile	EACH	**1**	**165.36337**		
d)	Forced vertical Vibration test					
	760 mm diameter pile	EACH	**1**	**167.92714**		

A2520	Extra over ST No A2504 for designing, providing and executing “Tube-a- Manchette” method of Toe grouting with all necessary materials, equipments etc so as to achieve at least 20% increase in safe load carying capacity of pile in vertical compression over the pile without base grouting as per specification and as directed by the engineer-in-charge. **All consumables supply including cement is in the scope of bidder.**					
a)	For 760 mm diameter pile	EACH	**1309**	**47.67650**		
A2522	Supply and installation of 50mm internal diameter and 1mm thick sonic logging mild steel tubes to be tied with reinforcement cage inside pile bore before concreting of the bored cast-in-situ RCC piles alongwith necessary couplers, connecting the extension piece with enlarged end bell mouth with push fit arrangement including rubber gasket etc. all complete as per specification, drawings and as directed by engineer-in-charge.	RM	**42900**	**0.07208**		
	Total Cost (in Rs.)					

NOTE:

1	Bidder's quoted price above shall be complete in all respect for the full scope defined in specification and in accordance with all terms & conditions of tender.
2	Contractor shall fully understand description and Specifications of items mentioned in BOQ.
3	Conditional price bids with any deviation / clarification etc. are liable to be rejected. No cutting / erasing / over writing shall be done.
4	Quantities mentioned in rate schedules are approximate only and liable for variation on either side depending upon site / design requirement. The tentative contract value (CV) of entire scope of work shall be calculated as per finally quoted / accepted rates & the Quantities indicated in BOQ cum Rate Schedule .
5	Contractor's total quoted price as per rate schedule will be taken as tentative only. The contractor undertakes to execute actual quantities as per advice of BHEL Engineer and accordingly the final contract price shall be worked out on the basis of quantities actually executed at site and payments will also be regulated for the same.
6	In case of any mis-match in rate and amount on price discrepency, the same will be dealt as per clause no. 1.4 of GCC.
7	Taxes (GST) shall be payable extra as per relevant clause in Technical Conditions of Contract.

1.0 Applicability:

The safety clauses are applicable to Engineering, Procurement and Construction Contracts.

2.0 Safety Guidelines:

2.1 The contractor shall provide and maintain all lights, fencing, guards, warning signs and caution board and similar items as required ensuring safe working conditions at work site.

2.2 The contractor and his sub-contractor shall comply with the instructions given by departmental safety officer or his representative(s) regarding safety precautions, protection measures and housekeeping etc.

2.3 The contractor shall comply with all provisions of "AERB Safety Guide for Works Contract" Document No. AERB/SG/IS-1 and other safety requirements as applicable to specific site. A copy of the guide can be obtained from NPCIL on request.

2.4 The contractor shall provide proper access and working platforms for all place of work as per laid down standards or as advised by Engineer-in-charge or Head-IS&F.

2.5 The contractor shall ensure that all floor openings in his work are guarded/barricaded during the course of work and at the end of each day's work.

2.6 The Contractor shall meet statutory requirements as well as regulatory requirements applicable to the project, in general, and NPCIL in particular, especially the requirements as per Factory Act-1948 (amended in 1987), Atomic Energy factories Rule-1996 (AEFR-1996 or latest version available at the time of work execution), safety guidelines for Job Hazard Analysis (JHA) & AERB notifications on Industrial & Fire safety. The copies of the same can be obtained from NPCIL on request.

2.7 The contractors' safety professionals shall be well aware about Acts, Rules connected with Industrial Safety and practices particularly applicable to the project and to that effect they have to undergo an assessment at the project within 15 days of their placement at the project at the cost of the contractor and then only he/she would be given permanent entry pass to plant and considered in the required strength of the safety professionals.

2.8 Workers in general shall not be deployed at work for more than 10 hrs/day and in no case more than 12 hrs/day.

2.9 All PPE procured and provided to workers shall conform to relevant Indian Standards and should be maintained in healthy condition by suitable storage, maintenance and inspection.

2.10 The contractor shall be held responsible for non-compliance of any of the safety measures, injuries, fatalities and compensation arising out of such situations or accidents, and shall be liable as per the Part-B clauses.

3.0 Employees Safety & Workmen Compensation:

Contractor shall be responsible for safety of all his employees during execution of the contract work. As per Workmen's Compensation Act, 1923 (Amended in 2000), the contractor will ensure the payment of compensation to his employees in case of an accident as early as possible within the time frame permitted by the law of land.

4.0 Safety organization of the contractor

4.1 Every contractor shall have an Industrial safety organization having qualified safety professionals as enumerated below prior to the execution of job at project. The minimum numbers of safety professionals shall be

(i) One graduate engineer having post/advance diploma in Industrial safety – for every 1000 workers or part thereof.

(ii) Two numbers of safety supervisors having diploma in engineering and diploma in Industrial safety or at least 6 years experience should be in each shift for every 1000 workers or part thereof. Additional one supervisor for every 500 workers.

4.2 The above is the minimum requirement of safety professionals. The Head (Industrial Safety and Fire) henceforth be termed as Head-IS&F, of the plant, can ask for more safety professionals depending upon nature of jobs being executed by the contractor.

4.3 Contractor's safety professionals shall technically report to Departmental safety organization under Head-IS&F at plant site. However, administrative control and management of safety in the contract work would be the responsibility of the contractor. A committee consisting of representatives of QA, Training and Industrial Safety Group of Headquarters would carry out the verification of safety professional qualification/competence time to time at site.

4.4 In case contractor fails to employ the required safety professionals, the department may at the cost and risk of the contractor deploy additional/required safety professionals. The cost incurred towards this shall be deducted from contractor's bill at following the rates.

1. Safety Engineer = Rs. 1500/day.
2. Safety Supervisor = Rs. 1000/day.

If the required safety professionals are not employed within a month of date of the observation/inspection the payment to the contractor shall be regulated as per S.No. 1 of Annexure-1 applicable for safety professionals

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5.0 Job Supervision at site

5.1 The contractor must ensure adequate job supervision through educated, qualified and experienced supervisors - at least one supervisor for each hazardous job activity to ensure safety during work execution. Similarly, there should be adequate on-site engineering support ensuring coverage of atleast one experienced engineer for every ten supervisors and part thereof.

5.2 In case, the contractor is unable to arrange required work supervisors and engineers for work technical support, a penalty of Rs 10000/- per month for each vacancy will be levied and such five penalties in a year will attract additional fine on him up to Rs 100000/- apart from the payment he has to make for cost of departmental effort to supplement the requirements as specified at 5.1 above. The decision of the Engineer-in-charge, in regard to the penalty imposed shall be final and binding. However, before imposition of penalty, a fair opportunity of being heard, shall be provided to the contractor.
The payment under this clause would be adjusted in Clause- 10.

6.0 Training requirements

6.1 Every Mega Package Contractor or large contractor must build all necessary infrastructure for imparting induction safety training, mock-up trainings and job specific training at plant site at his cost. The required space will be provided free of cost by NPCIL. The Training matters will be guided by Head, IS&F and will be monitored by Training Superintendents. The training evaluation for its effectiveness, will be assessed by nominee of Training Superintendent, QA and/or Head IS&F. The contractor site-in-charge should arrange induction safety training of four hours duration to all workmen prior to engaging them to work and refresher training on monthly basis covering 20% of the workman in a month with 100% coverage within 6 months. This training should be given with necessary Audio, Visual, Posters aids and as per syllabus approved by NPCIL safety group, under the guidance of Training Superintendent or Head IS&F or his representative. The training should be in the language understandable to workmen. This training shall include mock trials of wearing of helmet, use of safety belt and it's hooking up to an independent lifeline etc. The safety-training instructor must certify the workmen for having understood safety aspects and use of PPEs successfully in mockup trial. To ensure proper understanding of safety instructions and safety training, the contractor shall employ literate (at least able to read safety instructions) workers only.
In exceptional cases of not meeting literacy requirement the workers shall be imparted supplementary training.

6.2 The job supervisors and the engineers will have to undergo detailed safety training of at least three days duration at the plant in safety supervision and accident prevention techniques. This training would at the cost of the contractor and then only he/she would be given permanent entry pass to plant.

6.3 Contractor must note that in case the industrial safety induction training as per 6.2 is not conducted within 3 days his workmen shall not get plant entry pass.

7.0 Requirements and specification of PPEs Tools and Tackles

7.1 Every contractor must keep adequate stock of ISI certified (or of relevant international standards) personal protective equipment (PPE), safe working tools and safe working appliances like platforms and access ladders, guard railing etc. and shall ensure these are used during the job for safe execution of the work. These PPE, Tools and Appliances must

be inspected quarterly. Contractor on demand by NPCIL Authorities shall produce the record of such inspections.

7.2 All implements being used for height work like scaffold, access stairs/ladders, platform, railings etc. should be of ISI marked material meeting requirements of AEFR-1996 and should be certified by contractor safety professional prior to its safe use and to the effect that each implement should have display showing it can be safely used.
If any workman is found using sub-standard or damaged PPE, tools & appliance, or any unsafe condition/practices is observed it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, in regards to the regulation of payment shall be final and binding.

8.0 Work Practices

8.1 The Pre Job Briefing, prior to taking up the work, will be carried out by contractor Safety Engineer/Supervisor to all workers using plant guidelines. The Contractor shall make arrangements for adequate and qualified supervision using checklists during the execution of jobs. The contractor shall ensure that all his workmen must take safety permit for each high-risk job as per project procedure.
If any hazardous work is found without safety work permit/ JHA/ safe working procedure, it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, ~~in~~ with regard to the regulation of payment shall be final and binding.

8.2 Contractor working at height of more than 2.5 meter above stable floor or ground floor must acquire height pass as per procedure including the worker's medical fitness certificate by certifying surgeon (having MBBS qualification) and worker's height qualification etc.
If in any height work, the worker is found working without having height pass, it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, ~~in~~ with regard to regulation of payment shall be final and binding.

8.3 Contractor shall ensure safe movement of man and material as well as vehicles in site premises as per rules/regulations applicable at or issued by plant. In case of violation of the rules/regulation, it will be recorded for regulation of payment under clause-10. The decision of the Engineer-in-charge, with regards to the regulation of payment shall be final and binding.

9.0 Safety Plan

9.1 Contractor at his cost shall perform following tasks for the jobs having high risk as identified by Departmental Safety Group:

(i) Prepare Safe Working Procedures and ensure its implementation in field.
(ii) Carry out Job Hazard Analyses (JHA) and implement in field.
(iii) Based on JHA, the safe working procedures should be modified especially to include checklists as necessary checkpoints for job safety supervision.
(iv) Worker(s) must be trained based on the safe working procedure and explained about DOs & DON'Ts prior to assigning him the job.
(v) The workers must adhere to the safe working procedure for the job.

(vi) Contractor shall ensure that all Tools, Appliances, erecting equipment and their safe use by the contractor work force shall be meeting Indian standards. The contractor must ensure that necessary authorization exist with workmen prior to their deployment on a particular appliance/tool/equipment. The workmen would be required to acquire additional authorization for crane operation, crane signaling, blasting operation, welding and cutting operation, electrical work etc. and then only workmen shall be deployed for such job. He shall maintain all record of tools and equipment for their healthiness and safe use with a copy to departmental safety group.

(vii) Employing of any sub-contractor by the main contractor shall be with concurrence of plant authorities & Engineer-In-Charge as per applicable procedure of the plant. The main contractor shall ensure that all safety requirements/conditions are effectively communicated to and well understood by his sub-contractor. The main contractor should ensure safety training & availabilities of required PPEs and he will be responsible for the safety of the workmen of his sub-contractor.

10 Payments Linked with Safety Performance

10.1 2% of the payment of the value of work order or RA Bills shall be based on **Safety Performance** as per above clauses-4.1, 4.2 & 4.4; 5.2, 6.1 to 6.4; 7.1 to 7.3; 8.2, 8.4and 8.5 during the contract period. The checklist No. NPCIL/04710/Safety/2006/M/Checklist No.2 (attached at Annexure-I) shall be applicable for regulation of 2% safety linked payment which shall be duly certified by the committee consisting of the representative of Head (IS &F), QA and Engineer-in-charge.

10.2 The deduction towards other clauses, e.g. Penalties for serious accidents as defined under clause-11, and workman compensation as defined under ~~in~~ clause-3 of Part-A will be in addition to payments regularized under clause 10.1

11.0 Penalties for Serious Accidents

Following shall be the penalties for each category of serious accident:

(i) For each Serious accident (Loss of man days 21 or more) - Rs. 10,000/-.

(ii) For ~~a~~ each fatality – Rs.10, 00, 000/-

12.0 Safety performance Record

On completion of the contract work, a safety performance certificate of the safety record during the execution of the work will be jointly made by Engineer-in-charge, Head (IS&F) and QA representative and that shall be referred in future contract evaluation. Certificate shall be based on Annexure-I and Serious Accident record.

Annexure – I

NPCIL/04710/Safety/2006/M/Checklist No. 02

Checklist cum Certificate for RA Bill payment based on Safety Performance

Sr. No.	Safety Parameters	Safety Clause	% of Running Account (RA) bill for safety compliance	Actual payable
01.	**Safety Professional** Required nos. of Safety Professional employed as per clause.	4.1, 4.2 & 4.4	0.4%of RA Bill (Max.) 0.0% if requisite no. of Safety Professionals are not posted at site within one month.	
02	**Job Supervision at site** Required nos. of Job Supervisors employed as per clause.	5.2	0.1% of RA Bill (Max.) 0.0% if requisite no. of Job Supervisors are not posted at site within fifteen days.	
03.	**Safety Training** i) Safety training imparted to all employees (100%). ii) Safety training imparted to < 80% of its employees.	6.1 to 6.4	0.4% of RA Bill (Max.) 0.0% of RA Bill	
04.	Use of proper PPEs & tools, Safe working condition/practices.	7.1 to 7.3	0.3% (Max.) of RA Bill 0.0% of RA Bill if more than ten nos. of unsafe conditions/ practices observed.	
05.	**Work Practices** 4.1 Adherence to Pre-job Briefing, JHA, Safety Work Permit & Safe Working Procedure for Hazardous works 4.2 All employees working at height have height pass.	8.2 8.4	0.3% of RA Bill (Max.) 0.0% of RA Bill value for > 5 cases as per condition given in clause 8.2. 0.3% of RA Bill (Max.) 0.0% of RA Bill value for > 5 cases as per condition given in clause 8.4.	
06	Safe movement of man and material as per rule and regulation applicable at the site.	8.5	0.2% of RA Bill (Max.) 0.0% of RA Bill if more than 5 violations were observed in a month as per clause 8.5	

Payment certified by :

Engineeer-in-Charge (Works) QA Representative Head (IS & F)

GOVERNMENT OF INDIA

AERB SAFETY GUIDE

SAFETY GUIDE FOR WORKS CONTRACT

ATOMIC ENERGY REGULATORY BOARD

SAFETY GUIDE

FOR

WORKS CONTRACTS

Government of India
Atomic Energy Regulatory Board
Bombay – 400 095

August 1991

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III

F O R E W O R D

Generally the number of accidents are more during construction phase of a Project. These accidents involve mostly contractor workers. A need for a single document in the form of a guide or a manual defining the work situations during construction phase and the required safety precautions/procedures/equipment to be taken/followed/used was recognized by DAE SRC. In its meeting No. 259 held on 5th February, 1986, a Committee with Shri K.S. Somayaji as the Convenor was constituted to look into the type of accidents occurring during construction phase and also to evolve a guide to contain safety precautions that are required to be taken in the construction activities.

This Sub-Committee's report was discussed by DAE SRC in its meeting No. 271 held on 18th June 1986 but unfortunately could not be finalized. On January 3, 1990, this document was circulated to all the units of DAE and also to members of SARCOP for their comments. Several units and members of SARCOP have given their comments and these comments were further reviewed by another Group in consultation with Shri K.S. Somayaji. This Group eventually finalized the guide in its present form taking note of the comments from all the agencies.

In this guide certain qualitative terms like adequate, minimum, near, suitable, good quality, sufficient, etc. have been used, since it is not possible to quantify them for the varied nature of jobs that are being handled at the construction sites. It is recommended that the Safety Engineer and the concerned Engineer In-Charge may be consulted for their better judgment on meeting the qualitative requirements.

IV

This guide was finally discussed at SARCOP Meeting No. 88 held on 22nd August, 1990 and was approved. Every unit of DAE and its Undertakings are required to use the document as a guide to be followed in the award of works contracts to the contractors for compliance with the safety precautions laid down. It is incumbent that this guide be included as part of the tender document for effective compliance.

SARCOP places on record its appreciation for the interest shown by various agencies and individuals in scrutinizing the draft and sending their comments. SARCOP also places on record its appreciation of the time and effort put in by the Committee and the Group to bring this guide in its final form.

(S.D. Soman)
Chairman, AERB

Bombay
August 1991

SAFETY GUIDE FOR WORKS CONTRACT

1. INTRODUCTION

Many of the works of Department of Atomic Energy at its various sites are executed by the contractors. During these works, contractors personnel are likely to be exposed to different types of hazards. Similarly, unsafe acts of contractors personnel may generate hazards for Departmental staff and/or workmen of other contractors working at the site. Such unsafe acts may also pose danger to the existing installations and even to members of public. This guide is prepared to facilitate safe working during execution of contract works. It is hoped that units of DAE may issue this guide as a part of contract documents while awarding contracts.

2. GENERAL SAFETY PROVISIONS

2.1 The Contractor shall take all safety precautions during the execution of awarded work and shall maintain and leave the site safe at all times. At the end of each working day and at all times when the work is temporarily suspended, he shall ensure that all materials, equipment and facilities will not, cause damage to existing property, personal injury or interfere with the other works of the Project or Station. The Contractor shall comply with all applicable provisions of the safety regulations, clean up programme and other measures that are in force at the site.

2.2 The Contractor shall provide and maintain all lights, guards, fencing, warning signs, caution boards and other safety measures and provide for vigilance as and where necessary or as required by the Engineer-in-charge or by any duly constituted authority for the protection of workers or for the safety of others. The caution boards shall also have appropriate symbols.

2.3 Adequate lighting facilities such as flood lights, hand lights and area lighting shall be provided by the Contractor at the site of work, storage area of materials and equipment and temporary access roads within his working area. The Contractor shall obtain written approval of the Engineer-in-charge to the lighting scheme and place of tapping prior to its installation.

2.4 The Contractor shall plan his operations so as to avoid interference with the other Departmental works, other Contractors or sub-Contractors at the site. In case of any interference, necessary coordination shall be sought by the contractor from the Department for safe and smooth working.

2.5 The Contractor and his sub-contractor, if any shall comply with the instructions given by the Safety Engineer or his authorized nominee regarding safety precautions, protective measures, house keeping requirements, etc. The Safety Engineer with due intimation to Engineer-in-Charge shall have the right to stop the work of the Contractor, if in his opinion proceeding with the work will lead to an unsafe and dangerous condition. Engineer-In-Charge shall get the unsafe condition removed or provide protective equipment at the contractors cost. The contractor can employ his own Safety Engineer or nominate one of his officers for liaison with Departmental Safety Engineer for ensuring compliance of all safety rules. Contractor shall ensure that all his workmen are aware about the nature of risk involved in their work and have adequate training for carrying out their work safely.

2.6 The contractor shall be held responsible for non-compliance of any of the safety measures and delays, implications, injuries, fatalities and compensation arising out of such situations or incidents.

3. TRAFFIC

3.1 The Contractor shall conduct his operations so as to interfere as little as possible with the use of existing roads at or near locations where the work is being performed.

3.2 When interference to traffic is inevitable, notice of such interference shall be given to the Engineer-in-charge well in advance (atleast 48 hours) with the details of start of the work and time required, storage of materials, and details of the proposed methods of providing the required facilities for safe and continuous use of roads and obtain his clearance.

3.3 The Contractor shall, at his own expense, make such approved temporary provisions as are required to maintain atleast one lane of traffic by bridging the excavation, providing ramps over surface obstructions or providing suitable temporary bye-pass around the obstructions. The Contractor shall exercise full care to ensure that no damage is caused by him or his workmen, during the operation, to the existing water supply, sewerages, power or telecommunication lines or any other services or works. The Contractor shall be required to provide and erect before construction, substantial barricades, guard-rails, and warning signs. He shall furnish, place and maintain adequate warning lights, signals, etc., as required by Engineer-in-charge.

4. SAFE MEANS OF ACCESS

4.1 Adequate and safe means of access and exit shall be provided for all work places, at all elevations. Using of scaffolding members (avoiding a ladder) for approach to high elevations shall not be permitted.

4.2 Suitable scaffolds shall be provided for workmen for all works that cannot safely be done from the ground, or from solid construction except such short duration work as can be done safely from ladders. Ladder shall be of rigid construction having sufficient strength for the intended loads and made either of good quality wood or metal and all ladders shall be maintained well for safe working condition. An extra mazdoor shall be engaged for holding the ladder if ladder is not securely fixed. If the ladder is used for carrying materials as well, suitable foot holds and hand holds shall be provided on the ladder. The ladder shall be given an inclination not steeper than 1 in 4 (1 horizontal and 4 vertical). Ladders shall not be used for climbing carrying materials in hands. While climbing both the hands shall be free.

4.3 Scaffolding or staging more than 3.5 m above the ground or floor, swung or suspended from an overhead support or erected with stationary support shall have a standard guard rail properly attached, bolted, braced or otherwise secured at least 1.0 m high above the floor or platform of such scaffolding or staging. The guard rail shall extend along the entire exposed length of the scaffolding with only such opening as may be necessary for the delivery of materials. Standard railing shall have posts not more than 2 m apart and an intermediate rail halfway between the floor or platform of the scaffolding and the top rail. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure. Scaffolding and ladder shall conform to relevant IS specification (IS 3696-1966). Timber/Bamboo scaffolding shall not be used.

4.4 Working platforms of scaffolds shall have toe boards atleast 15 cm in height to prevent materials from falling down.

4.5 A sketch of the scaffolding proposed to be used shall be prepared and approval of the Engineer-in-charge obtained prior to start of erection of scaffolding. All scaffolds shall be examined by Engineer-In-Charge before use.

4.6 Working platform, gangways and stairways shall be so constructed that they shall not sag unduly or unequally and if the height of the platform or gangway or stairway is more than 3.5 m above ground level or floor level, they shall be closely boarded, shall have adequate width for easy

movement of persons and materials and shall be suitably guarded as described in 3.3 above.

4.7 The planks used for working platform shall not project beyond the end supports to a distance exceeding four times the thickness of the planks used. The planks shall be rigidly tied at both ends to prevent sliding and slippage. The thickness of the planks shall be adequate to take load of men and materials and shall not collapse.

4.8 Every opening in the floor of a building or in a working platform shall be provided with suitable means to prevent fall of persons or materials by providing suitable fencing or railing, the minimum height of which shall be 1.0 m, along with 15 cm high sheet obstruction at floor level along the railing.

4.9 Safe means of access shall be provided to all working platforms and other elevated working places. Every ladder shall be securely fixed. No single portable ladder shall be over 9 m in length. For ladders upto 3m in length the width between side rails in the ladder shall in no case be less than 300 mm. For longer ladders this width shall be increased by atleast 20 mm for each additional meter of length. Step spacing shall be uniform and shall not exceed 300 mm.

4.10 Adequate precautions shall be taken to prevent danger from electrical lines and equipment. No scaffolding, ladder, working platform, gangway runs, etc. shall exist within 3 meters of any uninsulated electric wire. Whenever electric power and lighting cables are required to run through (pass on) the scaffolding or electrical equipments are used, such scaffolding structures shall have minimum two earth connections with earth continuity conforming to IS Code of Practice.

5. EXCAVATION, TRENCHING AND EARTH REMOVAL

5.1 All trenches 1.2 m or more in depth shall at all times be supplied with at least one ladder for each spacing of 30 m in length or fraction thereof. Ladder shall be extended from bottom of the trench to at least 1 m above the surface of the ground.

5.2 The sides of the trench which are 1.2 m or more in depth shall be stepped back to give suitable slope (angle of repose) or securely held by timber bracing, so as to avoid the danger of sides from collapsing. The excavated material shall not be placed within 1.5 m of the edges of the trench or half of the depth of the trench, whichever is more. Cutting shall be done from top to bottom. Under no circumstances mining or under-cutting shall be done.

5.3 The contractor shall ensure the stability and safety of the excavation, adjacent structures, services and the works.

5.4 Open excavations shall be fenced off by suitable railing and warning signals installed at night at well lit places so as to prevent slipping or falling into the excavations.

5.5 All blasting operations shall be carried out on the basis of procedures approved by Inspector of Explosives. All works in this connection shall be carried out as per IS Code of Practice. Barricades, Warning Signs etc. shall be placed on the roads/open area. Prior approval of such operation shall be obtained from Safety Engineer/Engineer-In-Charge of works.

5.6 a) For removal of earth from an earth mound a written permission shall be obtained from the Engineer-In-Charge of the work and the Engineer-In-Charge of the earth mound.

b) As far as practical, earth shall be removed mechanically.

c) Wherever manual removal of earth is involved, earth shall be removed from the top by maintaining the proper slope equal to the angle of re-pose of the earth.

d) Such work shall be constantly supervised by the contractor's responsible person and frequently inspected by the departmental representative to ensure that no under-cutting is done.

6. CONCRETING

Shuttering and supporting structures shall be of adequate strength and approved by Engineer-In-Charge. This shall be ensured before concrete is poured. The procedure approved by Engineer-In-Charge shall be followed for mixing, transporting and pouring of concrete.

7. DEMOLITION

Before any demolition work is commenced and also during the progress of the work:

(a) All roads and open area adjacent to the work site shall either be closed or suitably protected. Appropriate warning signs shall be displayed for cautioning approaching persons.

(b) Before demolition operations begin, the Contractor shall ensure that the power on all electric service lines is shut off and the lines cut or disconnected at or outside the demolition site. If it is necessary to

maintain electric power during demolition operation, the required service lines shall be adequately protected against damage. Persons handling heavy materials/equipments shall wear safety shoes.

(c) No floor, roof or other part of the building shall be overloaded with debris or materials as to render it unsafe.

(d) Entries to the demolition area shall be restricted to authorized persons only.

8. PERSONAL PROTECTIVE EQUIPMENT

All necessary personal protective equipment as considered necessary by the Engineer-In-Charge shall be kept available by contractor for the use of the persons employed on the site and maintained in a condition suitable for immediate use. Also the Contractor shall take adequate steps to ensure proper use of equipment by those concerned. The personal protective equipments are to be provided by the contractor.

(a) All persons employed at the construction site shall use safety helmets. For other types of works, persons working in that area shall also use safety helmets, if advised by Safety Engineer/Engineer-In-Charge.

(b) Workers employed on mixing asphaltic materials, cement and lime mortars shall use protective goggles, protective foot wear and hand gloves. Use of proper respirators shall be an advantage.

(c) Persons engaged in welding and gas cutting works shall use suitable welding face shields. The persons who assist the welders shall use suitable goggles. Protective goggles shall be worn while chipping and grinding.

(d) Stone breakers shall use protective goggles. They shall be seated at sufficiently safe intervals of distance.

(e) Persons engaged in or assisting in shot blasting operations and cleaning the blasting chamber shall use suitable gauntlets, overalls, dust-proof goggles, boots and protective hood supplied with fresh air at the minimum rate of 9 m^3 /hr.

(f) All persons working at heights more than 4.5 m above ground or floor and exposed to risk of falling down shall use safety belts, unless otherwise protected by cages, guard railings, etc. In places where the use of safety belts is impractical, suitable net of

adequate strength fastened to substantial supports shall be employed.

(g) All powered two-wheeler motorcycle and scooter drivers an their pillion riders shall wear crash helmets inside the Project/Plant sites.

(h) When workers are employed in sewers and inside manholes which are in use, the Contractor shall ensure that the manholes are opened and are adequately ventilated atleast for an hour. After it has been well-ventilated, the atmosphere inside the space shall be checked for the presence of any toxic gas or oxygen deficiency and recorded in the register before the workers are allowed to get into the manholes. The manholes opened shall be cordoned off with suitable railing and provided with warning signals or caution boards to prevent accidents. There shall be proper illumination in the night.

9. PAINTING

9.1 The Contractor shall not employ women on the work of painting with products containing lead in any form. Only men above the age of 18 years shall be employed on the work with lead paint. The following precautions shall be taken during the work.

* Supplied air respirators shall be provided for use by the workers when paint is applied in the form of spray, or a surface having lead paint is dry rubbed or scraped.

* Overalls shall be supplied by the Contractors to the workmen and adequate facilities shall be provided to enable the painters to wash at the cessation of work.

* All painting jobs, especially those in which lead paints are used shall be kept under industrial hygiene surveillance.

9.2 Smoking, open flames or sources of ignition shall not be allowed in places where paints and other flammable substances are stored, mixed or used. A caution board, with the instructions written in national/regional language, “SMOKING – STRICTLY PROHIBITED” shall be displayed in the vicinity where painting is in progress or where paints are stored. Symbols shall also be used for caution boards.

Suitable fire extinguishers/sand buckets shall be kept available at places where flammable paints are stored, handled or used.

When painting work is done in a closed room or in a confined space, adequate ventilation shall be provided. If adequate ventilation cannot be provided, workers shall wear suitable respirators.

9.3 Epoxy resins and their formulations used for painting shall not be allowed to come in contact with the skin. The workers shall use plastic gloves and/or suitable barrier creams.

Adequate ventilation shall be provided especially when working with hot resin mixes.

Increased personal hygiene shall be practiced to control inadvertent contact with the resin and eliminate its effects.

Workers shall thoroughly wash hands and feet before leaving the work. Work clothes shall be changed and laundered frequently.

10. LIFTING MACHINES AND TACKLES

10.1 Use of lifting machines and tackles including their attachments, anchorage and supports shall conform to the following standards or conditions.

(a) Lifting machines and tackles shall be of good mechanical construction, sound material and adequate strength and free from any defects and shall be kept in good repair and in good working order.

Every rope used in hoisting or lowering materials or as a means of suspension shall be of good quality and adequate strength and free from any defect.

(b) Every crane operator or lifting appliance operator shall be properly qualified. No person under the age of 21 years shall be in charge of any hoisting machine or give signal to operator of such machines.

(c) In case of every lifting machine (and of every chain, ring, hook, shackle, swivel and pulley block used in hoisting or as means of suspension) the safe working load shall be ascertained and clearly marked. In case of a lifting machine having a variable safe working load, each safe working load and the conditions under which it is applicable shall be clearly indicated. No part of any machine or any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing. This shall be approved by the Safety Engineer.

(d) In case of departmental machines, the safe working load shall be notified by the Engineer-in-charge. As regards Contractor's machines, the Contractor shall notify the safe working load of the machine to the Engineer-in-charge whenever he brings any machinery to site of work and get it verified by the Engineer-in-charge, supported by a valid test certificate by the Competent Person.

(e) Thorough inspection and load testing of lifting machines and tackles shall be done by a competent person atleast once every 12 months and records of such inspection and testing shall be maintained.

10.2 Motors, gearing transmission, couplings, belts, chain drives and other moving parts of hoisting appliances shall be provided with adequate safeguards. Hoisting appliances shall be provided with such means as will reduce to the minimum the risk of any part of a suspended load becoming accidentally displaced or lowered.

11. WELDING AND GAS CUTTING

11.1 Welding and gas cutting operations shall be done only by qualified and authorized persons and as per IS specifications and Code of Practice.

11.2 Welding and gas cutting shall not be carried out in places where flammable or combustible materials are kept and where there is danger of explosion due to presence of gaseous mixtures.

11.3 Welding and gas cutting equipment including hoses and cables shall be maintained in good condition.

11.4 Barriers shall be erected to protect other persons from harmful rays from the work. When welding or gas cutting is done in elevated positions, precautions shall be taken to prevent sparks or hot metal falling on persons or flammable materials.

11.5 Suitable type of protective clothing consisting of fire resistant gauntlet gloves, leggings, boots and aprons shall be provided to workers as protection from heat and hot metal splashes. Welding shields with filter glasses of appropriate shade shall be worn as face protection.

11.6 Adequate ventilation shall be provided while welding in confined space or while brazing, cutting or welding zinc, brass, bronze, galvanized or lead coated materials.

11.7 Welding and gas cutting shall not be done on drums, barrels, tanks or other containers unless they have been emptied, cleaned thoroughly and it is made certain that no flammable material is present.

11.8 Fire extinguisher shall be available near the location of welding operations. Fire Safety Permit shall be obtained for working at vulnerable areas and operating areas before flame cutting/welding is taken up.

11.9 For electric (Arc) welding the following additional safety precautions shall be taken :

i) When electrical welding is undertaken near pipe lines carrying flammables, such pipe lines shall not be used as part of earth conductor but a separate earth conductor shall be connected to the machine directly from the job.

ii) Personnel contact with the electrode or other live parts of electric welding equipment shall be avoided.

iii) Extreme caution shall be exercised to prevent accidental contact of electrodes with ground.

iv) The welding cables shall not be allowed to get entangled with power cables. It shall be ensured that the cables are not damaged by movement of materials.

12. GRINDING

12.1. All portable grinders shall be used only with their wheel guards in position to reduce the danger from flying fragments should the wheel break during the use.

12.2. Grinding wheels of specified diameter only shall be used on a grinder – portable or pedestal – in order not to exceed the prescribed peripheral speed.

12.3. Goggles shall be used during grinding operation.

13. ELECTRICTY

Guidelines for providing temporary power supply at the site and general safety procedures for using electricity are given in the enclosed Annexure.

14. HOUSE KEEPING

14.1 The Contractor shall at all times keep his work spot, site office and surroundings clean and tidy from rubbish, scrap, surplus materials and unwanted tools and equipment.

14.2 Welding and other electrical cables shall be so routed as to allow safe traffic by all concerned.

14.3 No materials on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public. The Engineer-in-charge may require the Contractor to remove any materials which are considered to be of danger or cause inconvenience to the public. If necessary, the Engineer-in-charge may cause them to be removed at the Contractor's cost.

14.4 At the completion of the work, the Contractor shall have removed from the work premises all scaffoldings, surplus materials, rubbish and all huts and sanitary arrangements used/installed for his workmen on the site.

14.5 The Engineer-in-charge has the right to stop work if the Contractor fails to improve upon the housekeeping after having been notified.

15. FIRE SAFETY

All necessary precautions shall be taken to prevent outbreak of fires at the construction site. Adequate provisions shall be made to extinguish fires should they still break out.

(a) Quantities of combustible materials like timber, bamboos, coal, paints, etc., shall be the minimum required in order to avoid unnecessary accumulation of combustibles at site.

(b) Containers of paints, thinners and allied materials shall be stored in a separate room which shall be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using.

(c) Fire extinguishers as approved by the Engineer-in-charge shall be located at the construction site at appropriate places.

(d) Adequate number of Contract workmen shall be given education and training in fire fighting and extinguishing methods.

16. SAFETY WORK PERMIT

16.1 In order to ensure safety of work for hazardous operation (such as entry into confined spaces, welding/cutting on equipment/pipes where explosion hazards is present, works on high voltage and main medium voltage lines, blasting etc.,) special Safety Work Permits (SWP) shall be raised. The SWP's shall also to be obtained for any other work as recommended by Safety Engineer.

16.2 The Contractor shall strictly ensure all the safety conditions and requirements stipulated in the Safety Work Permit. The decision of the Safety Engineer shall be final in this regard.

17. WORK IN RADIATION AREA

The Contractor shall follow the stipulated procedure regarding work in the radiation area and other works related with radiography.

18. WORK IN AND AROUND WATER BODIES

When the work is done near any place where there is risk of drowning, all necessary rescue equipment such as life buoys and life jackets shall be provided and kept ready for use and all necessary steps taken for prompt rescued of any person in danger and adequate provision shall be made for prompt first-aid treatment of all injuries likely to be sustained during the course of the work. Persons who do not know swimming shall not be engaged alone for any work where risk of drowning exists. Sufficient number of life buoys or life jackets shall be provided.

19. MEDICAL FACILITIES

19.1 The Contractor shall arrange adequate facilities for medical aid and treatment for his staff and workers engaged on the work site including the first-aid facilities if they are not available at the Project Site.

19.2 First-aid appliances including sterilized dressing, cotton wool and antiseptic cream shall be made available at a readily accessible places at every work site. These shall be maintained in good order under the charge of a responsible person.

19.3 At large work places where hospital facilities are not available within easy reach of the works, first-aid posts shall be established and be manned by a trained compounder. An ambulance shall be available during the entire period of work for attending to injury cases.

20. SAFETY OFFICER/SAFETY COORDINATOR

The Contractor shall have a Safety Officer or a supervisor to be designated as a Safety Coordinator in order to specifically look into the implementation of different safety requirements of the contract work. The person thus designated will in general co-ordinate with the Engineer-in-charge on matters of safety and in particular ensure that the Safety Guide is complied with fully. His name shall be displayed on the Notice Board at a prominent place at the work site.

21. REPORTING OF ACCIDENT

21.1 All accidents leading to property damage and/or personnel injuries shall be reported to the Engineer-in-charge immediately who shall inform SARCOP to be followed up with detailed accident reports in prescribed form.

21.2 Contractor shall also submit a monthly statement of accidents to Engineer-in-charge by 4^{th} of every month showing details of accident, nature of injury including disability, days lost, treatment required etc., and the extent of property damage.

22. PUBLIC PROTECTION

The Contractor shall make all necessary provisions to protect the public. He shall be bound to bear the expenses for defence of every action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of any precaution required to be taken to protect the public. He shall pay any damage and cost which may be awarded in any such suit, action or proceedings to any such person, or the amount which may be fixed as a compromise by any such person.

23. OTHER STATUTORY PROVISIONS

Notwithstanding the above clauses from 1 to 21 there is nothing in these to exempt the Contractor from the provisions of any other Act or Rules in force in the Republic of India. In particular all operations involving the transport, handling, storage and use of explosives shall be as per the standing instructions and conform with the Indian Explosives Act, 1884 and The xplosives Rules, 1983. Handling, transport, storage and use of compressed gas cylinders and pressure vessels shall conform with the Gas Cylinder Rules 1981 and Static and Mobile Pressure Vessels (Unfired) Rules 1981. In addition, The Indian Electricity Act 1910 and Indian Electricity Rules 1956, the Atomic Energy Act, 1962, the Radiation Protection Rules 1971, Radiation Protection Manual of Nuclear Facilities

and the Atomic Energy (Factories) Rules 1988 and various rules and Act related to mining shall also be strictly complied with.

ANNEXURE

GUIDELINES AND GENERAL PROCEDURES FOR SUPPLY AND USE OF ELECTRICITY AT SITE

1. GENERAL

Following safety requirements shall be complied with before the Contractor uses the power supply.

1.1 The Contractor shall submit a list of licensed electrical staff to be posted at site.

1.2 It shall be the responsibility of the Contractor to provide and maintain complete installation on the load side of the supply point with regard to the safety requirements at site. All cabling and installation shall comply with the appropriate statutory requirements given below and shall be subject to approval of the Departmental Engineer-in-charge/Electrical Engineer.

a) Indian Electricity Act, 1910

b) Electricity (Supply) Act, 1948

c) Indian Electricity Rules, 1956

d) National Electric Code 1985

e) Other relevant rules of Local Bodies and Electricity Boards.

After installation of the electrical power wiring works by the contractor, form of completion certificate as per IS 732 (Form SGCW-1) shall be submitted by the contractor duly signed by the authorized valid licensed electrical contractor and/or supervisor along with one copy of the contractor's license and/or competency certificate of supervisor issued by the Electricity Board/Government Electricity Organization as per the enclosure.

The power supply shall be regulated as per the terms and conditions of the supply of the respective electricity boards.

1.3 (a) For purposes of electrical load and power planning by the electrical section, the contractor shall furnish along with the tender, the estimated load requirement of electric power for the execution of the contract works in terms of maximum Kilo Watt or KVA demand during various periods/months of the contract period along with the details of the construction electrical equipment/machinery with their individual load details and location/locations of power supply

required for availing temporary electric power supply in the standard proforma enclosed (Form SGCW-2).

(b) The electric power supply will be generally made available at one point in the works site of the contractor by the department.

(c) Where distribution boards are located at different places the Contractor shall submit schematic drawing indicating all details like size of wires, Over Head or cable feeders, earthing etc. The position and location of all equipment and switches shall be given.

1.4 The Contractor shall make his own arrangements for main earth electrode and tappings thereof. The existing earth points available at site can be used at the discretion of the Departmental Electrical Engineer with prior permission. Method of earthing, installation and earth testing results shall conform to relevant I.S. Specifications (IS-3043)

1.5 All three phase equipment shall be provided with double earthing. All light fixtures and portable equipment shall be effectively earthed to main earthing.

1.6 All earth terminals shall be visible. No gas pipes and water pipes shall be used for earth connection. Neutral conductor shall not be treated as earth wire.

1.7 The Contractor shall not connect any additional load without prior permission of Departmental Electrical Engineer. For obtaining additional power required, test reports of the tests mentioned in (d) of Form SGCW-1 shall be submitted.

1.8 Joints in earthing conductors shall be avoided. Loop earthing of equipment shall not be allowed. However, tappings from an earth bus may be done.

1.9 The entire installation shall be subjected to the following tests before energisation installation including portable equipment :

a) Insulation resistance test

b) Polarity test of switches

c) Earth continuity test

d) Earth electrode resistance

The test procedures and their results shall conform to relevant IS Specifications. The Contractor shall submit a test report for his complete installation every 2 months or after rectifying any faulty section in the specimen test report. One such test report for the complete installation shall be submitted before onset of monsoon.

2. The following are provided for general guidance of the Contractor and shall be read as specific requirement, in addition to complying with Indian Electricity Act, Indian Electricity Rules and IS Specifications.

2.1 Installation

a) Only persons having valid wireman's license/competency certificate shall be employed for carrying out electrical work and repair of electrical equipment, installation and maintenance at site. The job shall be supervised by a qualified licensed Supervisor.

b) Electrical equipment and installations shall be installed and maintained as to prevent danger from contact with live conductors and to prevent fires originating from electrical causes like short circuits, overheating etc. Installation shall not cause any hindrance to movement of men and materials.

c) Materials for all electrical equipment shall be selected with regard to working voltage, load and working environment. Such equipment shall conform to the relevant standards.

d) The minimum clearance to be maintained for all overhead lines along roads and across roads shall be as per the statutory requirements as listed in clause 1.2 of Annexure.

e) Grounding conductor of wiring system shall be of copper or other corrosion-resistant material. An extra grounding connection shall be made in appliances/equipment where chances of electric shock is high.

f) Electric fuses and/or circuit breakers installed in equipment circuits for short circuit protection shall be of proper rating. It is also recommended that high rupturing capacity (HRC) fuses be used in all circuits. For load of 5 KW or more earth leakage circuit breaker shall be provided in the circuits.

g) Wherever cables or wires are laid on poles, a guard wire of adequate size shall be run along the cables/wires and earthed effectively. Metallic poles as a general rule, shall be avoided and if used shall be earthed individually. Anticlimbing guards and danger

notices shall be provided on poles. Each equipment shall have individual isolating switches.

h) Wires and cables shall be properly supported and an approved method of fixing shall be adopted. Loose hanging of wires & cables shall be avoided. Lighting and power circuits shall be kept distinct and separate.

i) Reinforcement rods or any metallic part of structure shall not be used for supporting wires and cables, fixtures, equipment, earthing etc.

j) All cables and wires shall be adequately protected mechanically against damages. In case the cable is required to be laid under ground, it shall be adequately protected by covering the same with bricks, Plain Cement Concrete (PCC) tile or any other approved means.

k) All armoured cables shall be properly terminated by using suitable cable glands. Multistranded conductor cables shall be connected by using cable lugs/sockets. Cable lugs shall preferably be crimped. They shall be of proper size and shall correspond to the current rating and size of the cable. Twisted connections will not be allowed.

l) All cable glands, armouring and sheathing of electric cables, metal circuits and their fittings, metallic fittings and other non-current carrying parts of electrical equipment and apparatus shall be effectively grounded.

m) All the Distribution Boars, Switch Fuse units, Bus bar chambers, ducts, cubicles etc. shall have MS enclosures and shall be dust, vermin and water proof. The Distribution Boards, switches etc. shall be so fixed that they shall be easily accessible. Changes shall be done only after the approval of the Departmental Electrical Engineer.

n) The Contractor shall provide proper enclosures/covers of approved size and shape for protection of all the switch board, equipment etc. against rain. Exposed live parts of all electrical circuits & equipment shall be enclosed permanently. Crane trolley wires and other conductors which cannot be completely insulated shall be placed such that they are inaccessible under normal working conditions.

o) Iron clad industrial type plug outlets are preferred for additional safety.

p) Open type Distribution Boards shall be placed only in dry and ventilated rooms; they shall not be placed in the vicinity of storage batteries or otherwise exposed to chemical fumes.

q) Isolating switches shall be provided close to equipment for easy disconnection of electrical equipment or conductors from the source of supply when repair or maintenance work has to be done on them.

r) In front of distribution boards a clear space of 90 cm shall be maintained in order to have easy access during an emergency.

s) Adequate working space shall be provided around electrical equipment which require adjustment or examination during operation.

t) As far as possible electrical switches shall be excluded from a place where there is danger of explosion. All electrical equipment such as motors, switches and lighting fittings installed in work room where there is possibility of explosion hazards shall be explosion proof.

u) All connections to lighting fixtures, starters or other power supplies shall be provided with PVC insulated, PVC sheathed twin/three/four core wires to have better mechanical protection for preventing possible damage to equipment or injury to personnel. Taped joints shall not be allowed and the connections may be made in looping system. Electric starter of motors, Switches shall not be mounted on wooden boards. Only sheet steel mounting or iron frame work shall be used.

v) All the lighting fixtures and lamp holders shall be of good quality and in good condition. Badly repaired or broken holders, etc. shall not be used.

w) Only PVC insulated and PVC sheathed wires or armoured PVC insulated and sheathed cables shall be used for external power supply connections of temporary nature. Weather proof rubber wires shall not be used for any temporary power supply connections. Taped joints in the wires shall not be used.

x) The bulbs/lamps used for illumination and testing purpose shall have cover or guard to protect them from accidental breakages.

Only 24 V supply system shall be used for hand lamps etc. while working inside metallic tanks or conducting vessels.

y) After installation of new electric system and or other extensive alterations to existing installations, thorough inspection shall be made by Departmental Electrical Engineer before the new system or new extension is put in use.

z) Contractor shall ensure that power factor for their loads shall be maintained at 0.85. In case the power factor falls below 0.85, necessary capacitor units shall be provided by the contractor.

2.2 Operation & Maintenance

a) All persons who work with electrical installation/equipment shall be aware of the electrical hazards, use of protective devices and safe operational procedures. They shall be given training in fire fighting, first aid and artificial resuscitation techniques.

b) The supervisor shall instruct the workers in the proper procedure, specify and enforce the use of necessary protective equipment such as adequately insulated pliers, screw drivers, fuse pullers, testing lamps and similar hand tools. Only wooden ladders shall be used to reach the heights in electrical work.

c) No material or earth work shall be allowed to be dumped below or in the vicinity of the bare overhead line conductors.

d) Separate work permits shall be issued for individual group leaders working on the same system which shall be returned after the completion of the work to Safety Supervisor and no system shall be energized without the clearance of Safety Supervisor.

e) Before any maintenance work is commenced on electrical installations/equipment, the circuits shall be de-energized and ascertained to be dead by positive test with an approved voltage testing device. Switches shall be tagged or the fuse holders withdrawn before starting the work. Adequate precautions shall be taken in two important aspects viz.

i) That there shall be no danger from any adjacent live parts and

ii) That there shall be no chances of re-energisation of the equipments on which the persons are working.

f) While working on or near a circuit, whenever possible the use of one hand may be practiced even though the circuit is supposed to be dead. The other hand may preferably be kept in pocket.

g) When it is necessary to touch electrical equipment (for example when checking for overload of motors) back of the hand may be used. Thus, if accidental shock were to cause muscular contractions, one would not 'freeze' to the conductor.

h) Operation of electrical equipment shall be avoided when standing on wet floor or when hands are wet.

i) Before blown fuses are replaced, the circuit shall be locked out and an investigation shall be made for the cause of the short circuit or overload.

j) When two persons are working within reach of each other, they shall never work on different phases of the supply.

k) When structural repairs, modification or painting work are to be undertaken, appropriate measures shall be taken for the protection of persons whose work may bring them into the proximity of live equipment/circuit.

l) It shall be ensured that the insulation and wire size of extension cords are adequate for the voltage and current to be carried.

m) While tapping electricity from the socket, plug top must be used. It shall be ensured that no extension boards are over loaded while tapping. Only standard three pin plugs shall be used for tapping electricity. Broken sockets/plugs shall be replaced immediately with goods ones. Only joint free cables shall be used for connecting equipment/apparatus.

n) Floors shall be kept free from trailing electrical cables to avoid tripping hazard.

o) Power supply to all the machines and lighting fixture, shall be switched off when not in use.

p) Temporary electrical connections shall be removed as soon as the stipulated work is over. After completion of the works, the Contractor shall dismantle the distribution boards and the other facilities he may have erected.

q) Unauthorized tapping of power by others from distribution boards under the control of the contractor shall be prohibited at all circumstances.

r) No flammable materials shall be stored in any working area near the switch boards.

s) Safety work permits shall be used for switching off the main feeder and equipment by the contractor.

t) “MEN ON LINE” “DO NOT SWITCH ON” “DANGER” or “CAUTION” board as applicable shall be used during maintenance works on the electrical equipment.

2.3 Portable electrical equipment

a) Portable electrical equipment shall be regularly examined, tested and maintained to ensure that the equipment and its leads are in good order. Register shall be maintained for inspection recording the testing dates and results of the equipments.

b) All portable appliances shall be provided with three core cable and three pin plug. The third pin of the plug shall invariably be earthed. It shall be ensured that the metal part of the equipment shall be effectively earthed.

c) All connections to portable equipment or machines from the panel/distribution board/extension board shall be taken using 3 core double insulated PVC flexible copper wire in one length. No joints shall be allowed in this flexible wire. In case single length of wire is not sufficient for a particular location then the supply can be tapped by providing another extension board comprising of switch and socket.

d) Flexible cables for portable lamps, tools, and apparatus shall be regularly examined, tested periodically and maintained to ensure safety.

FORM NO. SGCW – 1

FORM FOR COMPLETION CERTIFICATE

(Prescribed under cl. 1.2 of Annexure)

I/We certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief, it complies with Indian Electricity Rules, 1956 as well as IS:732-1963 code of practice for Electrical Wiring Installations. (System voltage not exceeding 650 Volts (Revised).

Electric installation at …….

Voltage and system of supply ……..

a)	Particulars of work	Number	Total load	Type of system of wiring
		---	---	---
	i) Light Points			
	ii) Fan points			
	iii) Plug points (3 pin)			
	iv) Motors			

b) If the work involves installation of overhead lines and/or underground cable _____

c) Earthing:

Description of earthing electrode, size of earth wire and number of electrodes provided:

d) Test results:

1. Insulation resistance for the whole installation:

   i) Between conductors
   ii) Between each conductor and earth

2. Resistance of earthing electrode or earthing system.
3. Maximum earthing resistance of installation

Signature of Supervisor
Name and address
of Supervisor.

Signature of Contractor
Name and address
of Contractor.

FORM NO. SGCW – 2

'A' APPLICATION FOR SERVICE CONNECTION BY CONTRACTOR

(Prescribed under cl. 1.3 of Annexure)
(to be filled in triplicate)

1. Name & Address of Contractor :

2. Reference to Tender & Work Order :

3. Completion period :

4. Connected load details (please attach details in a separate sheet) :

5. Max. demand anticipated :

6. Nature of service connection required (whether single or three phase) :

7. Place where service required :

   a) Works :

   b) Colony :

8. If supply of electricity is free or chargeable (please enclose extract of conditions from the tender) :

9. Details of meter provided :

   a) If meter required from the Department, whether SD is paid :

   b) Details of SD (Security Deposit) :

   c) Whether meter is tested or not, if tested, attach test report, if not, details of testing fee deposited :

10. Name of Supervisor/Electrician in charge of installation and maintenance :

11. Electrical license No. of person mentioned against col. 10 :

12. Electrical safety appliances available for use :

13. Fire extinguishers available for use :

14. First Aid facility/box available for use, if any. :

(Signature of the Contractor)

Date: Name:

‘B’ CERTIFICATE BY THE CONTRACTOR

Certified that my/our installations have been carried out in accordance with I.E. Rules and that I/We have employed competent persons to handle the installations.

I/we am/are agreeable to the bills, in respect of this service connections being raised on the basis the connected load furnished above, in case the actual consumption falls below the one stipulated by the tender conditions.

(Signature of the Contractor)

Name :

Address:

Date :

……

‘C’ CERTIFICATE BY THE CONTRACT CONTROL ENGINEER

Verified the particulars and forwarded to the Engineer-in-charge.

(Signature of Contract control Engineer)

Name:

Section: Civil/Electrical/Mechanical.

……

‘D’ CERTIFICATE BY THE ENGINEER IN CHARGE

Certified that the particulars furnished by the Contractor are true to the best of my knowledge and belief and that I have satisfied myself as to the safe conditions of electrical installations for which the service connection is applied for.

Signature :

Name:

Date: Designation with section:

‘E’ CERTIFICATE BY THE SAFETY ENGINEER

Certified that I have inspected the electrical installations referred herein and after satisfying myself about the safe conditions of the installation, I hereby recommend that the service connection be given to the Contractor.

Signature of Safety Engineer.

Name:

Date:

……

‘F’ AUTHORIZATION BY THE ELECTRICAL ENGINEER

Service connection may be/may not be given for the reasons noted hereunder.

Signature of Electrical Engineer.

Name:

Date: Designation:

‘G’ “REPORT OF COMPLIANCE”

Service connection is given by me on

a) Meter Nos. 1.

2.

3.

b) Initial readings: 1.

2.

3.

c) Locations: 1.

2.

3.

d) Meter sealings

Signature of Electrical Engineer
(Metering and Billing)

Name:

Date: Designation:

Note:

1st copy to Contract Control Engineer
2nd copy to Safety Engineer
and 3rd copy to Electrical Engineer

After all the formalities are completed and Report of Compliance in (G) are filled up by the Electrical Engineer after power supply is given.

ANNEXURE-1

IMPORTANT RULES OF ATOMIC ENERGY

(FACTORIES) RULES, 1996

APPLICABLE TO

ENGINEERING, PROCUREMENT
&
CONSTRUCTION CONTRACTS

CHAPTER III

HEALTH

8. RECORD OF WHITEWASHING, ETC.- The record of dates on which whitewashing, colourwashing, varnishing, etc. are carried out shall be entered in a register maintained in a manner specified in Form 2.

9. CLEANLINESS OF WALLS, CEILINGS AND COMPOUND AREA.-

(1) Clause (d) of sub-section (1) of section 11 of the Act shall not apply to the class or description of factories or parts of factories specified in the Table to this rule and subject to the condition that they are kept in a clean state by washing, sweeping, brushing, dusting, vacuum cleaning or other effective and adequate means:

Provided the said clause shall continue to apply-

(a) as respects units/factories or parts of units/factories specified in part A of the said Table, to workrooms in which the amount of cubic space allowed for every person employed in the room is less than 14.0 m^3

(b) as respects factories or parts of factories specified in part B of the said Table, to workrooms in which the amount of cubic space allowed for every person employed in the room is less than 70.0 m^3 ;

(c) to engine-houses, fitting shops, lunchrooms, canteens, shelters, creches, cloakrooms, rest-rooms and wash places; and

(d) to such parts of walls, sides and tops of passages and staircases as are less than 6 m. above the floor or stair.

(2) If it appears to the Competent Authority that any part of a factory, to which by virtue of sub-rule (1) any of the provisions of the said clause (d) do not apply or apply as modified by sub-rule (1), is not being kept in a clean state, it may, by written notice, require the occupier to whitewash or colourwash, wash, paint or varnish the same, and in the event of the occupier failing to comply with such requisition within two months from the date of the notice, sub-rule (1) shall cease to apply to such part of a factory, unless the Competent Authority otherwise determines.

(3) The compound surrounding every factory shall be maintained in a sanitary and clean condition free of rubbish, filth or debris.

TABLE

Part A

1. Chemical works.

2. The following parts of units/factories:-

   (a) Rooms used only for storage of articles.

   (b) Rooms in which the walls or ceilings consist of galvanised iron and/or asbestos cement sheets.

   (c) Rooms in which graphite articles are manufactured / processed

   (d) Parts of walls, partitions, ceilings or tops of rooms which are at least 6 m. above the floor.

Part B

1. Electric generating or transforming stations.

2. Engineering works.

3. Foundries other than foundries in which brass casting is carried on.

10. DISPOSAL OF WASTES AND EFFLUENTS.- The arrangements made in every factory after the treatment of wastes and effluents due to the manufacturing processes carried on therein shall be in accordance with those approved by the relevant Water and Air pollution Boards appointed under Water (Prevention & Control of Pollution) Act, 1974, the Air (Prevention & Control of Pollution) Act, 1981, the Environmental Protection Act, 1986 and such other authorities as may be notified by the Central Government in this behalf.

11. ILLUMINATION, TEMPERATURE AND VENTILATION.-

(1) Illumination.-

   (a) General : Adequate lighting is necessary for all buildings and in the open area so as to-

      (i) promote work and other activities carried out in the area;

      (ii) promote safety of the people; and

      (iii) create a pleasing environment conducive for feeling of well-being.

   (b) Adequate lighting will be achieved by,-

(i) planning of brightness in relation to task itself, immediate background of the task and the general surrounding;

(ii) avoiding glare produced by excessive contrast or abrupt and large change in brightness; and

(iii) planning of lighting for movement about a building and around.

(c) The recommended values of illumination for different locations is given in the Table below:

TABLE

Sr.No.	Visual Tasks			Illumination (Lux)
1.	Industrial Buildings & Process			
	(a)	General Factory Areas		100-150
		-canteens, cloakrooms, entrances		
		corridors, stairs		
	(b)	Factory- outside Areas		
		-Stockyards, main entrances		20
	(c)	Assembly, Inspection, Wood working,		
		Welding & Soldering, Machine & Fitting		
		Shops,		
		(i)	Rough Work - Frame assembly	150
		(ii)	Medium Work - Assembly of parts	300
		(iii)	Fine Work - Electronic assembly,	700
			inspection	
		(iv)	Very Fine Work - Assembly of	1500
			precision parts, optical aids	
			to be provided.	
		(v)	Very Precise Work	3000
	(d)	Boiler Houses		
		(i)	Coal & ash handling	100
		(ii)	Boiler rooms-operating area	100
		(iii)	Boiler rooms- other areas	20-50
		(iv)	Outdoor plants	150

Rule 11(Tab.)

(e)	Chemical Works			
	(i)	Hand furnace, boiling tanks, driers, evaporators etc.		150
	(ii)	Controls, gauges, valves etc. (Supplementary lighting for viewing)		100
	(iii)	Control rooms		200-300
(f)	Electricity Generating Station (indoor)			
	(i)	Turbine halls		200
	(ii)	Auxiliary equipment areas	100	
	(iii)	Boiler houses		70-100
	(iv)	Boiler house & Turbine house		100
	(v)	Basement areas		70
	(vi)	Conveyer areas		70-100
	(vii)	Control rooms		200-300
	(viii)	Nuclear reactors & steam generating plants		150-200
	(g)	Engraving		1000
	(h)	Foundries		
		(i) Charging floors, tumbling etc.		150
		(ii) Fine moulding, core making & inspection		300
		(iii) Repairs		300
	(i)	Garages		
		(i) Parking areas		70
		(ii) Washing, polishing etc.		150
		(iii) Repairs		300
	(j)	Gauge & Tool room (Supplementary lighting if required)		700

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(k)	Laboratories & Test Rooms		
	(i)	General Labs & balance rooms	300
	(ii)	Electronic & Instrument Labs	450
(l)	Laundries, Dry cleaning & ironing		200-300
(m)	Paint Shops & Spraying Booths		
	(i)	Dipping, rubbing	150-300
	(ii)	Fine painting & retouching	450-700
(n)	Plating Shops		
	(i)	Vat & baths	150
	(ii)	Final buffing & polishing	Special lighting
(o)	Structural Steel Fabrication Plants		
	(i)	General	150
	(ii)	Marking off	300
(p)	Libraries		
	(i)	Shelves	70-150
	(ii)	Reading rooms	150-700
	(iii)	Cataloguing, sorting	150-300
	(iv)	Book binding etc.	300-700
(q)	Offices		
	(i)	Entrance & Reception	150
	(ii)	Conference rooms & Gen. office	30
	(iii)	Drawing offices	300-450
	(iv)	Corridors & Lifts	70
	(v)	Stairs, Lift landing	100-150
	(vi)	Telephone exchanges	150-200

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(r)	Hospitals		
	(i)	General & Wards	150
	(ii)	Operating Theatres General	300
	(iii)	Operation table	Special lighting
	(iv)	Laboratories	300
	(v)	Radiological rooms	100
	(vi)	Other areas	100-300
(s)	Restaurants		
	(i)	Dining room tables	100
	(ii)	Self service counters	300
	(iii)	Kitchen	200
	(iv)	Cloak room & toilets	100

(2) Temperature.- It is essential to provide such temperature in work environment so that workers can be exposed to it repeatedly without adverse health effects. The nature of work can be light , moderate or heavy and the corresponding heat loads for the type of work are 200, 200-350 & 350-500 K Cal/hr. The heat stress is measured in terms of Wet Bulb Globe Temperature (WBGT) Index.* (* Note - on page 12)

The permissible WBGT index in degrees Celsius is given in the following WBGT Table.

WBGT TABLE

	Work Load		
Work-Rest Regimen in each hour	Light	Moderate	Heavy
Continuous Work	30.0	26.7	25.0
75% Work - 25% Rest	30.6	28.0	25.9
50% Work - 50% Rest	31.4	29.4	27.9
25% Work - 75% Rest	32.2	31.1	30.0

The Competent Authority shall specify the optimum working temperature & humidity and also the rest periods for specific factories & jobs.

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(3) Ventilation.- Ventilation shall be provided in buildings to supply fresh air for respiration & to dilute inside air to prevent vitiation by body odours & to remove any other products of combustion or other air contaminants. Contaminants from concentrated sources such as smoke, heat & fumes shall be collected separately by local exhaust ventilation. The recommended air changes per hour for various areas is given in the Table below:

TABLE

Area	**Air Changes/hour**
Factories	3 - 6
Dining Hall	12 - 15
Garages	12 - 15
Kitchen	6 - 9
Laboratories	3 - 6
Offices	3 - 6
Bathrooms & Toilets	6 - 12

Provided that the competent authority may relax the requirements regarding the number of air changes if it is satisfied that having regard to the location of the factory, orientation of the workroom, prevailing winds, roof height and the nature of manufacturing process carried on, sufficient supply of fresh air into the workroom is afforded during most part of the working time:

Provided further that in the regions where in summer (15th March-15th July) dry-bulb temperatures of outside air in the shade during most part of the day exceed 35 degrees Celsius and simultaneous wet-bulb temperatures are 25 degrees Celsius or below and in the opinion of the Inspector the manufacturing process carried on in the workroom of a factory permits thermal environments with relative humidity of 50% or more, the Inspector may serve on the manager of the factory an order to have sufficient supply of outside air for ventilation cooled by

* (a) Outdoors with Solar load

WBGT = 0.7NWB + 0.2GT + 0.1DB

(b) Indoor or Outdoor without Solar load

WBGT = 0.7 NWB + 0.3GT

Where NWB = Natural Wet Bulb Temperature

DB = Dry Bulb Temperature

GT = Globe Thermometer Temperature

passing it through water sprays either by means of unit type of evaporative air coolers(desert coolers) or, where supply of outside air is provided by mechanical means through ducts in a plenum system, by means of central air washing plants.

12. QUANTITY OF DRINKING WATER.- The quantity of drinking water to be provided per day for the workers in every factory shall be at least 5 litres per worker employed in the factory and such drinking water shall be readily available at all times during working hours.

13. SOURCE OF SUPPLY.- The water provided for drinking shall be supplied,-

(a) from the public water supply system, or

(b) from any other source approved in writing by the local Health Officer concerned.

14. MEANS OF SUPPLY.- If drinking water is not supplied directly from taps either connected with public water supply system or any other water supply system of the factory approved by the local Health Officer concerned, it shall be kept in suitable vessels, receptacles or tanks fitted with taps and having dust proof covers, and placed on raised stands or platforms in shade and having suitable arrangement of drainage to carry away the spilt water. Such vessels, receptacles or tanks shall be kept clean and the water renewed at least once every day. All practicable measures shall be taken to ensure that the water is free from contamination.

15. CLEANLINESS OF WELL OR RESERVOIR.-

(1) Drinking water shall not be supplied from any open well or reservoir unless it is so constructed, situated, protected and maintained as to be free from the possibility of pollution by chemical, or bacterial and extraneous impurities.

(2) Where drinking water is supplied from such a well or reservoir, the water in it shall be sterilised once a week or more frequently if the inspector by written order so requires, and the date on which sterilising is carried out shall be recorded:

Provided that this requirement shall not apply to any such well or reservoir if the water therein is filtered and treated to the satisfaction of the local Health Officer concerned before it is supplied for consumption.

16. REPORT FROM LOCAL HEALTH OFFICER CONCERNED.- The Inspector may by order in writing direct the manager to obtain, at such time or at such intervals as he may direct, a report from the local Health Officer concerned as to the fitness for human

consumption of the water supplied to the workers, and to submit to the Inspector a copy of such report as soon as it is received from the local Health Officer.

17. COOLING OF WATER.- In every factory wherein more than two hundred and fifty workers are ordinarily employed,-

(1) The drinking water supplied to the workers shall be cooled by an effective method for the period specified by the Inspector;

(2) The cool drinking water shall be supplied in every canteen, lunchroom and rest-room and also at conveniently situated points throughout the factory which for the purpose of the rules shall be called "water centres";

(3) The water centres shall be sheltered from the weather and adequately drained and shall be located outside the work-places where toxic materials are handled or processed;

(4) The number of water centres to be provided shall be one "centre" for every 150 persons employed at any one time in the factory:

Provided that in the case of a factory where the number of persons employed exceeds 500 it shall be sufficient if there is one such "centre" as aforesaid for every 150 persons up to the first 500 and one for every 500 persons thereafter:

Provided further that its distance between the place of work shall be such as may be specified by the Inspector.

(5) Every water centre shall be maintained in a clean and orderly condition; and

(6) The means of supply of cooled drinking water shall be either directly through taps connected to water coolers or any other system for cooling of water, or by means of vessels, receptacles or tanks fitted with taps and having dust proof covers and placed on raised stands or platforms in shade, and having suitable arrangement of drainage to carry away the spilt water. Such vessels, receptacles or tanks shall be kept clean and the water refilled at least once every day.

18. LATRINE ACCOMMODATION.- Latrine accommodation shall be provided in every factory on the following scale, namely:-

(a) where females are employed, there shall be at least one latrine for every 25 females;

(b) where males are employed, there shall be at least one latrine for every 25 males;

Provided that where the number of males exceeds 100, it shall be sufficient if there is one latrine for every 25 males up to the first 100 males, and one for every 50 males thereafter.

Note:- In calculating the number of latrines required under this rule, any odd number of workers less than 25, or 50 as the case may be, shall be reckoned as 25 or 50.

19. **TOILET BLOCKS .**- The toilet block shall consist of wash basins, latrines and urinals (in case of male workers). The number of wash basins will the same as number of latrines. Each wash basin shall be provided with mirror and liquid/cake soap. Each toilet block shall be provided with clean towel or electric hand drier. The number, size and location of the toilet block shall be as per the decision of Inspector & Public Health Authority.

20. **PRIVACY OF TOILET.**- Every latrine shall be under cover and so partitioned off as to secure privacy, and shall have a proper door and fastenings, which shall be maintained in good working order at all time.

21. **SIGN BOARDS TO BE DISPLAYED**.- Where workers of both sexes are employed, there shall be displayed outside each latrine block a notice "For Men Only" or "For Women Only" as the case may be, in the language understood by the majority of the workers. The notice shall also bear the figures of a man or of a woman as the case may be.

22. **URINAL ACCOMMODATION.**- Urinal accommodation shall be provided for the use of male workers and there shall be at least one urinal for every 50 males:

Provided that where the number of males employed exceeds 500, it shall be sufficient if there is one urinal for every 50 males up to the first 500 employed, and one for every 100 thereafter.

Note:- In calculating the urinal accommodation required under this rule any odd number of workers less than 50, or 100, as the case may be, shall be reckoned as 50 or 100.

23. **URINALS TO CONFORM TO PUBLIC HEALTH REQUIREMENTS.**- Urinals other than those connected with an efficient water-borne sewage system, and urinals in a factory wherein more than two hundred and fifty workers are ordinarily employed shall comply with the requirements of the Public Health Authorities.

24. **CERTAIN LATRINES AND URINALS TO BE CONNECTED TO SEWERAGE SYSTEM.-** When any general system of underground sewerage with an assured water supply for any particular locality is provided in a municipality, all latrines and urinals of a factory situated in

such locality shall, if the factory is situated within 30 metres of an existing sewer, be connected with that sewerage system suitably.

25. WHITEWASHING, COLOURWASHING OF LATRINES AND URINALS.- The walls, ceilings and partitions of every latrine and urinal shall be whitewashed or colourwashed and the whitewashing or colourwashing shall be repeated at least once in a period of four months. The dates on which the whitewashing or colourwashing is carried out shall be entered in the prescribed register (Form 2):

Provided that this rule shall not apply to latrines and urinals, the walls, ceilings or partitions of which are laid in glazed tiles or otherwise finished to provide a smooth, polished, impervious surface and that they are washed with suitable detergents and disinfectants at least once in every period of four months.

26. CONSTRUCTION AND MAINTENANCE OF DRAINS.- All drains carrying waste or sullage water shall be constructed in masonry or other impermeable material and shall be regularly flushed and the effluent disposed of by connecting such drains with a suitable drainage line:

Provided that where there is no such drainage line, the effluent shall be deodorized and rendered innocuous and then disposed of in a manner suitable to the satisfaction of the local Health Officer concerned.

27. WATER TAPS IN LATRINES.- Where piped water supply is available, a sufficient number of water taps, conveniently accessible, shall be provided in or near latrine accommodation. A tap per each latrine is to be preferred. There shall be at least one tap for every ten latrines or part thereof. The water taps shall be connected to the Municipal water supply or to an overhead storage tank of sufficient capacity, so that water is available from the taps during all hours when the workers are in the factory. Wherever commode type of latrines are provided arrangements shall be made for providing toilet paper and soap solution, in addition to the water tap. The toilet paper and soap solution shall be regularly replenished.

28. NUMBER AND LOCATION OF SPITTOONS.- The number and location of the spittoons to be provided shall be to the satisfaction of the Inspector. Such spittoons shall be placed on a stand or a bracket 90 cm. high.

29. TYPE OF SPITTOONS.- The spittoons shall be of either of the following types, namely:-

(a) a galvanized iron container with a conical funnel-shaped cover. A layer of suitable disinfectant liquid shall always be

maintained in the container; or

(b) a container filled with dry clean sand, and covered with a layer of bleaching powder; or

(c) any other type approved by the Competent Authority.

30. CLEANING OF LATRINES, URINALS, WORKPLACES & SPITTOONS.- Latrines, urinals, washplaces & spittoons shall be maintained in clean & sanitary conditions by employing adequate number of sanitary staff.

31. Qualifications of competent person with reference to various Sections of the Act are given in the schedule below.

SCHEDULE

The Competent Person is a person who is having a degree in the discipline mentioned or equivalent followed by experience as specified, in responsible position in the field and designated by the Competent Authority.

Sl. No.	Rules made under section of the Act requiring competency	Type of work	Discipline	Experience
1	2	3	4	5
1.	Section(6)	Civil construction structural work.	Civil & structural engineering	Minimum 10 yrs in design, construction testing or repairs of structures, knowledge of various codes pertaining to the non destructive testing methods.
2.	Section21(2)	Operation of dangerous machines	Electrical or mechanical engineering or equivalent	Minimum 7 yrs in design, operation maintenance, testing of relevant machinery, guards, safety devices etc.
3.	Section 28	Lifts & Hoists	- do -	Min. 7 yrs. in design, erection maintenance, inspection and test procedures of Hoists & lifts.

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1	2	3	4	5
4.	Section 29	Lifting Machinery Lifting tackles	Electrical, Mechanical or Metallurgical	Min.7 yrs. in design, erection maintenance, inspection. testing of lifting machinery or lifting tackle
5.	Section 31	Pressure plant	Chemical, Electrical or mechanical or metallurgical Engineering or equivalent	Min. 10 yrs experience in design, erection, maintenance, testing examination, inspection of pressure plants and knowledge of non destructive testing & codes of safety requirement of pressure vessels.
6.	Section 36	Dangerous fumes	Chemical engineering or masters degree in chemistry	Min.7 yrs. experience in collection and analysis of environmental samples and calibration of monitoring equipment.
7.	Section 41-C (b)	Supervision of handling of hazardous substances	Chemical engineering or masters degree in chemistry	Min. 7 yrs. experience on the shop floor in handling & disposal of hazardous chemicals.
8.	Section 87	Ventilation system	Electrical or mechanical engg.	Min.7 yrs. in design, fabrication, installation, testing of ventilation systems and systems used for collection of dusts, fumes etc.

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CHAPTER IV

SAFETY

32. Without prejudice to the provisions of sub-section (1) of section 21 of the Act in regard to fencing , the further precautions specified in Schedules annexed here to shall apply to machines mentioned in each Schedule.

SCHEDULE I

WOODWORKING MACHINERY

1. Definitions.-For the purposes of this schedule -

(a) "woodworking machine" means a circular saw, band saw, planing machine, chain mortising machine or vertical spindle moulding machine operating on wood or cork;

(b) "circular saw" means a circular saw working in a bench (including a rack bench), but does not include a pendulum or similar saw which is moved towards the wood for the purpose of cutting operation;

(c) "band saw" means a band saw, the cutting portion of which runs in a vertical direction but does not include a log saw or band re-sawing machine; and

(d) "planing machine" means a machine for overhead planing or for thicknessing or for both operations.

2. Stopping and starting device.- An efficient stopping and starting device shall be provided on every woodworking machine. The control of this device shall be in such a position as to be readily and conveniently operated by the person in charge of the machine.

3. Space around machines.- The space surrounding every woodworking machine in motion shall be kept free from obstruction.

4. Floors.-The floor surrounding every woodworking machine shall be maintained in good and smooth condition, and shall not be allowed to become slippery, and as far as practicable shall be kept free from chips or other loosely scattered material.

5. Training and supervision.-

(a) No person shall be employed at a woodworking machine unless he has been sufficiently trained to work that class of machine, or unless he works under the adequate supervision of a person who has a thorough knowledge of the working of the machine.

(b) A person who is being trained to work a woodworking machine shall be fully and carefully instructed as to the dangers of the machine and the precautions to be observed to secure safe working of the machine.

6. Circular saws.-Every circular saw shall be fenced as follows:-

(a) behind and in direct line with the saw there shall be a riving knife, which shall have a smooth surface, shall be strong, rigid and easily adjustable, and shall also conform to the following conditions:-

(i) the edge of the knife nearer the saw shall form an arc of a circle having a radius not exceeding the radius of the largest saw used on the bench;

(ii) the knife shall be maintained as close as practicable to the saw, having regard to the nature of the work being done at the time, and at the level of the bench table. The distance between the front edge of the knife and the teeth of the saw shall not exceed 12 millimeters; and

(iii) for a saw of a diameter of less than 60 cm., the knife shall extend upwards from the bench table to within 25 mm. of the top of the saw, and for a saw of a diameter 60 cm. or over shall extend upwards from the bench table to a height of at least 23 cm.

(b) the top of the saw shall be covered by a strong and easily adjustable guard, with a flange at the side of the saw farthest from the fence. The guard shall be kept so adjusted that the said flange shall extend below the roots of the teeth of the saw. The guard shall extend from the top of the riving knife to a point as low as practicable at the cutting edge of the saw; and

(c) the part of the saw below the bench table shall be protected by two plates of metal or other suitable material, one on each side of the saw; such plates shall not be more than 15 cm. apart, and shall extend from the axis of the saw outwards to a distance of not less than 5 cm. beyond the teeth of the saw. Metal plates, if not beaded, shall be of a thickness of at least 2.5 mm., or if beaded, be of a thickness of at least 1.25 mm.

7. Push Sticks.-A push stick or other suitable appliance shall be provided for use at every circular saw and at every vertical spindle moulding machine to enable the work to be done without unnecessary risk.

8. Band saws.-Every band saw shall be guarded as follows:-

(a) both sides of the bottom pulley shall be completely encased by sheet or expanded metal or other suitable material;

(b) the front of the top pulley shall be covered with sheet or expanded metal or other suitable material; and

(c) all portions of the blade shall be enclosed or otherwise securely guarded, except the portion of the blade between the bench table and the top guide.

9. Planing machines.-

(a) A planing machine (other than a planing machine which is mechanically fed) shall not be used for overhand planing unless it is fitted with a cylindrical cutter block.

(b) Every planing machine used for overhand planing shall be provided with a "bridge" guard capable of covering the full length and breadth of the cutting slot in the bench, and so constructed as to be easily adjusted both in a vertical and horizontal direction.

(c) The feed roller of every planing machine used for thicknessing, except the combined machine for overhand planing and thicknessing, shall be provided with an efficient guard.

10. Adjustment and maintenance of guards.-The guards and other appliances required under this schedule shall be -

(a) maintained in an efficient state;

(b) constantly kept in position while the machinery is in motion; and

(c) so adjusted as to enable the work to be done without unnecessary risk.

11. Exemptions.-Paragraphs 6, 8, 9 and 10 shall not apply to any woodworking machine in respect of which it can be proved that other safeguards are provided, maintained and used which render the machine as safe as it would be if guarded in the manner prescribed in this schedule.

SCHEDULE II

CENTRIFUGAL MACHINES

1. Definition.-"Centrifugal machines" include centrifugal extractors, separators and driers.

2. Every part of centrifugal machine shall be

(a) of good design and construction and of adequate strength;

(b) properly maintained; and

(c) examined thoroughly by a competent person at regular intervals to check for unbalance & in case unbalance at high speeds is observed steps to restore the balance shall be taken before commissioning the machine.

3. Interlocking guard for drum or basket.-

(a) The cage housing the rotating drum or basket of every centrifugal machine shall be provided with a strong lid. The design and construction of the cage as well as the lid shall be such that no access is possible to the drum or basket when the lid is closed.

(b) Every centrifugal machine shall be provided with an efficient interlocking device that will effectively prevent the lid referred to in sub-paragraph (a) from being opened while the drum or basket is in motion and prevent the drum or basket being set in motion while the lid is in the open position.

4. Braking arrangement.-Every centrifugal machine shall be provided with an effective braking arrangement capable of bringing the drum or basket to rest within as short a period of time as reasonably practicable after the power is cut off.

5. Operating speed.-No centrifugal machine shall be operated at a speed in excess of the manufacturer's rating which shall be legibly stamped at easily visible places both on the inside of the basket and on the outside of the machine casing.

SCHEDULE III

POWER PRESS

1. Application.- The Schedule shall apply to all types of power presses including press brakes, except when used for working hot metal.

2. Definition.- For the purpose of this Schedule -

(a) "approved" means approved by the Competent Authority;

(b) "fixed fencing" means fencing provided for the tools of a power press being fencing which has no moving parts associated with or dependent upon the mechanism of a power press and includes that part of a closed tool which acts as a guard;

(c) "power press" means a machine used in metal or other industries for moulding, pressing, blanking raising drawing and similar purposes;

(d) "safety device" means the fencing and any other safeguard provided for the tools of a power press.

3. Starting and stopping mechanism.- The starting and stopping mechanism shall be provided with a safety stop so as to prevent

over running of the press or descent of the ram during tool setting, etc.

4. Protection of tool and die.-

(a) Each press shall be provided with a fixed guard with a slip plate on the underside enclosing the front and sides of the tool.

(b) Each die shall be provided with a fixed guard surrounding its front and sides, and extending to the back in the form of a tunnel through which the pressed article falls to the rear of the press.

(c) The design, construction and mutual position of the guards referred to in (a) and (b) such as to preclude the possibility of the worker's hand or fingers approaching the danger zone.

(d) The machine shall be fed through a small aperture at the bottom of the die guard, but a wider aperture may be permitted for second or subsequent operations if feeding is done through a chute.

(e) Notwithstanding anything contained in sub-clauses (a) and (b) an automatic or an inter-locked guard may be used in place of a fixed guard, but where such guards are used they shall be maintained in an efficient working condition and if any guard develops a defect, the power press shall not be operated unless the defect of the guard is removed.

5. Appointment of persons to prepare power presses for use .-

(a) Except as provided in paragraph (4), no person shall set, re-set, adjust or try out the tools on a power press or install or adjust any safety device thereon, being installation or adjustment preparatory to production of die proving, or carry out an inspection and test of any safety device thereon required by paragraph 8 unless he-

(i) has attained the age of eighteen;

(ii) has been trained in accordance with the sub-paragraph (b); and

(iii) has been appointed by the occupier of the factory to carry out those duties in respect of the class or description of power press or the class or description of safety device to which the power press or the safety device (as the case may be) belongs; and the name of every such person shall be entered in a register in Form 1.

(b) The training shall include suitable and sufficient practical instruction in the matters in relation to each type of power press & safety device in respect of which it is proposed to appoint the person being trained.

6. Examination and testing of power presses and safety devices.-

(a) No power press or safety device shall be taken into use in any factory for the first time in that factory, or in case of a safety device for the first time on any power press, unless it has been thoroughly examined and tested, in the case of a power press, after installation in the factory, or in the case of a safety device, when in position on the power press in connection with which it is to be used.

(b) No power press shall be used unless it has been thoroughly examined and tested by a competent person within the immediately preceding period of 12 months.

(c) No power press shall be used unless every safety device (other than fixed fencing) thereon has within the immediately preceding period of six months when in position on that power press, been thoroughly examined and tested by a competent person.

(d) The competent person carrying out an examination and test under the foregoing provisions shall make a report of the examination and test containing the following particulars and every such report shall be kept readily available for inspection:

(i) name of the occupier of the factory;

(ii) address of the factory;

(iii) identification number or mark sufficient to identify the power press or the safety device;

(iv) date on which the power press or the safety device was first taken into use in the factory;

(v) the date of each periodical thorough examination carried out as per requirements of sub-paragraph (b) above;

(vi) particulars of any defects affecting the safe working of the power press or the safety device found at any such thorough examination and steps taken to remedy such defects;

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7. Defects disclosed during a thorough examination and tests .-

(a) Where any defect is disclosed in any power press or in any safety device by any examination and test under paragraph 6 and in the opinion of the competent person carrying out the examination and test, either-

(i) the said defect is a cause of danger to workers and in consequence the power press or safety device (as the case may be) ought not to be used until the said defect has been remedied; or

(ii) the said defect may become a cause of danger to workers and in consequence the power press or safety device (as the case may be) ought not to be used after the expiration of a specified period unless the said defect has been remedied.

Such defect shall, as soon as possible after the completion of the examination and test, be notified in writing by the competent person to the occupier of the factory and, in the case of a defect falling within clause (ii) of this sub-paragraph such notification shall include the period within which, in the opinion of the competent person, the defect ought to be remedied.

(b) In every case where notification has been given under this paragraph, a copy of the report made under paragraph 6(d) shall be sent by the competent person to the inspector for the area within fourteen days of the completion of the examination and test.

(c) Where any such defect is notified to the occupier in accordance with the foregoing provisions of this paragraph the power press or safety devise (as the case may be) having the said defect shall not be used -

(i) in the case of a defect falling within clause(i) of sub- paragraph (a) until the said defect has been remedied; and

(ii) in the case of defect falling within clause (ii) of sub-paragraph (a), after the expiration of the specified period.

(d) As soon as is practicable after any defect of which notification has been given under sub-paragraph(a) has been remedied, a record shall be made by or on behalf of the occupier stating the measures by which and the date on which the defect was remedied.

8. Inspection and test of safety devices.-

(a) No power press shall be used after the setting, resetting or adjustment of the

tools thereon unless a person appointed or authorised for the purpose under Paragraph 5 has inspected and tested every safety device thereon while it is in position on the said power press:

Provided that any inspection, test and certificate as aforesaid not be required where any adjustment of the tools has not caused or resulted in any alteration to or disturbance of any safety device on the power press and if, after the adjustment of the tools, the safety devices remain, in the opinion of such a person as aforesaid, in efficient working order.

(b) Every power press and every safety device thereon while it is in position on the said power press shall be inspected and tested by a trained person every day.

9. Defects disclosed during an inspection and test.-

(a) Where it appears to any person as a result of any inspection and test carried out by him under paragraph 8 that any necessary safety device is not in position or is not properly in position on a power press or that any safety device which is in position on a power press is not in his opinion suitable, he shall notify the manager forthwith.

(b) Except as provided in sub-paragraph (c) where any defect is disclosed in a safety device by any inspection and test under paragraph 8, the person carrying out the inspection and test shall notify the manager forthwith.

(c) Where any defect in a safety device is the subject of a notification in writing under paragraph 7 by virtue of which the use of the safety device may be continued during a specified period without the said defect having been remedied, the requirement in sub-paragraph (b) of this paragraph shall not apply to the said defect until the said period has expired.

10. Identification of power presses and safety devices.- For the purpose of identification every power press and every safety device provided for the same shall be distinctively and plainly marked.

11. Training and instructions to operators.- The operators shall be trained and instructed in the safe method of work before starting work on any power press. It shall be ensured by adequate supervision that correct operating procedures are being followed.

12. Exemptions.-

(a) If in respect of any factory, the Competent Authority is satisfied that owing to the circumstances or infrequency of the processes or for any other reason, all or any of the provisions of this Schedule are not necessary for the

protection of the workers employed on any power press or any class or description of power press or in the factory, the Competent Authority by a certificate in writing(which he may in his discretion revoke at any time), exempt such factory from all or any of such provisions subject to such conditions, if any, as he may specify therein.

(b) Where such exemption is granted, a legible copy of the certificate, showing the conditions (if any) subject to which it has been granted, shall be kept posted in the factory in a position where it may be conveniently read by the persons employed.

SCHEDULE IV

WELDING AND GAS CUTTING

1. Arc Welding.-

(a) Definition.- Arc welding is a welding process wherein coalescence is produced by heating with an electric arc, with or without application of pressure and with or without the use of filler metal.

(b) Correct and proper electric earthing shall be provided for the welding machine, the casing and the job to be welded. These shall be electrically checked for any leakage of current by an authorised and trained electrician.

(c) The welding machine shall be kept at a dry place and materials shall not be kept around it.

(d) The welding cable shall be in good condition. The metal wire shall not be in an exposed state anywhere. The welding cable connections shall be tight. The cable shall not lie on wet surface nor shall it pass through water. Building structure, fuel tanks, railings etc., shall not be used to support welding cables. As far as possible cable shall not be laid across the passages.

(e) The welder shall not wear any wet dresses, footwear, hand gloves etc. These articles must be dry before working with welding machines. The welder shall wear rubber shoes, hand gloves and use welding screens while doing welding jobs. Welding screen shall be used around the welding area to stop welding flashes from affecting others. The welder must check the welding holder thoroughly before starting the job and shall also see that the insulation of the holder is proper.

(f) The welding cable and holder etc., shall be fastened to the overhead structures with non-conductors to prevent these from dropping down.

(g) Scaffolding made of corrugated sheets shall be used below the areas where welding is to be done to prevent sparks dropping down below.

(h) While welding in confined areas like inside of tanks, pipes etc., proper ventilation shall be provided with the help of a fan.

(i) Welding on a gas or fuel line shall never be done without a special approved procedure written specially for the particular job.

(j) All welding work shall be started only after obtaining a welding permit from authorised agency indicating special precautions including the fire fighting details.

(k) For welding work on overhead equipment such as crane etc. a separate earth cable shall be run up to the work place and shall be connected to work piece.

2. Gas Cutting.-

(a) Definition.- Gas cutting is a process used for cutting mild steel by a flame torch using compressed gases Hydrogen/Acetylene and oxygen to preheat the metal and cutting it by forcing oxygen at higher pressure.

(b) The gas cylinders shall be kept well away from any fire or hot areas. The rubber pipes, joints, gas torches, valve connections shall be thoroughly checked for leakage of gas.

(c) The gas cutter shall use proper safety appliances viz. gas cutters goggles, hand gloves, safety shoes, helmets and safety belts.

(d) The rubber hose shall not come in contact with any hot material and it shall not be taken through hot areas.

(e) The gas torch shall be fastened to a fixed overhead structural or with the body of the gas cutter to stop it from dropping down.

(f) The rubber hose shall not obstruct the movement of others. When necessary to lower the rubber hose with fittings, a fibre rope should be used. A metal sheet shall be used below the job to arrest any sparks/hot slags from falling down.

(g) Before starting any gas cutting, a written permit clearance shall be obtained from authorised person which will indicate all Safety precautions including fire fighting details.

(h) Gas cutting at or near fuel line/hazardous area etc., shall be done only after obtaining a special approved procedure for that job.

(i) Provisions of Gas Cylinder Rules shall be complied with.

Rule 32 (Sch.V)

SCHEDULE V

SHEARS, SLITTERS AND GUILLOTINE MACHINES

1. Definition.- For the purpose of this Schedule -

   (a) "guillotine" means a machine ordinarily equipped with straight, bevel-edged blade operating vertically against a stationery resisting edge and used for cutting metallic or non- metallic substances;

   (b) "shears" or "shearing machine" means a machine ordinarily equipped with straight, bevel-edged blades operating vertically against resisting edges, or with rotary, overlapping cutting wheels, and used for shearing metals or non-metallic substances; and

   (c) "slitter" or "slitting machine" means a machine ordinarily equipped with circular disc-type knives, and used for trimming or cutting into metal or non-metallic substances or for slitting them into narrow strips; for the purpose of this Schedule, this term includes bread or other food slicers equipped with rotary knives or cutting discs.

2. Guillotine and Shears.-

   (a) Where practicable, a barrier metal guard of adequate strength shall be provided at the front of the knife, fastened to the machine frame and shall be so fixed as would prevent any part of the operator's body to reach the descending blade from above, below or through the barrier guard or from the sides:

   Provided that in case of machines used in the paper printing and allied industries, where a fixed barrier metal guard is not suitable on account of the height and volume of the material being fed, there shall be provided suitable starting devices which require simultaneous action of both the hands of the operator or an automatic device which will remove both the hands of the operator from the danger zone at every descent of the blade.

   (b) At the back end of such machines, as inclined guard shall be provided over which the slit pieces would slide and be collected at a safe distance in a manner as would prevent a person at the back from reaching the descending blade.

   (c) Power-driven guillotine cutters, except continuous feed trimmers, shall be equipped with -

      (i) starting devices which require the simultaneous action of both hands to start the cutting motion and of at least one hand on a control during the complete stroke of the knife; or

(ii) an automatic guard which will remove the hands of the operator from the danger zone at every descent of the blade, used in conjunction with one-hand starting devices which require two distinct movements of the device to start the cutting motion, and so designed as to return positively to the non-starting position after each complete cycle of the knife.

(d) Where two or more workers are employed at the same time on the same power-driven guillotine cutter equipped with two- hand control the device shall be so arranged that each worker shall be required to use both hands simultaneously on the safety trip to start the cutting motion, and at least one hand on a control to complete the cut.

(e) Power-driven guillotine cutters, other than continuous trimmer, shall be provided, in addition to the brake or other stopping mechanism, with an emergency device which will prevent the machine from operating in the event of failure of the brake when the starting mechanism is in the non-starting position.

3. Slitting Machines.-

(a) Circular disc-type knives on machines for cutting metal and leather, paper, rubber, textiles or other non-metallic substances shall, if within reach of operators standing on the floor or working level, be provided with guards enclosing the knife edges at all times as near as practicable to the surface of the material, and which may either-

(i) automatically adjust themselves to the thickness of the material; or

(ii) be fixed or manually adjusted so that the space between the bottom of the guard and the material will not exceed 6 mm (1/4 in.) at any time.

(b) Portions of blades underneath the tables or benches of slitting machines shall be covered by guards.

4. Index Cutters and Vertical Paper Slotters.- Index cutters, and other machines for cutting strips from the ends of books, and for similar operations, shall be provided with fixed guards, so arranged that the fingers of the operators cannot come between the blades and the tables.

5. Corner Cutters.- Corner cutters, used in the manufacture of paper boxes, shall be equipped with -

(a) suitable guard fastened to the machines in front of the knives and provided with slots or perforations to afford visibility of the operations; or

(b) other guards equally efficient for the protection of the fingers of the workers.

Rule 32(Sch.V-VI)

6. Band Knives.- Band wheels on band knives, and all portions of the blades except the working side between the sliding guide and the table on vertical machines, or between the wheel guards on horizontal machines, shall be completely enclosed with hinged guards of sheet metal not less than 1 mm(0.04 in) in thickness or of other material of equal strength.

SCHEDULE VI

AGITATORS AND MIXING MACHINES

1. Definition.- "Agitators and Mixing Machines" means a tank or other container equipped with power-driven mixing arms, blades or paddle wheels fixed to revolvable shafts or other simple mechanical devices for blending stirring liquids with other liquids or with solid substances or combinations of these.

2. When the top of an open agitator tank, beater tank or paddle tank or similar vessel is less than 1 M above the adjacent floor or working level, adequate standard railings shall be installed on all open sides.

3. Agitators and mixing machines shall be provided with an efficient inter-lock arrangement for the top lid, to prevent access to the agitating, stirring or similar devices, whilst in motion and would prevent restart under power with the lids in open position.

4. When other inspection or examination openings are provided at the top or sides of the containers vessels of the agitator and mixing machines, such openings shall be provided with standard grill guards as would prevent access of any part of the operator's body coming in contact with agitator stirring or similar devices whilst in motion.

5. When discharge holes, openings, chutes or similar arrangements are provided at bottom or at the sides of the container vessels of the agitator and mixing machines, they shall, be so designed, shaped guarded, or situated as would prevent access of any part of operator's body coming in contact with agitating, stirring or similar devices, whilst in motion inside the vessel.

Rule 32 (Sch. -VII)

SCHEDULE VII

CONVEYORS

1. Application.- The schedule shall apply to all types of conveyors.

2. Definition.- Conveyor means a horizontal, inclined or vertical device for moving or transporting bulk materials, packages & objects in a path predetermined by the design of device and having points of loading or discharge fixed or selective.

3. General.- The conveyors shall be so designed installed, operated & maintained as per the national code & standards. Safe procedures shall be laid down to include the following, namely:-

   (a) All moving parts of conveyors such as gears, sprockets, sheaves etc. shall be guarded;

   (b) The starting switch of conveyor shall be located at such a place so that the operator shall have clear view of the entire conveyor length;

   (c) The entire system shall be so interlocked by electrical or mechanical means that it can stop automatically if there is a blockage at any place along the length;

   (d) Conveyors operating in series shall have controls so designed that if one of the conveyor stops others shall automatically stop;

   (e) Electrical machines operating the conveyors equipped with brakes which are mechanically applied or released by movement of operating device, shall be so designed that if the electrical power is interrupted with brakes in OFF position, load can descend only at controlled speed;

   (f) Antirunaway or backstop devices shall be provided on reversible type of conveyors where reversing can cause hazard;

   (g) Overload protecting devices shall be provided on conveyors which shall disconnect the electrical power. All restarting devices shall remain locked till the cause of overload is removed;

   (h) For conveyors feeding the hopper at or near level of floor, the hopper shall be provided with screen or railing and toe-board;

   (i) Conveyors handling flammable material or fine powders shall have only explosion proof electrical fixtures. The dust levels in the area shall be restricted to PLE Limits by suitable means; and

   (j) Conveyors running in tunnels & pits shall have sufficient clearance at sides for workers engaged in lubricating or repair works.

4. Conveyors at height.-

   (a) Conveyors at elevated locations shall be provided with access platform with toe-board & guard rails.

(b) Conveyors installed within 2 metres of floor or walkway surface shall be provided with crossovers or passages

(c) Overhead conveyors shall be provided with sideboards along the edges & screen guards underneath. Underpasses shall be provided with sheet metal ceiling for protection of the persons crossing.

(d) Conveyors passing through building floors, walls shall have interlocks installed in such a way that all will have to operate at one time to start the system. These switches shall be clearly marked & area near them shall be kept clean and free of obstructions. The openings shall be guarded with hand rails, toe-boards etc.

5. Maintenance.- The operation, maintenance of conveyors shall be done under work permit system keeping in mind the nature of materials handled. The entire mechanism of conveyors, electrical switches, interlocks etc. shall be inspected and maintained regularly especially for brakes, back stops, anti-runaway devices, overload releases and such other safety devices.

6. Fire Fighting.- The entire length of the conveyor shall be covered by installation of fire detection and warning system. Wherever conveyor passes through wall or floor openings, automatic system shall be installed for closing of them to stop the passage of flame through them. Wherever necessary automatic water sprinkler system shall also be provided.

33. Register of workers employed for work on or near machinery in motion.-In every factory a register shall be maintained in Form 1 in which the name and other particulars of every such worker as may be employed for such examination or operation as referred to in the proviso to sub-section (1) of section 21 shall be entered.

34. HOISTS AND LIFTS.-

(1) A register shall be maintained to record particulars of examination of hoists and lifts and shall give particulars as shown in Form 3.

(2) In pursuance of the provisions of sub-section (4) of Section 28, in respect of any class or description of hoist or lift specified in the first column of the following Schedule, the requirements of section 28 specified in the second column of the said Schedule and set opposite to that class or description of hoist or lift shall not apply.

SCHEDULE

Class or description of hoist or lift	Requirements which shall not apply
Hoists or lifts mainly used for raising materials for charging blast furnaces or lime kilns.	Sub-section 1(b) in so far as it requires a gate at the bottom landing; sub-section1(d); sub-section 1(e)
Hoists not connected with mechanical power and which are not used for carrying persons.	Sub-section 1(b) in so far as it requires the hoistway or liftway enclosure to be so constructed as to prevent any person or thing from being trapped between any part of the hoist or lift and any fixed structure or moving part; sub-section 1(e)

35. LIFTING MACHINES, CHAINS, ROPES AND LIFTING TACKLES.-

(1) No lifting machine and no chain, rope or lifting tackle, except a fibre rope or fibre rope sling, shall be taken into use in any factory for the first time in that factory unless it has been tested and all parts have been thoroughly examined by a competent person and a certificate of such a test and examination specifying the safe working load or loads and signed by the person making the test and the examination, has been obtained and is kept available for inspection.

(2) Every jib-crane so constructed that the safe working load may be varied by the raising or lowering of the jib, shall have attached there to either an automatic indicator of safe working loads or an automatic jib angle indicator and a table indicating the safe working load at corresponding inclinations of the jib or corresponding radii of the load. An audio-visual alarm be preferably provided in addition, to give alarm wherever the limits given in table are exceeded.

(3) A table showing the safe working loads of every kind and size of chain, rope or use, and, in the lifting tackle in case of a multiple sling, the safe working loads at different angles of the legs, shall be pasted in the store in which the chains, ropes or lifting tackles are kept, and in prominent positions on the premises, and no chain, rope or lifting tackle not shown in the table shall be used:

Provided that this sub-rule shall not apply in respect of such lifting tackle if the safe working load thereof, or in the case of a multiple sling, the safe working load at different angles of the legs, is plainly marked upon it.

(4) The register to be maintained under clause (a)(iii) of sub-section (1) of Section 29 of the Act shall contain the report as given in Form - 4, giving following particulars and shall be kept readily available for inspection:-

(a) Name of occupier of factory.

(b) Address of factory.

(c) Distinguishing number or mark, if any, and description sufficient to identify the lifting machine, chain, rope, or the lifting tackle.

(d) Date when the lifting machine, chain, rope or lifting tackle was first taken into use in the factory.

(e) Date and number of the certificate relating to any test and examination made under sub-rules (1) and (15) together with the name and address of the person who issued the certificate.

(f) Date of each periodical thorough examination made under clause (a) (iii) of sub-section(1) of Section 29 of the Act and sub-section (3) and by whom it was carried out.

(g) Date of annealing or other heat treatment of the chain and other lifting tackle made under sub-rule (7) and by whom it was carried out.

(h) Particulars of any defects affecting the safe working load found at any such thorough examination or after annealing and of the steps taken to remedy such defects.

(5) All rails on which a travelling crane moves and every track on which the carriage of a transporter or runway moves shall be of proper size and adequate strength and have an even running surface; and every such rail or track shall be properly laid, adequately supported and properly maintained.

(6) To provide access to rail tracks of overhead travelling cranes suitable passage-ways of at least 50 centimeters width with toeboards and double hand rails 90 centimeters high shall be provided alongside, and clear of, the rail tracks of overhead travelling cranes, such that no moving part of the crane can strike persons on the ways, and the passage-way shall be at a lower level than the crane track itself. Safe access ladders shall be provided at suitable intervals to afford access to these passage-ways, and from passage-ways to the rail tracks:

Provided that the Competent Authority may, for reasons to be specified in writing, exempt any factory in respect of any overhead travelling crane from the operation of any provision of this sub-rule subject to such conditions as it may specify.

(7) All chains and lifting tackles except a rope sling shall, unless they have been subjected to such other heat treatment as may be approved by the Competent Authority of Factories, be effectively annealed under the supervision of a competent person at the following intervals:-

(a) all chains, slings, rings, hooks, shackles and swivels used in connection with molten metal or molten slag or when they are made of 12.5 millimeters bar or smaller, once at least in every six months; and

(b) all other chains, rings, hooks, shackles and swivels in general use, once at least in every twelve months:

Provided that chains and lifting tackle not in frequent use shall, subject to the Competent Authority's approval, be annealed only when necessary. Particulars of such annealing shall be entered in a register prescribed under sub-rule (4).

(c) Slinging-

(i) Chains shall not be joined by bolting or wiring links together. They shall not be shortened by tying knots. A chain in which the links are locked, stretched or do not move freely shall not be used. The chain shall be free of kinks and twists. Proper eye splices shall be used to attach the chain hooks.

(ii) Pulley blocks of the proper size shall be used to allow the rope free play in the sheave grooves and to protect the wire rope from sharp bends under load. Idle sling shall not be carried on the crane hook along with a loaded sling. When idle slings are carried they shall be hooked.

(iii) While using multileged slings, each sling or leg shall be loaded evenly and the slings shall be of sufficient length to avoid a wide angle between the legs.

(iv) Sling hitches on loads shall be made under the supervision of experienced persons.

(8) Nothing in the foregoing sub-rule (7) shall apply to the following classes of chains and lifting tackles, namely:-

(a) chains made of malleable cast iron;

(b) plate link chains;

(c) chains, rings, hooks, shackles and swivels made of steel or of any non-ferrous metal;

(d) pitched chains, working on sprocket or pocketed wheels;

(e) rings, hooks, shackles and swivels permanently attached to pitched chains, pulley blocks or weighing machines;

(f) hooks and swivels having screw threaded parts or ball bearing or other case hardened parts;

(g) socket shackles secured to wire ropes by white-metal capping; and

(h) bordeaux connections:

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Provided that such chains and lifting tackles shall be thoroughly examined by a competent person once at least in every twelve months, and particulars entered in the register kept in accordance with sub-rule (4).

(9) Cranes shall be operated only by authorised persons who are well trained and experienced, operators shall ensure that all safety devices are functioning properly before crane is put into operation.

(10) A mobile crane shall be operated so that none of its parts can approach live electric lines closer than 3 m. While lifting loads such a crane shall be located on level ground.

(11) Standard signals shall be used and operators shall recognise signals from only one person during crane operation. Signal men shall direct equipment movement at fills, quarries, pits, intersections or any other place where necessary to prevent possible accidents.

(12) No person shall be permitted to work or walk under a load.

(13) Thorough inspection and load testing of a crane shall be done by a competent person at least once every 12 months. The load to be used for the purpose of testing shall be as follows:

Safe working load Test load

Up to 20 tons 25% in excess

20 - 50 tons 5 tons in excess

Over 50 tons 10% in excess

(14) All lifting machines, ropes, chains and lifting tackles, except a fibre rope or fibre sling, which have been lengthened, altered or repaired by welding or otherwise, shall, before being again taken into use, be adequately re-tested and re-examined by a competent person and certificate of such test and examination be obtained, and particulars entered in the register kept in accordance with sub-rule (4).

(15) No person under 18 years of age and no person who is not sufficiently competent and reliable shall be employed as driver of a lifting machine whether driven by mechanical power or otherwise, or to give signals to a driver.

(16) Where the Competent Authority is satisfied that in a factory due to shutdown or for any other reasons it is not practicable to maintain a minimum distance of 6 metres between the person employed or working on or near the wheel track of a travelling crane and the crane, it may on the request of the manager reduce the distance to such extent as it may consider necessary and also prescribe further precautions indicating appointment of suitable number of supervisors to ensure the safety of the persons while they are employed or working on or near the track.

36. PRESSURE VESSELS OR PLANTS.-

(1) Interpretation.-In this rule-

(a) "design pressure" means the maximum pressure that a pressure vessel or plant is designed to withstand safely when operating normally;

(b) "maximum permissible working pressure" means the maximum pressure at which a pressure vessel or plant is permitted to be operated or used under this rule and is determined by the technical requirement of the process;

(c) "plant" means a system of piping that is connected to a pressure vessel and is used to contain a gas, vapour or liquid under pressure greater than the atmospheric pressure, and includes the pressure vessel;

(d) "pressure vessel" means a vessel that may be used for containing, storing, distributing, transferring, distilling, processing or otherwise handling any gas, vapour or liquid under pressure greater than the atmospheric pressure and includes any pipeline fitting or other equipment attached thereto or used in connection therewith; and

(e) "competent person" means a person as defined in Sr.No. 5. of schedule to rule 31.

(2) Exceptions.-Nothing in this rule shall apply to -

(a) vessels made of ferrous materials having an internal operating pressure not exceeding 1 kilogram per square centimeter;

(b) steam boilers, steam and feed pipes and their fittings coming under the purview of the Indian Boilers Act, 1923;

(c) metal bottles or cylinders used for storage or transport of compressed gases or liquefied or dissolved gases under pressure covered by the Gas Cylinder Rules, 1981 framed under the Indian Explosives Act, 1884;

(d) vessels in which internal pressure is due solely to the static head of liquid;

(e) vessels with a nominal water capacity not exceeding 500 litres connected in a water-pumping system containing air that is compressed to serve as a cushion;

(f) vessels for nuclear energy application shall be covered by rules framed by Competent Authority;

(g) refrigeration plant having a capacity of 3 tons or less of refrigeration in 24 hours; and

(h) working cylinders of steam engines or prime movers, feed pumps and steam traps; turbine casings; compressor cylinders; steam separators or dryers; steam strainers; steam de-super- heaters; oil separators; air receivers for fire sprinkler installations; air receivers of monotype machines provided the maximum working pressure of the air receiver does not exceed 130 kPa (1.33 kg/sq.cm) and the capacity 85 litres; air receivers of electrical circuit breakers; air receivers of electrical relays; air vessels on pumps, pipe coils, accessories of instruments and appliances such as cylinders and piston assemblies used for operating relays and interlocking type of guards; vessels with liquids subjected to static head only; and hydraulically operating cylinders other than any cylinder communicating with an air loaded accumulator.

(3) Design and construction.-Every pressure vessel or plant used in a factory -

(a) shall be properly designed on sound engineering practice;

(b) shall be of good construction, sound material, adequate strength and free from any patent defects; and

(c) shall be properly maintained in a safe working condition:

Provided that the pressure vessel or plant in respect of the design and construction of which there is an Indian standard or a standard of the country of manufacture or any other law or regulation in force, shall be designed and constructed in accordance with the said standards, law or regulation, as the case may be, and a certificate thereof shall be obtained from the manufacturer or from the competent person which shall be kept and produced on demand by an Inspector.

(4) Safety devices.-Every pressure vessel shall be fitted with-

(a) a suitable safety valve or other effective pressure relieving device of adequate capacity to ensure that the maximum permissible working pressure of the pressure vessel shall not be exceeded. It shall be set to operate at a pressure not exceeding the maximum permissible working pressure and when more than one protective device is provided, only one of the devices need be set to operate at the maximum permissible working pressure and the additional device shall be set to discharge at a pressure not more than 5 percent in excess of the maximum permissible working pressure;

(b) a suitable pressure gauge with a dial range not less than 1.5 times the maximum permissible working pressure, easily visible and designed to show at all times the correct internal pressure and marked with a prominent red mark at the maximum permissible working pressure of the pressure vessel;

(c) a suitable nipple and globe valve connected for the exclusive purpose of attaching a test pressure gauge for checking the accuracy of the pressure gauge referred to in clause (b) of this sub-rule;

(d) a suitable stop valve or valves by which the pressure vessel may be isolated from other pressure vessels or plant or source of supply of pressure. Such a stop valve or valves shall be located as close to the pressure vessel as possible and shall be easily accessible;

which shall be 1.5 times the maximum permissible working pressure:

Provided that the pressure vessel or plant which is so designed and constructed that it cannot be safely filled with water or liquid or is used in service when even some traces of water cannot be tolerated, shall be pneumatically tested at a pressure not less than the design pressure or maximum permissible working pressure as the case may be:

Provided further that the pressure vessel or plant which is lined with glass shall be tested hydrostatically or pneumatically as required at a pressure not less than the design pressure or maximum permissible working pressure as the case may be.

Explanation:- Design pressure shall be not less than the maximum permissible working pressure and shall take into account the possible fluctuations of pressure during actual operation.

(b) No pressure vessel or plant shall be used in a factory unless there has been obtained from the maker of pressure vessel or plant or from the competent person a certificate specifying the design pressure or maximum permissible working pressure thereof, and stating the nature of tests to which the pressure vessel or plant and its fittings (if any) have been subjected, and every pressure vessel or plant so used in a factory shall be marked so as to enable it to be identified as to be the pressure vessel or plant to which the certificate relates and certificate shall be kept available for perusal by the Inspector.

(c) No pressure vessel or plant shall be permitted to be operated or used at a pressure higher than its design pressure, or the maximum permissible working pressure as shown in the certificate.

(7) In-service test and examinations.-

(a) Every pressure vessel or plant in service shall be thoroughly examined by a competent person -

(i) externally, once in every period of six months; and

(ii) internally, once in every period of twelve months:

Provided that if by reason of the construction of a pressure vessel or plant, a thorough internal examination is not possible, this examination may be replaced by a hydrostatic test which shall be carried out once in every period of two years:

Provided further that for a pressure vessel or plant in continuous process which cannot be frequently opened, the period observations, findings and conclusions with other relevant remarks with reasons and may authorise the pressure vessel or plant to be used and kept in operation subject to a lowering of maximum permissible working pressure, or to more frequent or special examination or test, or subject to both of these conditions.

(b) A report of every examination or test carried out shall be completed in Form 5 and shall be signed by the person making the examination or test, and shall be kept available for perusal by the Inspector at all hours when the factory or any part thereof is working.

(c) Where the report of any examination under this rule specified any condition for securing the safe working of any pressure vessel or plant, the pressure vessel or plant shall not be used unless the specified condition is fulfilled.

(d) The competent person making report of any examination under this rule, shall within seven days of the completion of the examination, send to the Competent Authority a copy of the report in every case where the maximum permissible working pressure is reduced or the examination shows that the pressure vessel or plant or any part thereof cannot continue to be used with safety unless certain repairs are carried out or unless any other safety measure is taken.

(10) Application of other laws.-

(a) The requirements of this rule shall be in addition to and without any prejudice to and not in derogation of the requirements of any other law in force.

(b) Certificates or reports of any examination, or test of any pressure vessel or plant to which sub-rules (7) to (9) do not apply, conducted or required to be conducted under any other law in force and other relevant record relating to such pressure vessel or plant, shall be properly maintained as required under the said law and shall be produced on demand by the Inspector.

38. EXCESSIVE WEIGHTS.-

(1) No person, unless aided by another person or any mechanical device, shall carry or move by hand or head any material, article, tool or appliance exceeding the maximum limit in weight set out in the following Table:-

TABLE

Persons	Max. weight of material, article, tool or appliance in kg
a) Adult Male	55
b) Adult female	30

Provided that the dimensions of material, tool or appliance shall be such as not to make worker unstable and not to hurt others:

Provided further that pregnant females shall not be engaged for lifting loads.

(2) No female worker shall engage in conjunction with others, in lifting carrying or moving by hand or on head any material article, tool or appliance if the weight thereof exceeds the lowest weight fixed by Table to sub rule (1) above for any of the persons engaged multiplied by the persons engaged.

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39. PROTECTION OF EYES.- Effective screens or suitable goggles shall be provided for the protection of persons employed in or in the immediate vicinity of the following processes, namely:-

(1) The processes specified in Schedule I to this rule, being processes which involve risk of injury to eyes from particles or fragments thrown off in the course of the processes.

(2) The processes specified in Schedule II to this rule, being processes which involve risk of injury to eyes by reason of exposure to excessive light or infra-red or ultra-violet radiations.

SCHEDULE I

INJURY TO EYE FROM PARTICLES

1. Breaking, cutting, dressing or carving of bricks, stone, concrete, slag or similar materials by means of a hammer, chisel, pick or similar hand tool, or by means of a portable tool driven by mechanical power, and the dry grinding of surfaces of any such materials by means of a wheel or disc driven by mechanical power, where in any of the foregoing cases, particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

2. Dry grinding of surfaces of metal by applying them by hand to a wheel, disc or band driven by mechanical power, and of surfaces of metal by means of a portable tool driven by mechanical power.

3. Dividing into separate parts of metal, bricks, stone, concrete or similar materials by means of a high speed saw driven by mechanical power or by means of an abrasive cutting-off wheel or disc driven by mechanical power.

4. Turning of metals or articles of metal, where particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

5. Drilling by means of portable tools, where particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

6. Welding and cutting of metals by means of an electric, oxy- acetylene or similar process.

7. Hot fettling of steel castings by means of a flux-injected burner or air torch, and de-seaming of metal.

8. Fettling of metal castings involving the removal of metal, including runners, gates and risers, and removal of any other material during the course of such fettling.

9. Chipping of metal, and chipping, knocking out, cutting out or cutting off of cold rivets, bolts, nuts, lugs, pins, collars or similar articles from any structure or plant, or from part of any structure or plant, by means of a hammer, chisel, punch or similar hand tool, or by means of a portable tool driven by mechanical power.

10. Chipping or scurfing of paint, scale, slag, rust or other corrosion from the surface of metal and other hard materials by means of a hand tool or by a portable tool driven by mechanical power.

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11. Breaking of scrap metal by means of a hammer or by means of a tool driven by mechanical power.

12. Routing of metal, where particles or fragments are liable to be thrown off towards the face of the operator in the course of the process.

13. Work with drop hammers and power hammers used in either case for the manufacture of forgings, and work by any person not working with such hammers, whose work is carried on in such circumstances and in such a position that particles or fragments are liable to be thrown off towards his face during work with drop hammers or power hammers.

14. Work at a furnace where there is risk to the eyes from molten metal.

15. Pouring or skimming of molten metal.

16. Work involving risk to the eyes from hot sand being thrown off.

17. Truing or dressing of an abrasive wheel.

18. Handling in open vessels or manipulation of strong acids or dangerous corrosive liquids or materials, and operation, maintenance or dismantling of plant or any part of plant being plant or part of plant which contains or has contained such acids, liquids or materials, unless the plant or part of plant has been so prepared (by isolation, reduction of pressure, or otherwise), treated, or designed and constructed as to prevent risk of injury.

19. Any other process wherein there is a risk of injury to eyes from particles or fragments thrown off during the course of the process.

SCHEDULE II

INJURY TO EYE FROM LIGHT AND RADIATION

1. Welding or cutting of metals by means of an electrical, oxy- acetylene or similar process.

2. All work on furnaces where there is risk of exposure to excessive light or infra-red radiations.

3. Process such as rolling, casting or forging of metals, where there is risk of exposure to excessive light heat or infra-red radiations.

4. Any other process wherein there is a risk of injury to eyes from exposure to excessive light or infra-red or ultra-violet radiations.

40. MINIMUM DIMENSIONS OF MANHOLES.- Every chamber, tank, vat, pipe, flue or other confined space, which persons may have to enter and which may contain dangerous fumes to such an extent as to involve risk of the persons being overcome thereby, shall unless there is other effective means of egress, be provided with a manhole which may be rectangular, oval or circular in shape, and shall have the following dimensions as minimum, namely:-

Rectangular shape- 50 cm X 30 cm

Oval shape - Major & minor axis diameters 50 cm. and 30 cm. respectively.

Circular shape - 50 cm diameter

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41. EXEMPTIONS.- The requirements of sub-section (4) of section 37 of the Act shall not apply to the following processes carried on in any factory, namely:-

(1) the operation of repairing a water sealed gasholder by the electric welding process, subject to the following conditions, namely:-

(a) the gasholder shall contain only the following gases, separately or mixed at a pressure greater than atmospheric pressure, namely, town gas, coke-oven gas, producer gas, blast furnace gas, or gases other than air, used in their manufacture:

Provided that this exemption shall not apply to any gasholder containing acetylene or mixture of gases to which acetylene has been added intentionally; and

(b) welding shall only be done by the electric welding process and shall be carried out by experienced operatives under the constant supervision of a competent person;

(2) the operations of cutting or welding steel or wrought iron gas mains and services by the application of heat, subject to the following conditions, namely:-

(a) the main or service shall be situated in the open air, and it shall contain only the following gases, separately or mixed at a pressure greater than atmospheric pressure, namely, town gas, coke-oven gas, producer gas, blast furnace gas, or gases other than air, used in their manufacture;

(b) the main or service shall not contain acetylene or any gas or mixture of gases to which acetylene has been added intentionally;

(c) the operation shall be carried out by an experienced person or persons and at least 2 persons (including those carrying out the operations) experienced in work on gas mains and over 18 years of age shall be present during the operation;

(d) the site of the operation shall be free from any flammable or explosive gas or vapour;

(e) where acetylene gas is used as a source of heat in connection with an operation, it shall be compressed and contained in a porous substance in a cylinder; and

(f) prior to the application of any flame to the gas main or service, this shall be pierced or drilled and the escaping gas ignited.

45. PLANNING OF BUILDING CONSTRUCTION & ROADS, SIDEWALKS.-

(1) General.- All constructions shall conform to National Building Code of Indian Standards Institution now Bureau of Indian Standards.*

(2) Means of access for industrial buildings.-

(a) Means of access for industrial buildings & those buildings which attract large crowd shall be adequate.

The length of the main access shall be determined by the distance from the farthest building to the public street. The length of the subsidiary accessories shall be measured from the point of its' origin to the next wider road on which it meets.

(b) Pathways: The approach to the buildings from road/street/internal means of access shall be adequate and through paved pathways.

(c) Intersection of Roads: For intersection junction of roads meeting at right angles as well as other than right angles, the rounding off or cut off or splay or similar treatment shall be done, depending upon the width of the roads, traffic, sighting angle etc. to provide clear sight distance.

(d) Speed Breakers & Pedestrian Passage: Speed breakers shall be provided on all roads which lead to main road near the junction. The pedestrian crossings shall be marked.

(e) Sign Boards & Signs: Sign boards displaying information on maximum permissible speeds and appropriate road signs wherever required shall be provided. The maximum permissible speed on internal roads shall be decided by the manager of the factory depending on the traffic, size and number of vehicles, number of persons working in a particular building etc. The sign boards, road signs & pedestrian crossings shall be of fluorescent paint. The speed limit on various roads shall be decided by the factory manager.

(3) Guarding of pits, sumps, trenches, manholes etc.-Pits, sumps, trenches, manholes and any other openings in the wall or floor shall be adequately covered or guarded. these shall be periodically checked and record maintained.

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* Note-The Code covers aspects of administrative regulations, development control rules & general building & fire protection requirements; rules for design of electrical, etc. installations; regulation for ventilation etc. & plumbing services; measures to ensure safety of workers & public during construction etc.

Rule - 46

46. CONSTRUCTION & ERECTION.-Manager shall take appropriate measures with the approval of the Inspector to minimise the effects of occupational hazards arising out of animals, reptiles, rodents, poisonous plants and weeds, weather conditions and living conditions.

(1) General.-

(a) Site preparation - While preparing the site for construction, bush and other wood, debris, etc, shall be removed and promptly disposed of so as to minimize the attendant hazards.

Temporary buildings for construction offices and storage shall be so located as to cause the minimum fire hazards and shall be constructed from non-combustible materials as far as practicable.

(b) Access for Fire Fighting Equipment & Vehicles - Access for fire fighting equipment shall be provided to the construction site at the start of construction and maintained until all construction work is completed:

(i) Free access from the street to fire hydrants/static water tanks, where available, shall be provided and maintained at all times;

(ii) No materials for construction shall be placed within 3m of hydrants/static water tanks; and

(iii) During building operations, free access to permanent, temporary or portable first-aid fire fighting equipment shall be maintained at all times.

(c) Access to the Upper Floors During Construction- In all buildings over two storeys high, at least one stairway shall be provided in usable condition at all times. This stairway shall be extended upward as each floor is completed. As far as possible, there shall be a handrail on the staircase.

(2) Storage, Stacking & Handling of Materials.-Construction of Plant and Building: Construction requires various kinds of materials such as cement; lime; masonary units; aggregate;. fly ash; timber; protective clothing; electrical fittings etc. These shall be stored and handled as per prevalent good practices & relevant national standards in order to ensure quality & quantity of materials used in the construction and safety of personnel handling these materials.

(3) Safety Requirements for Erection of Structural Steel Work.-

(a) Organization of Work - The agency responsible for erecting the steel work shall analyze the proposed erection scheme for safety. The erection scheme shall cover safety aspects right from the planning stage up to the actual execution of the work and make provision for personnel protective equipments.

(b) Safety of Men:

(i) General - Skilled workers trained in relevant jobs shall only be employed in jobs requiring skills.
(1) All personnel protective equipments like helmets, goggles, safety shoes, gloves, aprons etc. shall be suitable for the job & shall conform to relevant Indian Standards

(2) When the work is in progress, the area shall be cordoned off by barricades to structural components, or falling into excavated trenches or getting injured by falling objects.

(3) Warning signs shall be displayed where necessary to indicate hazards, for example (a) '440 VOLTS', (b) 'DO NOT SMOKE', (c) 'MEN WORKING AHEAD', etc.

(4) All electrically operated hand tools shall be provided with proper earthing.

(5) Hand lamps shall be of low voltage preferably 24 V to prevent electrical hazards.

(ii) Anchors for guys or ties shall be checked for proper placement. The weight of concrete in which the anchors are embedded shall be checked for uplift and sliding:

(1) Split-end eye anchors shall only be used in good, solid rock.

(2) The first load lifted by a guy derrick shall be kept at a small height for about 10 minutes and the anchors immediately inspected for any signs or indications of failure.

(3) When a number of trusses or deep girders are loaded in one car or on one truck, all but one being lifted shall be tied back unless they have been tied or braced to prevent their falling over and endangering men unloading.

(4) The erection gang shall have adequate supply of bolts, washers, rivets, pins, etc. of correct size. Enough number of bolts shall be used in connecting each piece using a minimum of two bolts in a pattern to ensure that the joint will not fail due to dead load and erection loads.

All splice connections in columns, crane girders, etc., shall be completely bolted or riveted or welded as specified in the drawing before erection.

(5) Safety belts shall always be provided & used for working at heights. The ropes shall be chemically treated to resist dew and rotting. These shall not be tied on sharp edges of steel structures. They shall be tied generally not more than 2 to 3 m. away from the belt.

(6) On a guy derrick or climbing crane job, the tool boxes used by the erection staff shall be moved to the new working floor each time the rig is changed. On a mobile crane job, the boxes shall be moved as soon as the crane starts operating in a new area too far away for the men to reach the boxes conveniently.

(7) Baskets or containers to hold small materials such as bolts and drift pins shall be provided to men working on floats or scaffolds. Men shall be trained to use such containers, and to keep small tools gathered up and put away in tool boxes when not in use. Material shall not be dumped overboard when a scaffold is to be moved. Rivet heaters shall have safe containers or buckets for hot rivets left over at the end of the day.

(8) During the erection of tall buildings, nylon nets at a height of 3 to 4 m. shall be provided to ensure safety of men if there is a fall from heights.

In case of industrial buildings the height of which is in excess of 4 m a temporary strong net shall be provided below the roof, at a height of 3 m to 4 m above the floor, over which workers are working.

(9) Safety Against Fire - A fire protection procedure shall be set up if there is to be any flame cutting, burning, heating, riveting or any operation that could start a fire. Following precautions shall be observed during welding and cutting operations.

(a) The workers shall be instructed not to throw objects like hot rivets, cigarette stubs, etc, around.

(b) Sufficient number of fire extinguishers, preferably of soda acid type shall be placed at strategic points. Extinguishers shall always be placed in cranes, hoists, compressors and similar places. Where electrical equipments are involved, CO2 or dry powder extinguishers shall be provided.

(10) Riding on a load, tackle or runner shall be prohibited.

(11) The load shall never be allowed to rest on wire ropes. Ropes in operation shall not be touched. Wire ropes/manila ropes conforming to acceptable standards shall be used for guying.

(12) Lifting Appliances - Necessary precautions as laid down in rule 37 shall be followed.

(c) Safety of Structure: General -The structure itself shall be safeguarded during its erection & erection of columns shall be immediately followed by vertical bracing between columns before the roof structure is erected.

Rule 46

(4) Excavation.-

(a) Excavation shall be planned in advance so that hazards due to falling and things falling are avoided. Accident prevention measures shall be adopted and effectively carried out on each job because of inherent dangers.

(b) Underground utilities such as water mains, drainage lines, electrical cables, gas lines etc. shall be located and protected wherever necessary.

(c) Adequate measures shall be taken to prevent dislodgement of loose or unstable earth, rock or other material from falling into the excavation by proper timbering.

(d) Cutting shall be done from top to bottom. Under no circumstances undermining or undercutting shall be done.

(e) No excavation below the level of any foundation of a building or structure (if the excavation is liable to effect the building) shall be commenced unless adequate shoring has been provided to prevent any danger to the building.

(f) In every excavation work along sloping ground, sides and slopes of ground shall be maintained in a safe condition by scaling, benching or barricading. Loose earth and loose rock shall be scaled continuously. To ensure safety of workers engaged on such work, each worker shall be provided with safety belt attached to a safety line. On steep slopes workers shall not be permitted to work one above the other. All such scaling work shall be done under good supervision.

(g) All trenches, 120 cm or more in depth, shall at all times be supplied with at least one ladder for each 30 meters in length or fraction thereof. Ladder shall be extended from bottom of the trench to at least one metre above the surface of the ground.

(h) Every accessible part on an excavation or an opening in the ground into which a person is liable to fall vertically through a height of 2 meters, shall be barricaded to a height of one metre.

(i) Measures shall be taken to prevent spectators and other workmen who are not engaged in excavation work, from approaching excavation areas by placing warning signals etc. near the site of the excavation. Provisions shall also be made to prevent animals from falling into excavation areas.

(5) Shoring.-

(a) Additional precautions by way of shoring and bracing shall be taken to prevent slides, slips or caveins when excavations or trenches are made in locations subject to vibrations from railway or road traffic, the operation of machinery or any other source of vibration.

(b) Excavation over 1.2 m in depth, unless in solid rock or hard soil shall be shored and braced or sloped to the angle of repose of the material when consolidated. All shoring and bracing shall extend to the bottom of the excavation when necessary.

(c) No person shall work in an excavation shaft, earth work of tunnel unless all timbering or planks used therein has been inspected by a competent person before the commencement of the work.

(6) Night work. –

(a) Excavated area shall be adequately lighted up for night work.

(b) During night, a red danger light shall be displayed at a conspicuous place near the excavation site to warn approaching traffic and men.

(7) Disposal of soil

The excavated material shall be dumped sufficiently away from the edge of the excavated trench to avoid the excavated material slipping and falling into the trench. The excavated materials and any other material or load shall not be dumped or placed within 1.5m of the edges of the trench or half of the depth of the trench whichever is more.

(8) Scaffolding:

(a) Suitable scaffolds shall be provided for workmen for all works that cannot be done safely from the ground.

(b) All the members of a scaffold such as planks, braces, vertical supports, horizontal supports shall be of sound material, good construction and of adequate strength. They shall be properly maintained.

(c) No plank shall be kept loose so that levering of the plank is avoided. Nails of proper size shall be used for construction of scaffolds in sufficient numbers and driven fully in.

(d) Scaffolding or staging more than 3.5 meters above the ground floor swung or suspended from an overhead support or erected with stationary support shall have a guard rail properly attached, bolted, braced and otherwise secured at least one metre high above the the floor or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such opening as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure.

(e) On unprotected scaffolds at high elevations the men must wear life belts suitably anchored to some substantial part of the structure.

(f) Side screens shall be provided on scaffold erected along passageways.

(g) The platform of a suspended scaffold shall not be less than 45 cm. wide and points of suspension not more than 3 m apart and so arranged, that, at the working position, the edge is as close as practicable to the working face when persons have to work in a sitting position. Suspended scaffolds shall be tested as before use to ensure that minimum safety factors are maintained. The test will be made by raising the working surface 30 cm. above the ground and loading it with at least three times the maximum weight that will be imposed upon it.

(h) A safe and convenient means of access shall be provided to the platform or scaffold. Means of access may be a portable ladder, fixed ladder, ramp or a stairway. The use of cross braces or frame work as means of access to the working surface shall not be permitted.

(i) All scaffolds, before use, shall be examined by the engineer in charge.

(j) Every working place and approach thereto, every place where raising or lowering operations with the use of lifting appliance are in progress and all openings dangerous to persons employed shall be adequately and suitably lighted.

(k) During dismantling of scaffolds necessary precautions shall be taken to prevent injury to persons due to fall of loose materials.

(l) Bracings and other members of the scaffolds shall not be removed prematurely while dismantling the entire scaffold which shall be maintained stable and rigid so as to avoid the danger of collapse.

(m) Care shall be taken to see that no uninsulated electric wire exists within 3 metres of the working platform, gangways, runs, etc. of the scaffold.

(n) Good house-keeping shall be maintained at all times upon scaffolds, platforms and ramps. Excessive storage of materials thereon shall be avoided. Care must be taken to avoid accumulation of small objects such as tools, pieces of

(c) A man shall be specially employed as signalman to watch the movement of the bucket and warn the crew and vibrator operators of the approaching bucket so that all workers may clear out of the area affected by the bucket. Signalman shall be so stationed in a safe place that they can see the entire area where concrete is being placed.

(12) Work in open areas and specially at height shall be stopped under adverse weather conditions such as strong winds, snowfall, rainfall and under any other conditions specified by Safety Officer/Inspector.

47. TEMPORARY ELECTRICAL WIRING.-

(1) Frayed and / or bare wires shall not be used for temporary electrical connections during construction. All temporary wiring shall be installed and supervised by a competent electrician. Adequate protection shall be provided for all electrical wiring laid on floor which may have to be crossed over by construction machinery or by the workmen. All flexible wiring connecting the electrical appliances shall have adequate mechanical strength and shall preferably be enclosed in a flexible metal sheath. Overhead wires/cables shall be so laid that they leave adequate head room. Clearance for the above shall be obtained from the competent person.

(2) All electrical circuits, other than those required for illumination of the site at night, shall be switched off at the close of day's work. The main switch board from which connections are taken for lighting, power operated machinery, etc, shall be located in an easily accessible and prominent place. No article of clothing nor stores shall be kept at the back of or over the board or anywhere near it. One 3-kg/4.5-kg CO_2 extinguisher or one 5-kg dry powder extinguisher shall be provided near the switch board.

48. BUILDINGS & STRUCTURES.- No building, wall, chimney, bridge, tunnel, road, gallery, stairway, ramp, floor, platform, staging, or other structure, whether of a permanent or temporary character, shall be constructed, situated or maintained in any factory in such a manner as to cause risk of bodily injury.

49. MACHINERY AND PLANT.- No machinery, plant or equipment shall be constructed, situated, operated or maintained in any factory in such a manner as to cause risk of bodily injury or adverse effect on health. The Safety Officer shall have authority to stop the work if he finds that unsafe practices are being followed and/or unsafe conditions exist.

50. METHODS OF WORK.- No process or work shall be carried in any factory in such a manner as to cause risk of bodily injury. Schedule for Hand Tools & Portable Power Tools is given below.

SCHEDULE

HAND TOOLS & PORTABLE POWER TOOLS

1. Hand tools:-

   (a) Definition: Hand tool means any tool which is used without any external motive power.

   (b) Hand tools shall be of good quality materials, conforming to relevant BIS standards and shall be used only for the job it is designed for. Non sparking tools such as that made of Beryllium Copper alloy shall be used for working in explosive areas.

   (c) Workers shall be trained & instructed for proper use of tools such as files, hammers, hacksaws etc.

   (d) Proper tool bags shall be provided to workers to carry the tools and not leaving them on floors, passages etc.

   (e) Protective equipments such as gloves, goggles etc. shall be provided to and worn by the workers.

   (f) The tools shall be inspected regularly, repaired and maintained.

2. Portable Power Tools.-

   (a) Definition: Portable Power Tool means a tool powered by electric or pneumatic power, operated by a single operator and which is transportable from place to place.

   (b) Portable power tools shall conform to the relevant BIS standards and shall be used for the job it is designed for. Starting switches shall be located at such places where accidental starting cannot take place.

   (c) Electrically operated tools shall be used only with 3 core cable with proper earthing provided. This should be checked before use.

(d) Electrically operated tools shall not be used where flammable vapours, gases or dusts are present, unless they are specially designed for use in such environment.

(e) Proper guards shall be provided for tools such as grinders, saws etc. and operators shall be provided with personal protective equipments wherever required.

(f) In case of pneumatic tools a short chain shall be provided for attaching the air hose and tools housings securely to prevent it from whipping in case of breaking of the coupling.

(g) Periodic inspection and maintenance shall be carried out for electrical insulation, earthing, integrity etc.

51. STACKING AND STORING OF MATERIALS, ETC.- No materials or equipment shall be stacked or stored in such a manner as to cause risk of bodily injury.

52. LADDERS.-

(1) Every ladder shall be of good construction, sound material and of adequate strength for the purpose for which it is used. The rungs shall be parallel, level and uniformly spaced at 30 cm.

(2) Ladders shall be inspected regularly and repaired immediately. No ladder with defective or missing rungs shall be used. Wooden ladders shall not be painted. For preserving the material from deterioration linseed oil or clear varnish shall be used.

(3) No portable single ladder shall be over 9 m in length while the width between side rails in rung ladder shall in no case be less than 28 cm for ladder up to and including 3 m in length. For longer ladders this width shall be increased at least 20 mm for each additional metre of length. Uniform step spacing shall not exceed 30 cm.

(4) All ladders with spreading bases such as step and trestle ladders shall be equipped with rigid spreads or some other means to prevent their premature opening or closing.

(5) Ladders shall be in a safe position before being climbed. The best angle for a ladder is 75 with the horizontal i.e., the distance of the base of the ladder from the wall, pole structure etc., as the case may be shall be 1/4th its length.

(6) A ladder shall be stored upon brackets and in sheltered locations.

(7) A ladder shall not be placed upon a box, barrel, or other movable insecure object and against a round or angular pillar such as pipe or narrow steel section etc.

(8) Two ladders must not be spliced together as far as possible. When it is inevitable they shall be tied together properly to ensure rigidity. Extra parallel members at the point of splicing may be added to each of the main members of the ladder. Two ladders shall not be spliced together to provide access to a greater height than when a single ladder is used.

(9) Bamboo ladders shall be provided with twisted wire loops enclosing both longitudinal members to prevent them from opening outwards. However, such ladders where longitudinal members are reinforced with metal/wire loops shall not be used when working on electrical circuits.

(10) Metal ladders with insulating rubber shoes shall only be used for working with electrical lines or in places where they may come in contact with such wires.

(11) No worker shall work from a plank placed on the rungs of ladders.

(12) All permanently installed vertical ladders above a height of 3 m shall have manguards provided.

53. OVENS AND DRIERS.-

(1) Application - This rule shall apply to ovens and driers, except those used in laboratories or kitchens of any establishment and those which have a capacity below 325 litres.

(2) Definition:- For the purpose of this rule, "oven or drier" means any enclosed structure, receptacle, compartment or box which is used for baking, drying or otherwise processing of any article or substance at a temperature higher than the ambient temperature of the air in the room or space in which explosive mixture of air and a flammable substance is likely to be evolved within the enclosed structure, receptacle, compartment or box or part thereof on account of the article or substance which is baked, dried or otherwise processed within it.

(3) Separate electrical connection.- Electrical power supplied to every oven or drier shall be by means of a separate circuit provided with an isolation switch.

(4) Design, Construction, examination and testing.-

(a) Every oven or drier shall be properly designed on sound engineering practice and be of good construction, sound materials and adequate strength, free from any patent defects and safe if properly used.

(b) No oven or drier shall be taken into use in a factory for the first time unless a competent person has thoroughly examined all its parts and carried out the tests as are required to establish that the necessary safe systems and controls provided for safety in operation for the processes for which it is to be used and a certificate of such examination and tests signed by that competent person has been obtained and is kept available for inspection.

55. EXAMINATION OF EYE SIGHT OF CERTAIN WORKERS.-

(1) No person shall be employed to operate a crane, locomotive or fork-lift truck, or to give signals to a crane or locomotive operator unless his eyesight and colour vision have been examined and declared fit by a qualified ophthalmologist to work whether with or without the use of corrective glasses.

(2) The eye sight and colour vision of the person employed as referred to in clause 1 shall be examined at least once in every period of 12 months up to the age of 45 years and once in every 6 months beyond that age.

(3) Any fee payable for an examination of a person under this sub-rule shall be paid by the contractor/occupier and shall not be recoverable from that person.

(4) The record of examination or re-examination carried out as required under sub-rule 1 shall be maintained in Form-1.

57. QUALITY OF PERSONAL PROTECTIVE EQUIPMENT.-

All Personal Protective Equipment provided to workers as required under any of the provisions of the Act or the Rules shall conform to the relevant Indian Standards.

58. PROTECTIVE EQUIPMENT.- The Inspector may, having regard to the nature of the hazards involved in work and process being carried out, order the occupier or the manager in writing to supply to the workers exposed to particular hazard any personal protective equipment as may be found necessary.

59. THERMIC FLUID HEATERS.-

(1) All heaters shall be of such construction that coils are removable for periodic cleaning, visual inspection and hydraulic test.

(2) Suitable arrangements shall be made for cooling the furnace effectively in case of power failure.

(3) Before restarting the furnace, it shall be effectively purged.

(4) Velocity of flow of the thermic fluid shall not be allowed to fall below the minimum recommended by the manufacturers while the heater is in operation.

(5) The thermic fluid shall be circulated in a closed circuit formation with an expansion cum deaerator tank. This tank shall be located outside the shed where the heater is installed.

(6) Every heater shall be provided with a Photo-resistor actuated audio-visual alarm to indicate flame failure and automatic burner cut off.

(7) The stack temperature monitor-cum-controller with audio- visual alarm shall be provided so as to warn the operator in case the outlet temperature exceeds the specified minimum.

(8) Where inspection doors are provided on the furnace they shall be interlocked with the burner itself so that they cannot be opened until burner is shut off and furnace is cooled sufficiently.

(9) All heaters shall also be provided with the following safety devices:-

(a) level control in the expansion tank;

(b) temperature control of thermic fluid;

(c) differential pressure switch on the outlet line of the heater tubes; and

(d) temperature control device for the fuel oil supply to the burner.

(10) All evices mentioned in sub-rule (9)shall have interlocking arrangement with burner so that in case of any predetermined limits being crossed the supply of fuel and air to burner shall automatically be cut-off.

(11) All safety interlocks when operated shall be indicated on the control panel of the heater by a suitable audio visual alarm.

(12) Every heater unit shall be provided as a standard accessory an arrangement for sniffing with low pressure steam or nitrogen for putting out the fire.

(13) Electric panel for the heater shall be located near the heater but not so close as to be exposed to spilling or leaking oil.

(14) The heater shall be located in a place segregated from other manufacturing activities.

(15) Explosion vent shall be so installed that release takes place at safe location.

(16) The heater oil shall be subjected to pressure test by competent person once at least in every 12 months. The test pressure shall not be less than twice the operating pressure.

(17) If repairs are carried out to the coil, it shall be tested before taking it into use.

(18) The thermic fluid shall conform to the specifications prescribed by the manufacturer and shall be tested by competent person for suitability at least once in every three months period. Such tests shall include test for acidity, suspended matter, ash contents, viscosity and flash point.

(19) Cleaning of the internal surface of the heater or soot and check up of refractory surface on the inside shall be carried out every month or as often as required depending upon working conditions. The coils shall be removed and surface of the coils cleaned thoroughly once at least in a period of six months. The burner, nozzles, oil filters and pumps shall be cleaned once a week during the period of use.

(20) A separate register containing the following information shall be maintained,-

(a) weekly checks carried out confirming the effectiveness of the interlock;

(b) weekly checks confirming that all accessories are in good state of repairs; and

(c) information regarding fuel oil temperature, pressure, thermic fluid inlet/outlet pressure and temperature, fuel gas temperature, recorded at 4 hourly interval.

(21) The heater when in operation shall always be kept in charge of a trained operator.

60. RECORD KEEPING & ANNUAL REVIEW.-Each factory shall maintain a record of field equipment failures and Failure Mode, Effect & Criticality Analysis in prescribed Forms 7 & 8 respectively. This data and analysis shall be used for preparation of preventive maintenance schedules and prevention of potential hazards. In addition, the factory shall conduct an annual review of unusual occurrences and accidents occurred and submit the report to the Competent Authority.

61. COLOUR CODING OF SERVICE LINES.-

(1) Pipelines for water, air, oil and gases shall be colour coded as per Indian Standard: 2379-1963 & Indian Standard: 5-1978.

(2) Electrical conduit panels shall be colour coded as per Indian Standard: 375-1951 & Indian Standard: 5-1978.

62. HAZARDOUS CHEMICALS.- The occupier of every factory involving hazardous process shall fill the Form 9 entitled `Material Safety Data Sheet' and inform all employees of the factory, and the Competent Authority about the hazards involved. The Competent Authority may, on the basis of Material Safety Data Sheet mentioned above direct the Manager in writing to supply the workers exposed to particular hazard any necessary personal protective equipment conforming to relevant Indian Standards and prescribe the information and manner in which this information is to be passed on to the general public residing in the vicinity of the factory.

Rule 63

CHAPTER V

WELFARE

63. WASHING FACILITIES.-

(1) There shall be provided and maintained, in every factory for the use of employed persons adequate and suitable facilities for washing which shall include soap and nail brushes or other suitable means of cleaning and the facilities shall be conveniently accessible and shall be kept in a clean and orderly condition.

(2) Without prejudice to the generality of the foregoing provisions, the washing facilities shall include-

(a) a trough with taps or jets at intervals of not less than 60 cm.; or

(b) wash basins with taps attached there to;or

(c) taps on stand-pipes; or

(d) showers controlled by taps; or

(e) circular troughs of fountain type:

Provided that the Inspector may having regard to the needs and habits of the workers, fix the proportion in which the aforementioned types of facilities shall be installed.

(3) (a) Every trough and basin shall have a smooth, impervious surface and shall be fitted with a waste-pipe and plug.

(b) The floor or ground under and in the immediate vicinity of every trough, tap, jet, wash-basin, stand-pipe, and shower shall be so laid or finished as to provide a smooth impervious surface and shall be adequately drained.

(4) For persons whose work involves contact with any injurious or noxious substance there shall be at least one tap for every fifteen persons, and for persons whose work does not involve such contact the number of taps shall be as prescribed in the Schedule given below.

SCHEDULE

Number of workers	Number of taps
(1)	**(2)**
Up to 20	1
21 to 35	2
36 to 50	3
51 to 150	4
151 to 200	5

(1)	(2)
Exceeding 200 but not exceeding 500	5 plus one tap for every 50 or fraction of 50
Exceeding 500	11 plus one tap for every 100 or fraction there of 100

(5) If female workers are employed, separate washing facilities shall be provided and so enclosed or screened that the interiors are not visible from any place where persons of other sex work or pass. The entrance to such facilities shall bear conspicuous notice "For Women Only" in the language understood by the majority of the workers and shall also be indicated pictorially.

(6) The water supply to the washing facilities shall be capable of yielding at least 27 litres a day for each person employed in the factory and shall be from a source approved in writing by the Medical Officer if the source of supply is not the same as for drinking water:

Provided that where the Competent Authority is satisfied that such an yield is not practicable he may by certificate in writing permit the supply of a smaller quantity not being less than 5 litres per day for every person employed in the factory.

64. FACILITIES FOR KEEPING CLOTHING.- All classes of factories mentioned in the Schedule to this rule shall provide facilities for keeping clothing not worn during working hours. Such facilities shall include the provision of arrangements approved by the Competent Authority. The Competent Authority shall have powers to add other factories under the Schedule given below:-

SCHEDULE

Chemical works.

Engineering workshops.

Glass works.

Automobile workshops.

Power Plants.

5. FIRST-AID AND FIRST-AID APPLIANCES.- The first-aid oxes or cupboards shall be distinctively marked with a red cross on white background and shall contain the following equipments, namely :-

(1) The manager of the factory shall lay down procedures for First-Aid and medical services

so that injured or ill person receives prompt attention or aid. The person here means, a worker of the factory, contractor's labour or even a visitor.

(2) For factories in which the number of persons employed does not exceed ten, or in the case of factories in which mechanical power is not used & the number of persons does not exceed fifty each first-aid box or cupboard shall contain the following equipments, namely:-

(a) Six small size sterilised dressings.

(b) Three medium size sterilised dressings.

(c) Three large size sterilised dressings.

(d) Three large size sterilised burn dressings.

(e) One (60 ml) bottle of centrimide solution (1%) or a suitable antiseptic solution.

(f) One (60 ml) bottle of mercury chrome solution (2%) in water.

(g) One (30 ml) bottle containing sal-volatile having the dose and mode of administration indicated on the label.

(h) One pair of scissors.

(i) One roll of adhesive plaster (2 cm X 1 m).

(j) Six pieces of sterilised eye pads in separate sealed packets.

(k) A bottle containing 100 tablets (each of 325 mg) of aspirin or any other analgesic.

(l) Polythene wash bottle (1/2 litre, i.e. 500 cc) for washing eyes.

(m) A snake-bite lancet.

(n) One (30 ml) bottle containing potassium permanganate crystals.

(o) One tourniquet.

(p) A supply of suitable splints, and

(q) One copy of First-Aid leaflet issued by the Competent Authority.

(3) For factories in which mechanical power is used and in which the number of persons employed exceeds ten but does not exceed fifty, each first-aid box or cupboard shall contain the following equipments, namely:-

(a) Double of the quantity as indicated in respect of items (a) to (g) of sub-rule (2) above.

(b) Six (15 gms) packets of sterilized cotton wool.

(c) One pair of scissors.

(d) Two rolls of adhesive plaster (2 cm X 1 m).

(e) Eight pieces of sterilized eye pads in separate sealed packets.

(f) One tourniquet.

(g) A supply of suitable splints.

(h) One dozen safety pins.

(i) A bottle containing 100 tablets (each of 325 mg) of aspirin or any other analgesic.

(j) One polythene wash bottle (1/2 litre i.e., 500 cc) for washing eyes.

(k) A snake-bite lancet.

(l) One(30 ml) bottle containing potassium permanganate crystals.

(m) One copy of the first-aid leaflet issued by the Competent Authority.

(4) For factories employing more than fifty persons, each First-Aid box or cupboard shall contain the following equipments, namely:-

(a) Double of the quantity as indicated in respect of items (a) to (e) of sub-rule (2) above.

(b) One (200 ml) bottle of centrimide solution(1%) or a suitable antiseptic solution.

(c) One (200 ml) bottle of mercury chrome (2%) solution in water

(d) One (120 ml) bottle of sal-volatile having the dose and mode of administration indicated on the label.

(e) One pair of scissors.

(f) One roll of adhesive plaster (6 cm X 1 m).

(g) Two rolls of adhesive plaster (2 cm X 1 m).

(h) Twelve pieces of sterilized eye pads in separate sealed packets.

(i) A bottle containing 100 tablets (each of 325 mg) of aspirin or any other analgesic.

(j) One polythene wash bottle (500 cc) for washing eyes.

(k) Twelve roller bandages 10 cm wide.

(l) Twelve roller bandages 5 cm wide.

(m) Six triangular bandages.

(n) One tourniquet.

(o) A supply of suitable splints.

(p) Two packets of safety pins.

(q) Kidney tray.

(r) A snake-bite lancet.

(s) One(30 ml) bottle containing potassium permanganate crystals.

(t) One copy of first-aid leaflet issued by the Competent Authority:

Provided that items (j) to (q) inclusive, need not be included in the standard first-aid box or cupboard where there is a properly equipped ambulance room, or if at least one box containing such items placed and maintained in accordance with the requirements of section 45 is separately provided:

Provided further that the medical officer of the factory may alter the type and quantity of the contents at his discretion. The list of contents shall, however, be pasted inside the first aid box.

(5) In lieu of the dressings required under items (a) and (b), these may be substituted by adhesive wound dressings approved by the Competent Authority and other equipment or medicines that may be considered essential and recommended by the Competent Authority from time to time.

66. NOTICE REGARDING FIRST-AID.- A notice containing the names of the persons working within the precincts of the factory who are trained in first-aid treatment and who are in charge of the first-aid boxes or cupboards shall be posted in every factory at a conspicuous place and near each such box or cupboard. The notice shall also indicate workroom where the said person shall be available. The name of the nearest hospital and its telephone number shall also be mentioned prominently in the said notice.

67. AMBULANCE ROOM.-

(1) Every ambulance room shall be under the charge of at least one whole-time qualified medical practitioner (hereinafter referred to as medical officer) who shall be assisted by at least one qualified nurse or dresser-cum-compounder and one nursing attendant in each shift. The medical officer shall be readily available on call during working hours of the factory:

Provided that where a factory works in more than one shift, the Competent Authority, if it is satisfied that on account of the size of the factory, nature of hazards or frequency of accidents, it is necessary to employ a whole time medical officer for each shift separately, may, order so in writing.

(2) There shall be displayed in the ambulance room a notice giving the name, address and telephone number of the medical practitioner in charge. The name of the nearest hospital and its telephone number shall also be mentioned prominently in the said notice.

(3) No medical officer shall be required or permitted to do any work which is inconsistent with or detrimental to his responsibilities under this rule.

(4) The ambulance room shall be separate from the rest of the factory and shall be used only for the purpose of first-aid treatment and rest. It shall have a floor area of at least 24 sq.m. and smooth, hard and impervious walls and floors, and shall be adequately ventilated and lighted by both natural and artificial means. There shall be attached to it at least one latrine & urinal of sanitary type. An adequate supply of wholesome drinking water shall be laid on and the room shall contain at least the following, namely:-

(a) A glazed sink with hot and cold water always available.

(b) A table with a smooth top at least 180 cm X 105 cm.

(c) Means for sterilizing instruments.

(d) A couch.

(e) Two stretchers.

(f) Two buckets or containers with close fitting lids.

(g) Two rubber hot water bags.

(h) A kettle and spirit stove or other suitable means of boiling water.

(i) Twelve plain wooden splints 900 mm X 100 mm X 6 mm.

(j) Twelve plain wooden splints 350 mm X 75 mm X 6 mm.

(k) Six plain wooden splints 250 mm X 50 mm X 12 mm.

(l) Six woolen blankets.

(m) Three pairs of artery forceps.

(n) One bottle of spiritus ammoniac aromaticus (120 ml)

(o) Smelling salts (60 gm).

(p) Two medium size sponges.

(q) Six hand towels.

(r) Four "Kidney" trays.

(s) Four cakes of toilet, preferably antiseptic soap.

(t) Two glass tumblers and two wine glasses.

(u) Two clinical thermometers.

(v) Two tea spoons.

(w) Two graduated (120 ml) measuring glasses.

(x) Two minim measuring glasses.

(y) One wash bottle (1000 cc) for washing eyes.

(z) One bottle (one litre) carbolic lotion 1 in 20.

(aa) Three chairs.

(bb) One screen.

(cc) One electric hand torch.

(dd) Four first-aid boxes or cupboards stocked to standards prescribed under(c)of rule 59.

(ee) An adequate supply of anti-tetanus toxiod.

(ff) Injections - morphia, pethidrine, atropine, adrenaline, coramine, novocain (6 each).

(gg) Coramine liquid (60 ml).

(hh) Tablets -25 each of antihistaminic, antispasmodic.

(ii) Syringes with needles - 2 cc, 5 cc, 10 cc and 50 cc.

(jj) Three surgical scissors.

(kk) Two needle holders, big and small.

(ll) Suturing needles and materials.

(mm) Three dissecting forceps.

(nn) Three dressing forceps.

(oo) Three scalpels.

(pp) One stethoscope.

(qq) Rubber bandage - pressure bandage.

(rr) Oxygen cylinder with necessary attachments.

(5) The occupier of every factory to which these rules apply shall for the purpose of removing serious cases of accidents or sickness, provide in the premises and maintain in good condition a suitable conveyance unless he has made arrangements for obtaining such a conveyance from a hospital.

(6) The Competent Authority may, by an order in writing exempt any factory from the requirements of this rule, subject to such conditions as it may specify in that order, if a hospital, ambulance room or dispensary is maintained at or within 200 m. of the precincts of the factory and such arrangements are made as to ensure the immediate treatment of all injuries sustained by workers within the factory and for providing rest to the workers so injured.

Explanation:- For the purpose of this rule, "qualified medical practitioner" means a person holding a qualification granted by an authority specified in the schedule to the Indian Medical Degrees Act, 1916 (7 of 1916), or in the schedules to the Indian Medical Council Act, 1956 (102 of 1956).

68. CANTEENS.-

(1) The occupier of every factory where in more than two hundred and fifty workers are ordinarily employed shall provide in or near factory an adequate canteen according to standard prescribed in these rules.

(2) The canteen building shall be situated not less than 15 meters from any boiler house, coal stacks, ash dumps and any other source of dust, smoke or obnoxious fumes:

Provided that the Competent Authority may in any particular factory relax the provisions of this sub-rule to such an extent as may be reasonable in the circumstances and may require measures to be adopted to secure the essential purpose of this sub-rule.

(3) The canteen building shall be constructed in accordance with the plans and shall accommodate at least a dining hall, kitchen, store room, pantry and washing places separately for workers and for utensils.

(4) In a canteen the floor and inside walls up to a height of 1.2 metres from the floor shall be made of smooth and impervious material; the remaining portion of the inside walls shall be made smooth by cement plaster or in any other manner.

(5) The doors and windows of a canteen building shall be of flyproof construction and shall allow adequate ventilation.

(6) The canteen shall be sufficiently lighted at all times when any persons have access to it.

(7) (a) In every canteen -

(i) all inside walls of rooms and all ceilings and passages and staircases shall be limewashed or colourwashed at least once in each year or painted once in three years dating from the period when last limewashed, colourwashed or painted, as the case may be;

(ii) all wood work shall be varnished or painted once in three years dating from the period when last varnished or painted; and

(iii) all internal structural iron or steel work shall be varnished or painted once in three years dating from the period when last varnished or painted:

Provided that inside walls of the kitchen shall be limewashed once every four months.

(b) Records of dates on which lime washing, colourwashing, varnishing or painting is carried out shall be maintained in the prescribed register (Form 2).

(8) The precincts of the canteen shall be maintained in a clean and sanitary condition. Waste water shall be carried away in suitable covered drains and shall not be allowed to accumulate so as to cause a nuisance. Suitable arrangements shall be made for the collection and disposal of garbage.

69. DINING HALL.-

(1) The dining hall shall accommodate at a time at least 30 per cent of the workers working at a time and shall be provided with adequate numbers of tables and chairs or benches:

Provided that, in any particular factory or in any particular class of factories, the Competent Authority may by a notification in this behalf alter the percentage of workers to be accommodated.

(2) The floor area of the dining hall, excluding the area occupied by the service counter and any furniture except tables and chairs, shall be not less than 1 sq.m per diner to be accommodated as prescribed in sub-rule (1).

(3) A portion of the dining hall and service counter shall be partitioned off and reserved for women workers in proportion to their number. Washing places for women shall be separate and screened to secure privacy.

70. EQUIPMENT.-

(1) There shall be provided and maintained sufficient utensils, crockery, cutlery, furniture and any other equipment necessary for the efficient running of the canteen. Suitable clean clothes for the employees serving in the canteen shall also be provided and maintained.

(2) The furniture, utensils and other equipment shall be maintained in a clean and hygienic condition. A service counter, if provided, shall have a top of smooth and impervious material. Suitable facilities including an adequate supply of hot water shall be provided for the cleaning of utensils and equipment.

71. ANNUAL MEDICAL EXAMINATION.-

(1) Annual medical examination for fitness of each member of the canteen staff who handles foodstuffs shall be carried out by the factory medical officer or the Certifying Surgeon, which should include the following, namely:-

(a) routine blood examination;

(b) routine and bacteriological testing, of faeces and urine for germs of dysentery and typhoid fever; and

(c) any other examination including chest X-ray that may be considered necessary by the factory medical officer or the Certifying Surgeon.

(2) Any person who in the opinion of the factory medical officer or the certifying surgeon is unsuitable for employment on account of possible risk to the health of others, shall not be employed as canteen staff.

Rule 72

72. SHELTERS, REST ROOMS AND LUNCH ROOMS.-

(1) The shelters, or rest rooms and lunch rooms shall conform to the following standards, namely:-

(a) the building shall be soundly constructed and all the walls and roof shall be of suitable heat resisting materials and shall be water-proof. The floor and walls to a height of 90 cm. shall be so laid or finished as to provide a smooth, hard impervious surface;

(b) the height of every room in the building shall be not less than 3.70 m from floor level to the lowest part of the roof and there shall be at least 1.10 sq.m of floor area for every person employed:

Provided that (i) workers who habitually go home for their meals during the rest periods may be excluded in calculating the number of workers to be accommodated, and (ii) in the case of factories in existence at the date of commencement of the Act, where it is impracticable owing to lack of space to provide 1.10 sq.m. of floor area for each person, such reduced floor area per person shall be provided as may be approved in writing by the Competent Authority;

(c) effective and suitable provision shall be made in every room for securing and maintaining adequate ventilation by the circulation of fresh air and there shall also be provided and maintained sufficient and suitable natural or artificial lighting;

(d) every room shall be adequately furnished with chairs or benches with back-rest; and

(e) sweepers shall be employed whose primary duty it is to keep the rooms, building and precincts thereof in a clean and tidy condition.

(f) suitable provision shall be made in every room for supply of drinking water and facilities for washing.

(2) The lunch rooms shall -

(a) comply with the requirements laid down in clauses (a) to (f) of sub-rule (1), and

(b) be provided with adequate number of tables with impervious tops for the use of workers for taking food:

Provided that the Competent Authority may exempt any factory from the provisions of this rule subject to the provisions being complied by some other means.

73. CRECHES.-

(1) The creche shall be conveniently accessible to the mothers of the children accommodated therein and so far as is reasonably practicable it shall not be situated in close proximity to any part of the factory where obnoxious fumes, dust or odours are given off or in which excessively noisy processes are carried on.

(2) The building in which the creche is situated shall be soundly constructed and all the walls and roof shall be of suitable heat resisting materials and shall be water-proof. The floor and internal walls of the creche shall be so laid or finished as to provide a smooth impervious surface.

(3) The height of the rooms in the building shall be not less than 3.70 m from the floor to the lowest part of the roof and there shall be not less than 2.00 sq.m of floor area for each child to be accommodated.

(4) Effective and suitable provision shall be made in every part of the creche for securing and maintaining adequate ventilation by the circulation of fresh air.

(5) The creche shall be adequately furnished and equipped and in particular there shall be one suitable cot or cradle with the necessary bedding for each child (provided that for children over two years of age it will be sufficient if suitable bedding is made available), at least one chair or equivalent seating accommodation for the use of each mother while she is feeding or attending to her child, and a sufficient supply of suitable toys for the older children.

(6) A suitably fenced and shady open air playground shall be provided for the older children:

Provided that the Competent Authority may by order in writing exempt any factory from compliance with this sub-rule if he is satisfied that there is not sufficient space available for the provision of such a play-ground.

74. WASHROOM.-

(1) There shall be in or adjoining the creche a suitable washroom for the washing of the children and their clothing. The washroom shall conform to the following standards, namely:-

(a) the floor and internal walls of the room to a height of 90 cm. shall be so laid or furnished as to provide a smooth impervious surface. The room shall be adequately lighted and ventilated and the floor shall be effectively drained and maintained in a clean and tidy condition;

(b) there shall be at least one basin or similar vessel for every four children accommodated in a creche at any one time together with a supply of water provided, if practicable, through taps from a source approved by the Health Officer. Such source shall be capable of yielding for each child a supply of at least 23 litres of water a day; and

(c) an adequate supply of clean clothes, soap and clean towels shall be made available for each child while it is in the creche.

(b) there shall be at least one basin or similar vessel for every four children accommodated in a creche at any one time together with a supply of water provided, if practicable, through taps from a source approved by the Health Officer. Such source shall be capable of yielding for each child a supply of at least 23 litres of water a day; and

(c) an adequate supply of clean clothes, soap and clean towels shall be made available for each child while it is in the creche.

(2) Adjoining the washroom referred to in sub-rule (1), a latrine shall be provided for the sole use of the children in the creche. The design of latrine and the scale of accommodation to be provided shall either be approved by the Public Health authorities or, where there is no such Public Health authority, by the Competent Authority.

75. SUPPLY OF MILK AND REFRESHMENT.-At least a quarter litre of clean pure milk shall be available for each child on every day if accommodated in the creche and the mother of such a child shall be allowed in the course of her daily work, four intervals of at least 15 minutes to feed the child. For children above two years of age there shall be provided in addition an adequate supply of wholesome refreshment.

76. CRECHE STAFF.- For each creche there shall be appointed a woman in-charge and an adequate number of female attendants to help the woman in-charge. No woman in-charge shall be appointed under this rule unless she possesses the qualifications prescribed for a midwife or produces a certificate that she has undergone training for a period of not less than 18 months in a hospital, maternity home or nursing home approved in this behalf by the Competent Authority or produces a certificate that she has received training for a pre-primary teacher in an institution approved by the State Government. The creche staff shall be provided with suitable clean clothes for use while on duty in the creche.

77. EXEMPTION FROM THE PROVISION OF CRECHE.-

(1) In factories where the number of married women or widows employed does not exceed 15 or where the factory works for less than 180 days in a calendar year, or where number of children kept in the creche was less than 5 in the preceding year, the Competent Authority may exempt such factories from the provisions of section 48 and the rules 73 to 76 made thereunder, if he is satisfied that alternate arrangements as stipulated under subrule (2) are provided by the factory.

(2) (a) The alternate arrangements required in sub-rule (1) shall include a creche building which has a minimum accommodation at the rate of 1.90 sq. m. per child and constructed in accordance with the plans approved by the Competent Authority.

(b) The creche building shall have -

(i) a suitable washroom for washing of the children and their clothing;

(ii) adequate supply of soap and clean clothes and towels; and

(iii) adequate number of female attendants who are provided with suitable clean clothes for use while on duty to look after the children in the creche.

(3) The exemption granted under sub-rule (1) may at any time be withdrawn by the Competent Authority if it finds after such enquiry as he may deem fit, that the factory has committed a breach of this rule.

Rules -78

78. WELFARE OFFICER.-

(1) Number of Welfare Officers.-

(a) The occupier of every factory employing between five hundred(500) and two thousand (2000) workers shall appoint at least one Welfare Officer, and where the number of workers exceeds 2000, there shall be an additional Welfare Officer for every additional 2000 workers or fraction thereof over 500. In a factory where both men and women workers are employed, the number of women Welfare Officers to be appointed shall be in proportion to the women workers employed provided that where the number of women employed is more than 100 and the total number of workers does not exceed 2500 an additional woman Welfare Officer shall be appointed.

(b) Where there are more than one Welfare Officer appointed, one of them shall be called the Chief Welfare Officer and the others Assistant Welfare Officers.

(2) Qualifications.- A person shall not be eligible for appointment as a Welfare Officer, unless he -

(a) possesses a degree of a University recognised by the Government in this behalf;

(b) has obtained a degree or diploma in social science with specialization in industrial relations from any institution recognised by the Government in this behalf; and

(c) has adequate knowledge of the language spoken by the majority of the workers in the factory to which he is to be attached:

Provided that the Competent Authority, may by notification grant exemption from the provisions of clause (b) in suitable cases till such time as qualified persons are available:

Provided further that, in the case of a person who is acting as a Welfare Officer at the commencement of these rules, the Competent Authority may, subject to such conditions as it may specify, relax all or any of the aforesaid qualifications.

(3) Appointment of Welfare Officers.-

(a) The appointment of welfare officers shall be done as per the extant government procedures.

(b) The appointment when made shall be notified by the occupier to the Competent Authority or such authority as the Competent Authority may specify for the purpose, giving full details of the qualifications, etc. of the officer appointed and the conditions of his service.

(4) Conditions of service of Welfare Officers.-

(a) A Welfare Officer shall be given appropriate status corresponding to the status of the other executive heads of the factory and he shall be started on a suitable scale of pay equivalent to that of group B officer, the minimum of which shall not be less than Rs.2000/- per month.

(b) The conditions of service of a Welfare Officer shall be the same as of other members of the staff of corresponding status in the factory.

(5) Duties of Welfare Officer.- The duties of a Welfare Officer shall be -

(a) to establish contacts and hold consultations with a view to maintaining harmonious relations between the factory management and workers;

(b) to bring to the notice of the factory management the grievances of workers, individual as well as collective, with a view of securing their expeditious redress and to act as a liaison officer between the management and labour;

(c) to study and understand the point of view of labour in order to help the factory management to shape and formulate labour policies and to interpret these policies to the workers in a language they can understand;

(d) to watch industrial relations with a view of using his influence in the event of a dispute between the factory management and workers and to help to bring about a settlement by persuasive effort;

(e) to advise on fulfillment by the management and the concerned departments of the factory of obligations, statutory or otherwise, concerning regulation of working hours, maternity benefit, medical care, compensation for injuries and sickness and other welfare and social benefit measures;

(f) to advise and assist the management in the fulfillment of its obligations, statutory or otherwise, concerning prevention of personal injuries and maintaining a safe work environment, in such factories where a Safety Officer is not required to be appointed under the enabling provisions under section 40 B;

(g) to promote relations between the concerned departments of the factory and workers which will bring about productive efficiency as well as amelioration in the working conditions and to help workers to adjust and adapt themselves to these working environments;

(h) to encourage the formation of Works and Joint Production Committees, Co-operative Societies and Welfare Committee, and to supervise their work;

(i) to encourage provision of amenities such as canteens, shelters for rest, creches, adequate latrine facilities, drinking water, sickness and benevolent scheme payments, pension and superannuation funds, gratuity payments, granting of loans and legal advice to workers;

(j) to help the factory management in regulating the grant of leave with wages and explain to the workers the provisions relating to leave with wages and other leave privileges and to guide the workers in the matter of submission of application for grant of leave for regulating authorised absence;

(k) to advise on provision of welfare facilities, such as housing facilities, foodstuffs, social and recreational facilities, sanitation, advice on individual personnel problems and education of children;

(l) to advise the factory management on questions relating to training of new starters, apprentices, workers on transfer and promotion, instructors and supervisors, supervision and control of notice board and information bulletins to further education of workers and to encourage their attendance at technical institutes; and

(m) to suggest measures which will serve to raise the standard of living of workers and in general promote their well- being.

(6) Welfare Officers not to deal with disciplinary cases or appear on behalf of the management against workers.- No Welfare Officer shall deal with any disciplinary cases against workers or appear before a conciliation officer in a court or tribunal on behalf of the factory management against a worker or workers.

(7) Powers of exemption.- The Competent Authority may, by notification exempt any factory or class or description of factories from the operation of all or any of the provisions of this chapter, subject to compliance with such alternative arrangements as may be approved by such Competent Authority.

Rule 88 (Sch. -X)

SCHEDULE X

FINISHING BY ABRASIVES PROPELLED BY COMPRESSED AIR/STEAM

Cleaning or Smoothening, Roughening, etc., of Articles, by a Jet of Sand, Metal Shot, or Grit, or other Abrasive Propelled by a Blast of Compressed Air or Steam:

1. Definition.- For the purposes of this Schedule

   (a) "blasting" means cleaning, smoothening, roughening, or removing of any part of the surface of any article by the use as an abrasive of a jet of sand, metal shot, or grit or other material, propelled by a blast of compressed air or steam;

   (b) "blasting enclosure" means a chamber, barrel, cabinet or any other enclosure designed for the performance of blasting therein;

   (c) "blasting chamber" means a blasting enclosure in which any person may enter at any time in connection with any work or otherwise; and

   (d) "cleaning of castings" where done as an incidental or supplemental process in connection with the making of metal castings, means the freeing of the casting from adherent sand or other substance and includes the removal of cores and the general smoothening of a casting, but does not include the free treatment.

2. Prohibition of sand blasting.- Sand or any other substance containing free silica shall not be introduced as an abrasive into any blasting apparatus and shall not be used for blasting:

   Provided further that no woman shall be employed or permitted to work at any operation of sand blasting.

3. Precautions in connection with blasting operations.-

   (a) Blasting shall not be done except in a blasting enclosure and no work other than blasting and any work immediately incidental thereto and clearing and repairing of the enclosure including the plant and appliances situated therein, shall be performed in a blasting enclosure. Every door, aperture and joint of blasting enclosure, shall be kept closed and air-tight while blasting is being done therein.

   (b) Blasting enclosure shall always be maintained in good condition and effective measures shall be taken to prevent dust escaping from such enclosure, and from apparatus connected therewith, into the air of any room.

   (c) There shall be provided and maintained for and in connection with every blasting enclosure, efficient apparatus for separating, so far as practicable, abrasive which has been used for blasting and which is to be used again as an abrasive, from dust or particles of other materials arising from blasting; and no such abrasive shall be introduced into any blasting apparatus and used for blasting until it has been so separated:

Provided that this clause shall not apply, except in the case of blasting chambers, to blasting enclosures constructed or installed before the coming into force of this schedule, if the Competent Authority is of opinion that it is not reasonably practicable to provide such separating apparatus.

(d) There shall be provided and maintained in connection with every blasting enclosure efficient ventilating plant to extract, by exhaust draught effected by mechanical means, dust produced in the enclosure. The dust extracted and removed shall be disposed of by such method and in such manner that it shall not escape into the air of any room; and every other filtering or settling device situated in a room in which persons are employed, other than persons attending to such bag or other filtering or settling device, shall be completely separated from the general air of that room in an enclosure ventilated to the open air.

(e) The ventilating plant provided for the purpose of sub-paragraph (d) shall be kept in continuous operation whenever the blasting enclosure is in use whether or not blasting is actually taking place therein, and in the case of a blasting chamber, it shall be in operation even when any person is inside the chamber for the purpose of cleaning.

4. Inspection and examination.-

(a) Every blasting enclosure shall be specially inspected by a competent person at least once in every week in which it is used for blasting enclosure, the apparatus connected therewith and the ventilating plant shall be thoroughly examined and in the case of ventilating plant, tested by a competent person at least once in every month.

(b) Particulars of the result of every such inspection, examination or test shall forthwith be entered in a register which shall be kept in Form 10 and shall be available for inspection by any workman employed in or in connection with blasting in the factory. Any defect found on any such inspection, examination or test this paragraph applies shall be deemed for the purposes of this Paragraph to have been constructed, reconstructed or converted for use as such after the making of this Schedule if the construction, reconstruction or conversion thereof was begun after the making of this Schedule.

5. Provision of protective helmets, gauntlets and overalls.-

(a) There shall be provided and maintained for the use of all persons who are employed in a blasting chamber, whether in blasting or in any work connected therewith or in cleaning such a chamber, protective helmets of a type approved by a certificate of the Competent Authority; and every such person shall wear the helmet provided for this use whilst he is in the chamber and shall not remove it until he is outside the chamber.

(b) Each protective helmet shall carry a distinguishing mark indicating the person by whom it is intended to be used and no person shall be allowed or required to wear a helmet not carrying his mark or a helmet which has been worn by another person and has not since been thoroughly disinfected.

(c) Each protective helmet when in use shall be supplied with clean and not unreasonably cold air at a rate of not less than 170 litres per minute.

(d) Suitable gauntlets and overalls shall be provided for the use of all persons while performing blasting or assisting at blasting, and every such person shall while so engaged, wear the gauntlet and overall provided.

6. Precautions in connection with cleaning and other work -

(a) Where any person is engaged upon cleaning of any blasting apparatus or blasting enclosure or of any apparatus or ventilating plant connected therewith or the surroundings thereof or upon any other work in connection with any blasting apparatus or blasting enclosure or with any apparatus or ventilating plant connected therewith so that he is exposed to the risk of inhaling dust which has arisen from blasting, all practicable measures shall be taken to prevent such inhalation.

(b) In connection with any cleaning operation referred to in paragraph 5, and with the removal of dust from filtering or settling devices all practicable measures shall be taken to dispose of the dust in such a manner that it does not enter the air of any room. Vacuum cleaners shall be provided and used wherever practicable for such cleaning operations.

7. Storage accommodation for protective wear.- Adequate and suitable storage accommodation for the helmets, gauntlets and overalls required to be provided by paragraph 5 shall be proved outside and conveniently near to every blasting enclosure and such accommodation shall be kept clean. Helmets and overalls when not in actual use shall be kept in this accommodation.

8. Maintenance and cleaning of protective wear.- All helmets, gauntlets, overalls and other protective devices or clothings provided and worn for the purposes of this schedule, shall be kept in good condition and so far as is reasonably practicable shall be cleaned on every weekday in which they are used. Where dust arising from the cleaning of such protective clothing or devices is likely to be inhaled, all practicable measures shall be taken to prevent such inhalation. Vacuum cleaners shall, wherever practicable, be used for removing dust from such clothing and compressed air shall not be used for removing dust from any clothing.

9. Maintenance of vacuum cleaning plant.- Vacuum cleaning plant used for the purpose of this schedule shall be properly maintained.

10. Medical facilities and records of examinations and tests.-

(a) The occupier of every factory to which the Schedule applies, shall

(i) employ a qualified medical practitioner for medical surveillance of the workers employed therein, and whose

employment shall be subject to the approval of the Competent Authority; and

(ii) provide to the said medical practitioner all the necessary facilities for the purpose referred to in clause (i) above.

(b) The record of medical examinations and appropriate tests carried out by the said medical practitioner shall be maintained in a separate register approved by the Competent Authority which shall be kept readily available for inspection by the Inspector.

11. Medical examination by Certifying Surgeon.-

(a) Every worker employed in any of the processes to which this schedule applies shall be examined by a Certifying Surgeon within 15 days of his first employment. Such examination shall include pulmonary function test and chest X-ray. No worker shall be allowed to work after 15 days of his first employment in the factory unless certified fit for such employment by the Certifying Surgeon.

(b) Every worker employed in the said processes shall be re-examined by a Certifying Surgeon at least once in every 12 calendar months and such re-examination shall, wherever the Certifying Surgeon considers appropriate, include pulmonary function test and chest X-ray once in every three years.

(c) The Certifying Surgeon after examining a worker, shall issue a Certificate of Fitness in Form 1 .The record of examination and re-examinations carried out shall be entered in the Certificate and the Certificate shall be kept in the custody of the manager of the factory. The record of each examination carried under sub-paragraphs (a) and (b), including the nature and the results of the tests, shall also be entered by the Certifying Surgeon in a health register in Form 1A.

(d) The Certificate of Fitness and the health register shall be kept readily available for inspection by the Competent Authority.

(e) If at any time the Certifying Surgeon is of the opinion that a worker is no longer fit for employment in the said processes on the ground that continuance therein would involve special danger to the health of the worker, he shall make a record of his findings in the said certificate and the health register. The entry of his findings in those documents shall also include the period for which he considers that the said person is unfit for work in the said processes. The person so suspended from the process shall be provided with alternate placement facilities unless he is fully incapacitated in the opinion of the Certifying Surgeon, in which case the person affected shall be suitably rehabilitated.

(f) No person who has been found unfit to work in the said processes as said in sub-paragraph (e) above shall be reemployed or permitted to work unless the Certifying Surgeon, after further examination, again certifies him fit for employment in those processes.

Rule 88(Sch. X)

12. Power to exempt or relax.-

(a) If the Competent Authority is satisfied that in any factory or any class of factories, the use of sand or other substance containing free silica as an abrasive in blasting is necessary for a particular manufacture or process (other than the process incidental or supplemental to making of metal castings) and that the manufacture or process cannot be carried on without the use of such abrasive or that owing to the special conditions or special method of work or otherwise any requirement of this schedule can be suspended either temporarily or permanently, or can be relaxed without endangering the health of the persons employed or that application of any of such requirements is for any reason impracticable or inappropriate, it may, with the previous sanction of the Central Government, by an order in writing exempt the said factory or class of factories from such provisions of this schedule, to such an extent and subject to such conditions and for such period as may be specified in the said order.

(b) Where an exemption has been granted under sub-paragraph (a), a copy of the order shall be displayed at a notice board at a prominent place at the main entrance or entrances to the factory and also at the place where the blasting is carried on.

89. NOTIFICATION OF ACCIDENTS.-

(1) Where any accident specified in sub-para (a) of para 1 of the Schedule to this rule or any occurrences specified in para 2 of the said schedule takes place in a factory, the Manager of the factory, in which the accident occurred, shall within four hours of the happening of such accident or occurrence, send notice there of in Form 11 by telephone, telex, telegram or special messenger to the inspector and the Competent Authority and when the accident is fatal or it is of such a nature that it is likely to prove fatal, notice as aforesaid shall also be sent to-

(a) the District Magistrate or sub Divisional Magistrate;

(b) the Officer In Charge of the nearest Police Station;

(c) the Electrical Inspector (In case of electrical accident); and

(d) the relatives of the injured or deceased person.

(2) The notice so given shall be confirmed by the Manager of the factory to the above mentioned authorities within 12 hours of the accident/occurrence by sending a written report in Form 12 and in case of electrical accidents in Form 13 to the Electrical Inspector.

(3) When any accident of a minor nature specified in sub-para (b) of the said para 1 of the schedule takes place in a factory, the Manager of the factory shall within 24 hours after the expiry of the period specified in the said sub-para (b) , send notice thereof in the Form 11 to the medical officer; & the Competent Authority.

Rule 89

(4) If, in case of an accident, the injured person subsequently dies due to such accident, information of his death whenever known shall be sent by the Manager of the factory by telephone, telex, telegram or special messenger within 24 hours of the occurrence to-

(a) the District Magistrate or Sub-Divisional Magistrate;

(b) the Officer In Charge of the nearest Police Station;

(c) the Competent Authority; and

(d) the Electrical Inspector (In case of Electrical accidents).

EXPLANATION: Accident of serious nature means an accident which results in either or all of the following, namely:-

(i) Immediate loss of any part of the body or any limb or part there of;

(ii) Crushed or Serious injury to any part of the body due to which loss of the same is obvious or any injury which is likely to prove fatal;

(iii) Unconsciousness;

(iv) Severe burns or scalds due to chemicals, steam or any other cause; and

(v) Any injury to man/animal due to electrical energy.

(5) The Manager of the factory shall lay down the procedures for investigation of all accidents and occupational illnesses reported as per Forms 12 and 14.

SCHEDULE

1. (a) Accidents which cause death to any person or are of a serious nature.

(b) Accidents which cause such bodily injury as prevents or will probably prevent the person injured from working for a period of 48 hours or more immediately following the accident.

2. The following classes of occurrences, whether or not they are attended by personal injury or disablement:-

(a) Bursting of a vessel used for containing steam under pressure greater than atmospheric pressure, other than plant which comes within the scope of the Indian Boilers Act.

(b) Collapse or failure of a crane, derrick, winch, hoist or other appliances used in raising or lowering persons or goods or any part thereof, or the overturning of a crane.

(c) Explosion, fire, bursting out, leakage or escape of any molten metal, or hot liquor or gas causing bodily injury to any person or damage to any room or place in which persons are employed.

(d) Explosion of a receiver or container used for the storage at a pressure greater than atmospheric pressure of any gas or gases(including air) or a liquid or solid resulting from the compression of gas.

(e) Collapse or subsidence of any floor, gallery, roof, bridge, tunnel, chimney, wall or building, forming part of a factory or within the compound or curtilage of factory.

3. Leakage or release of effluents to the outside environment above those specified by the Department of Environment and Air and Water Pollution Control Boards.

90. NOTICE OF POISONING OR DISEASE. - A notice in Form 14 shall be sent with in four hours to the Competent Authority by the manager of the factory in which there occurs a case of poisoning or disease due to items mentioned in the Third Schedule of section 45 of the Factories Act, 1948(63 of 1948).

98. REGISTER OF ACCIDENTS AND DANGEROUS OCCURRENCES. - The manager of every factory shall maintain a register of all accidents and dangerous occurrences which occur in the factory. All these shall be investigated thoroughly and causes established. Any deficiency found in respect of systems & practices shall be corrected & report thereof shall be made available to the inspector & Competent Authority.

99. MAINTENANCE OF INSPECTION BOOK.- The manager of every factory shall maintain a register of inspection reports and shall produce it when so required by the Competent Authority or Certifying Surgeon.

101. COMMUNICATION FACILITIES.- The Manager shall establish effective communication facilities so that in the normal as well as in emergency conditions the Shift-in-charge is able to contact without delay the factory manager, control room, security, fire station, dispensary, workers and the outside agencies such as police, fire brigade, hospital, district magistrate, civil defence post.

102. SPECIAL POWERS OF THE COMPETENT AUTHORITY.- The Competent Authority shall have powers to notify specific safety procedures, guides, manuals to enhance safety & health in any factory.

Form - 1

CERTIFICATE OF FITNESS TO WORK ON SPECIFIED JOB

(See rules 7(3), 32 Sch. III, 33, 55, 88)

1. Name of the Factory:

2. Name of the Person

   (In Block letters) and Employee No.

   Sex: M/F Date of birth:

3. Educational Qualifications:

4. Previous Experience :

   Field of Experience :

5. Details of Medical Examination : Date

   .1. Height..... .cm. .2. Weight..... ...kg.

   .3. Hearing (Auditory Examination): Normal/Not normal*

   .4. Eyesight : Normal/Normal with spects/Not normal*

   : Colour blindness : Yes/No

   .5. General Laboratory Investigations (Blood, urine, excreta, sputum etc.): Normal/Not normal*

   .6. Pulmonary function & Chest Examination : Normal/Not normal*

   (including X ray examination)

   .7. Nervous system: Normal/Not normal*

   .8. Overall health assessment:

* Specify the condition & remedial measures.

(2)

6. I certify that I have personally examined Dr./Shri/Smt./Kum.. …..... . and seen his/her other medical reports and my recommendations are recorded below.

7.	Work with/in/at	Recommendations
.1.	Chemicals and hazardous materials including prescribed materials	Fit/Unfit
.2.	Machines	
	.2.1 Cranes	Fit/Unfit
	.2.2 Locomotives	Fit/Unfit
	.2.3 Fork lifts	Fit/Unfit
.3.	Blasting by compressed air/steam for cleaning of articles.	Fit/Unfit
.4.	Radioactive Area	Fit/Unfit
.5.	Any other work specified by the Competent Authority...	Fit/Unfit

Signature of Certifying Surgeon

Name ……...

Date: Reg.No. ..

Note: Strike out whichever is not applicable.

Medical Examination Record

S.No.	**Date of**		**Remarks**
-----	**----------**		**----------**
	Last Examination	**Next Examination**	

Form - 1A

HEALTH REGISTER OF WORKERS EMPLOYED ON SPECIFIED JOBS

(See rules 7(4), 88)

Name of the Factory:

S.No.	Name	Age Yrs.	Nature of job	Date of			If suspended from work period of suspension	Date of resumption of duty	Signature with date of certifying surgeon
				Medical Exam.	Employment in present work	Learning or transfer to other work			

N.B. Against column Nature of job please write the applicable number as given below:

(1) Working with Chemicals & Hazardous materials.

(2) Working with-2.1 rotating machines; 2.2 lifting machines; 2.3 material handling equipment.

(3) Working with -3.1 electrical work-low & medium voltage; 3.2 electrical work-high voltage.

(4) At height.

(5) At blasting by compressed air/steam for cleaning of articles.

(6) Radioactive area.

Form - 3

REPORT OF EXAMINATION OF HOISTS & LIFTS

(See Rule 34)

1. Name of the Factory :

2.1 Type of hoist or lift and identification No. or description :

2.2 Date of construction/reconstruction :

3. Are all parts of the hoist or lift, of good mechanical construction, sound material and adequate strength (so far as ascertainable) :

4. Are the following parts of the hoist or lift properly maintained and in good working order? If not, state what defects have been found. :

.1. Enclosure of hoistway or liftway :

.2. Landing gates and cage gate(s) :

.3. Interlocks and the landing gates and cage gate(s) :

.4. Other gate fastenings :

.5. Cage and platform and fittings, guides, buffers, interior of the hoistway or liftway. :

.6. Overrunning devices :

.7. Suspension ropes or chain and their attachments. :

.8. Safety gear i.e. arrangement for preventing fall of platform or cage brakes. :

.9. Brakes :

.10. Worm or spur gearing :

.11. Other electrical equipment :

.12. Other parts :

5. What parts(if any) were inaccessible :

6. Repairs, renewals :

7. Maximum safe work load :

(2)

8. Is any of the lift made as per requirements of fire lift & if so its location & identification No. :

9. Other particulars :

I/we certify that on (date) ... . I/we thoroughly examined this hoist or lift and that the above is a correct report of the result.

Signature:

Date: **Name :**

Form - 4

REPORT OF EXAMINATION OF LIFTING MACHINES

Ropes & Lifting Tackles

(See rule 35(4))

1.	Name of the Factory	:
2.	Distinguishing number or mark (if any) and description sufficient to identify the lifting machine, chains, rope or lifting tackle.	:
3.	Date when lifting machine chain, rope or lifting tackle was first used in the factory.	:
4.	Date and number of certificate of last examination made under section 29(1)a (iii) and by whom it was carried out.	:
5.	Date and number of certificate relating to any test & examination made, under rules 35.1 & 35.15 together with the name & address of the certifying person.	:
6.	Date & certificate of annealing or other heat treatment of the chain and lifting tackle carried out as per rule 35.7 and by whom it was carried out.	:
7.	Particulars of any defect found at any such examination or after annealing and affecting the safe working load and steps taken to remedy such defect.	:

I/We certify that on .....…….... I/We thoroughly examined the above mentioned lifting machine/chain rope/lifting tackle and that the above is a correct report of the result.

Signature:

Date: **Name:**

Form - 7

ITEM FIELD PERFORMANCE REPORT

(See rule 60)

1.	Name of the Factory		:
2.	Item		:
	.1	Identification	:
	.2	Manufacturer	:
	.3	Number of items of the type	:
	.4	Date of manufacture	:
	.5	Date of modification/reconditioning	:
	.6	Date first placed in use	:
	.7	Cumulative operating time since above	:
	.8	Date & place where used after 2.5	:
	.9	Date/ cumulative operating time since above	:
	.10	Cumulative time-Non use (Storage/Maintenance)	:
4.	Operating environment		:
	.1	Temperature Range	:
	.2	Relative humidity range	:
	.3	Nature of atmosphere A.C./Clean/Dusty/Corrosive/...	:
	.4	Vibration level	:
5.	Mode of operation Continuous/Intermittent/Standby/...		:

6.	Item failure information		:
	.1	Symptoms of failure	:
	.2	Failure detected during Operation / Periodic check / Preventive maintenance	:
	.3	Functions affected by failure	:
	.4	Failure cause	:
		Inherent/Misuse/ Maintenance induced/	:
		External to item/ Secondary/Unknown	:
7.	Item failure analysis and correction		:
	.1	List of failed parts	:
	.2	List of replaced parts	:
	.3	Adjustments made	:
8.	Total active downtime		:
9.	Total downtime		:
10.	Any other information		:

Signature:

Date:

Name :

Designation:

Form - 8

FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

[F M E C A]

(See rule 60)

Name of the Factory:

System : ...

Sub System: ... Page _____of _____

Code No. : ...

No.	Part No.	Part		Failure Mode		Detection Method	Effect on System Plant	Remarks
		Name	Function	No.	Description			
1	2	3		4		5	6	7

Prepared By ... Checked By ... Approved By ...

Form - 11

PRELIMINARY REPORT OF ACCIDENT OR DANGEROUS OCCURRENCES

(See rules 89(1), 89(3))

1.	Name of the Factory	:	
2.	Name of injured person & address	:	
	Official	:	
	Residential	:	
3.	a) Sex : M/F	b)	Age:
	c) Designation :	d)	Pay:
4.	Date and hours of accident/dangerous occurrence	:	
5.	Cause & Nature of accident/dangerous occurrence	:	

Date: **Manager** **Signature:**

Place: **Name :**

1. District/Sub Divisional Magistrate
2. Officer in charge of nearest police station
3. Inspector concerned.
4. Competent Authority.
5. Relatives of the injured/deceased.
6. Electrical Inspector.[In case of Electrical Accidents.]

In case of fatal accident or if it is of such a nature that it is likely to be

Form -12

NOTICE OF ACCIDENTS OR DANGEROUS OCCURRENCE

(See rules 89(2), 89(5))

1.	Name of the Factory	:		
2.	Branch or section & exact place where the accident or dangerous occurrence happened	:		
3.	Name of injured person	:		
	Address Official	:		
	Residential	:		
4.	a) Sex : M/F		b)	Age :
	c) Designation :		d)	Pay :
5.	Date and hour of accident or dangerous occurrence	:		
6.	Hours at which he started work on the day of accident	:		
7.	a) Cause & nature of accident or dangerous occurrence	:		
	b) If caused by machinery	:		
	i) Name of the machine and part causing the accident, &	:		
	ii) Whether it was moved by mechanical power at that time	:	Yes/No	
	c) Exactly what injured person was doing at that time	:		
8.	Names & addresses of the witnesses to the accident	:	1)	
		:	2)	
9.	Nature & extent of Injury	:		
10.	Period of disability	:		

11.	If accident is not fatal, state whether injured person is likely to be disabled for 48 hours or more	:	Yes/No
12.	Name of Medical Officer in attendance on injured person	:	

I certify that to the best of my knowledge and belief that the above particulars are correct in every respect.

Date: **Manager** **Signature :**

Place: **Name :**

Competent Authority.

Form - 13

FORM FOR REPORTING ELECTRICAL ACCIDENTS

(See rule 44-A of the Indian Electricity Rules,1956;

&

Atomic Energy (Factories)Rules, 1996; rule 89(2))

1.	Date and time of accident	:
2.	Place of accident and district	:
3.	System & Voltage of supply	:
4.	Name of the licensee or person/persons or supplier or user of energy in whose premises or jurisdiction the accident occurred	:
5.	a) (i) Name of the person	:
	(ii) Animal(please specify the name and address of the owner)	:
	b) Address of such/each person	:
6.	Occupation and designation of such person/persons (and in particular whether employed in electrical works or elsewhere)	:
7.	Brief description of the job undertaken, if any	:
8.	Authority under which such person / persons was / were allowed to work on the job. State also whether he/they was/were authorised person/persons	:
9.	Describe fully nature and extent of injuries, e.g. fatal, disablement of any portion of body or other injury, etc.	:
10.	Detailed causes leading to the accident	:
11.	Action taken regarding first aid, medical attendance, etc. immediately after the occurrence of the accident.	:
12.	Whether appropriate Govt. Dist. and police station informed (if so, give the address).	:

(2)

13.	Steps taken to preserve the evidence in connection with the accident to the extent possible.	:
14.	Name and designation/s of the person/s assisting the person/s killed or injured.	:
15.	What safety equipment were given to and used by the person/s who met with this accident(e.g. rubber gloves, rubber mats, safety belts and ladders, etc.).	:
16.	Whether isolating switches and other sectionalising devices were employed to deaden the sections for working on the same, if so, whether these were earthed.	:
17.	Whether the work on live lines was undertaken by an authorized person/s. If so, the name and designation of such person/s may be given.	:
18.	Whether artificial resuscitation treatment was given to the person who met with electric accident. If yes, for how long was it continued, before abandonment.	:
19.	Steps proposed to be taken to avoid recurrence	:
20.	Names and designations of persons present at the time of accident.	:
21.	Any other remarks	:

Date: **Manager** **Signature :**

Time: **Name:**

1. Electrical Inspector of the region.

2. Competent Authority.

Form - 14

Notice of Poisoning or Disease

(See rules 89(5), 90)

1.	Name of the Factory		:	
2.	Name and address of the undertaking in which the patient presumes that he was exposed to the risk to which the poisoning or disease is attributed.		:	
3.	Harmful agent or process		:	
4.	Patient.	Name	:	
		Address	:	
5.	1. Sex : M/F		2.	Age :
	3. Designation:		4.	Pay :
6.	Precise occupation of the patient		:	
	.1 at the place or last place of employment		:	
	.2 at the undertaking in which the patient presumes that he was exposed to the risk.		:	
7.	Nature of poisoning or disease.		:	
8.	Approximate dates of beginning & cessation of exposure of the patient to the harmful agent or process mentioned in 3 above.		:	
9.	General particulars		:	

Manager, **Signature:**

Date: **Name:**

Competent Authority.

MODEL RULES FOR LABOUR WELFARE

MODEL RULES FOR LABOUR WELFARE

1. **Definitions:**

(a) "Work Place" means a place at which, on an average, twenty or more workers are employed.
(b) "Large work place" means a place at which, on an average 500 or more workers are employed.

2. **First Aid** :

At every workplace, there shall be maintained in a readily accessible place first aid appliances including an adequate supply of sterilized dressings and sterilized cotton wool as prescribed in the Factory Rules of the State in which the work is carried on. The appliances shall be kept in good order and in large work-places, they shall be placed under the charge of a responsible person who shall be readily available during working hours.

At large workplaces, where hospital facilities are not available within easy distance of the works First Aid Posts shall be established and be run by trained compounders.

Where large workplaces are remotely situated and far away from regular hospitals, an indoor ward shall be provided with one bed for every 260 employees.

Where large workplaces are situated in cities, towns or in their suburbs and no beds are considered necessary owing to proximity of city or town hospitals, suitable transport shall be provided to facilitate removal of urgent cases to these hospitals. At other workplaces, some conveyance facilities shall be kept readily available to take injured person or person suddenly taken seriously ill, to the nearest hospital.

At large workplaces these shall be provided and maintained an ambulance room of the prescribed sizes, containing the prescribed equipment and in the charge of such medical and nursing staff as may be prescribed. For the purpose the relevant provisions of the Factory Rules of the State Government of the area where the work is carried on may be taken as the prescribed standard.

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3. **Accommodation for Labour** :

The Contractor shall during the progress of the works provide, erect and maintain necessary temporary living accommodation and ancillary facilities for labour at his own expense and to standards and scales as approved by the Engineer-in-Charge.

4. **Drinking water** :

In every workplace, there shall be provided and maintained at suitable places easily accessible to labour, a sufficient supply of cold water fit for drinking.

Where drinking water is obtained from an intermittent public water supply each workplace shall be provided with storage where drinking water shall be stored.

Every water supply storage shall be at a distance of not less than 15 meters from any latrine drain or other source of pollution. Where water has to be drawn from an existing well, which is within such proximity of latrine, drain or any other source of pollution, the well shall be properly chlorinated before water is drawn from it for drinking. All such wells shall be entirely closed in and be provided with a trap door which shall be dust and water-proof.

A reliable pump shall be fitted to each covered well, the trap door shall be kept locked and opened only for cleaning or inspection which shall be done at least once a month.

5. **Washing and Bathing Places** :

Adequate washing and bathing places shall be provided separately for man women. Such places shall be kept in clean and drained condition.

6. **Scale of Accommodation in Latrines and Urinals** :

There shall be provided within the precincts of every workplace latrines and urinals in an accessible place, and the accommodation, separately for each of these, shall not be less than at the following scales:-

	No. of Seats
(a) Where number of persons does not exceed 50	2
(b) Where number of persons exceeds 50 but does not exceed 100	3

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(c) For additional persons per 100 or part thereof 3

In particular cases, the Engineer-in-Charge shall have the power to increase the requirement, where necessary.

7. **Latrines and Urinals** :

Except in workplaces provided with water flushed latrines connected with a water-borne sewage system. All latrines shall be provided with receptacles or dry-earth system which shall be cleaned at least four times daily and at least twice during working hours and kept in a strictly sanitary condition. Receptacles shall be tarred inside and outside at least once a year. If women are employed, separate latrine and urinals screened from those for men and marked in the vernacular in conspicuous letters "For Women Only" shall be provided on the scale laid down in rule 6. Those for men shall be similarly marked "For Men Only". A poster showing the figure of a man and of a woman shall also be exhibited at the entrance to latrines for each sex. There shall be adequate supply of water close to latrines and urinals.

8. **Construction of Latrines**:

Inside walls shall be constructed of masonry or some suitable heat resisting nonabsorbent materials and shall be cement washed inside and outside at least once a year. The dates of cement washing shall be noted in a register maintained for the purpose and kept available for inspection. Latrines shall have at least thatched roof.

9. **Disposal of Excreta** :

Unless otherwise arranged for by the local-sanitary authority, arrangements for proper disposal of excreta by incineration at the workplace shall be made by means of a suitable incinerator approved by the local medical health and municipal or cantonment authorities. Alternatively excreta may be disposed off by putting a layer of night soils at the Bottom of pucca tank prepared for the purpose and covering it with a 15 cm layer of waste or refuse and then covering it with a layer of earth for a fortnight(when it will turn into manure).

The Contractor shall, at his own expense, carry out all instructions issued to him by the Engineer-in-charge to effect proper disposal of soil and other conservancy work in respect of Contractor`s work people or employees on the Site. The Contractor shall be responsible for payment of any charges

which may be levied by municipal or cantonment authority for execution of such work on his behalf.

10. **Provision of shelters during rest** :

At every work place there shall be provided free of cost, four suitable sheds, two for meals and two others for rest, separately for use of men and women Labour. Height of each shelter shall not be less than 3 meters from floor level to lowest part of roof. Sheds shall be kept clean and the space provided shall be on the basis of at least 0.5 sq.m. per head.

11. **Crèches** :

At a place at which 20 or more women workers are ordinarily employed, there shall be provided at least one hut for use of children under the age of 6 years belonging to such women, Huts shall not be constructed to a standard lower than that of thatched roof, mud floor and wall with wooden plants spread over mud floor and covered with matting.

Huts shall provided with suitable and sufficient openings for light and ventilation. There shall be adequate provision of sweepers to keep the places clean. There shall be two dais in attendance. Sanitary utensils shall be provided to the satisfaction of local medical health and municipal or cantonment authorities. Use of huts shall be restricted to children their attendance and mothers of children.

Where the number of women workers is more than 25 but less than 50, the Contractor shall provide at least one hut and one dai to look after children of women workers.

Size of creche (s) shall vary according to the number of women workers employed.

Creche (s) shall be properly maintained and necessary equipment like toys etc., provided.

12. **Canteen** :

A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary.

13. **Planning** :

Setting and erection of the above mentioned structures shall be approved by the Engineer-in-Charge, and the whole of such temporary accommodation shall at all times during the progress of the works be kept tidy and in a clean and sanitary condition to the satisfaction of the Engineer-in-Charge and at the Contractor`s expenses. The Contractor shall conform generally to sanitary requirements of local medical, health and municipal or cantonment authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the Site.

On completion of the Works the whole of such temporary structures shall be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off and the whole of site left clean and tidy to the entire satisfaction of the Engineer-in-Charge and at the Contractor`s expenses.

14. **Anti-malarial precautions** :

The Contractor shall, at his own expense, conform to all anti-malarial instructions given to him by the Engineer-in-Charge, including filling up any borrow pits which may have been dug by him.

15. **Enforcement** :

The Inspecting Officer mentioned in the Contractors Labour Regulations or any other officer nominated in his behalf by the Engineer-in-Charge shall report to the Engineer-in-Charge all cases of failure on the part of the Contractor and or his subcontractors to comply with the provisions of these Rules either wholly or in part and the Engineer-in-Charge shall impose such fines and other penalties as are prescribed in the conditions.

16. **Interpretations etc**. :
On any question as to the application, interpretation or effect of these Rules, the decision of the Chief Labour Commissioner or Deputy Chief Labour Commissioner(Central) shall be final and binding.

17. **Amendments** :

Government may, from time to time add to or amend these Rules and issue such directions as it may consider necessary for the proper implementation of these Rules or for the purpose of removing any difficulty which may arise in the administration thereof.

GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)

GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)

GOVERNMENT OF INDIA

AERB SAFETY GUIDELINES

CONTROL OF WORKS

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)

CONTROL OF WORKS

Atomic Energy Regulatory Board
Mumbai-400 094
India

December 2011

Price

Order for this guidelines should be addressed to:

The Administrative Officer
Atomic Energy Regulatory Board
Niyamak Bhavan
Anushaktinagar
Mumbai-400 094
India

FOREWORD

Activities concerning establishment and utilisation of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act, 1962. In pursuance of the objective of ensuring safety of members of the public and occupational workers as well as protection of environment, the Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down safety standards and enforcing rules and regulations for such activities. The Board, therefore, has undertaken a programme of developing safety standards, safety codes and related guides and manuals for the purpose. While some of the documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning of nuclear and radiation facilities, other documents cover regulatory aspects of these facilities.

Safety codes and safety standards are formulated on the basis of nationally and internationally accepted safety criteria for design, construction and operation of specific equipment, structures, systems and components of nuclear and radiation facilities. Safety codes establish the objectives and set requirements that shall be fulfilled to provide adequate assurance for safety. Safety guides and guidelines elaborate various requirements and furnish approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific and technical information on the subject. These documents are prepared by experts in the relevant fields and are extensively reviewed by advisory committees of the Board before they are published. The documents are revised when necessary, in the light of experience and feedback from users as well as new developments in the field.

Construction work is a labor-intensive industrial activity with large number of unskilled and migratory workforce under various contracts ranging from a mega package contract to a small work contract. Accidents during construction work are of major concern because of the high severity of injuries. The analysis of the accidents at construction sites indicates that 'fall from height' type of accidents are significantly higher than the other types of accidents. AERB safety guide titled 'Works Contract' (AERB/SG/IS-1) was issued in 1991 to emphasise safety requirements and ensure their implementation in execution of contracts. In view of the continual development of construction technologies and the need for enhancement of indutrial safety in DAE units, inputs from AERB discussion meets on the subject, safety and occupational health professionals of DAE, AERB Fatal accident Assessment Committee, and directives on industrial safety issued by Chairman, AERB, the need for revision of the safety guide was felt.

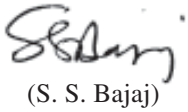
This revised 'safety guidelines' is effective from the date of issue and supersedes the earlier guide on the subject. Part-A of the revised safety guidelines highlights safety requirements by 'Facilities' and Part-B highlights the requirements on safe execution of jobs by 'Contractors'. The facility management shall be strictly liable as a principal

employer for ensuring the compliance with the safety requirements by the contractors as laid down in Part-B. It should be noted that Part-A and Part-B should be read in conjunction, as the requirements are complementary to each other. However the 'Facility' may issue the Part-B along with the tender documents. The requirements spelt out in this 'safety guidelines' are in addition to the statutory requirements such as Factories Act 1948, Atomic Energy (Factories) Rules, 1996 and other applicable statutory requirements.

Consistent with the accepted practice, 'shall' and 'should' are generally used to distinguish between a firm requirement and a desirable option respectively. Appendices are an integral part of the document, whereas bibliography are included to provide further information on the subject that might be helpful to the user.

Specialists in the field drawn from the Atomic Energy Regulatory Board, the Bhabha Atomic Research Centre and the Nuclear Power Corporation of India Limited and other consultants have prepared this 'safety guidelines' document. It has been reviewed by the Advisory Committee on Industrial and Fire Safety (ACIFS).

AERB wishes to thank all individuals and organisations who have prepared and reviewed the document and helped in its finalisation. The list of persons, who have participated in this task, along with their affiliations, is included for information.



(S. S. Bajaj)
Chairman, AERB

SPECIAL DEFINITIONS
(Specific for the Present 'Guidelines')

Approval

A type of written consent issued by the designated authority.

Construction Agency/Contractor

An individual or organisation rendering services of design/construction/fabrication/ installation/repair/inspection/review/maintenance/supplying items by the deployment of workers at site.

Dangerous Manufacturing Processes or Operations

The manufacturing processes or operations as specified under Rule 88 of the Atomic Energy (Factories) Rules, 1996.

Engineer-in-charge

A person designated by the Facility to act as an overall in-charge of work.

Facility

Any Unit of the Department of Atomic Energy awarding the contract.

Head, Industrial Safety

The chief safety officer or the overall in charge of Industrial Safety Section of the facility.

Line Managers

The person who has the field level managerial and supervisory control on the concerned work.

Safety Related Deficiency

The unsafe acts/unsafe practices/unsafe conditions in the work area, which have potential to cause injury/accident resulting into undesirable consequences to human beings or damage to the equipment/property/environment.

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PART-A

CONTROL OF WORKS
(FACILITIES)

1. INTRODUCTION

1.1 General

Department of Atomic Energy (DAE) through its constituent units execute various site works either by their own manpower or by manpower of various outside agencies. The nature of contracts with outside agencies can be works contracts, engineering procurement contracts, minor fabrication contracts etc. These site works involve entire gamut of conventional industrial activities like excavation, rock blasting, earth handling, construction, material handling, fabrication, installation, operation, maintenance etc. of nuclear or conventional plants/facilities. This is a challenging responsibility for the facility due to the complexity of problems like quality of workforce (which may be unskilled, illiterate, migratory) available for labor-intensive jobs, lack of coordination among agencies at site, lack of safety awareness among concerned authorities, time schedules of project etc. As primary employer of the workforce (facility or contractor) at site, it is the responsibility of the facility management to ensure health and safety of personnel engaged for the work. Any accidental injury or loss of life is detrimental to the facility as well as the society. This 'guidelines' covers the safety organisation and the safety management system requirements in sections two and three. The work specific safety precautions are covered in section four. The requirements relating to personal protective equipment and medical management are covered in sections five and six.

1.2 Objective

This 'guidelines' has a basic framework of industrial safety organisation, safety management systems, safe work procedures to maintain a safe working environment for all personnel and to prevent any unsafe condition/act endangering the life of personnel engaged for industrial activities. The major objectives of this 'guidelines' are:

(i) To create awareness among workers about industrial hazards and safe working procedures.

(ii) To lay down safe work procedures and systems to be followed for different type of industrial activities

(iii) To establish a robust safety management system.

(iv) To protect the health and ensure the safety of the workers from industrial activities.

1.3 Scope

This 'guidelines' is essential for implementation and assurance of conventional safety in areas such as industrial, chemical, electrical, fire, environmental and is applicable for all works taken up by the facility as well as contracted works like engineering procurement contract, minor fabrication contract etc. Where the execution of work is envisaged in radiation controlled area or involves handling and fabrication of any nuclear material, additional precautions noted in relevant AERB safety documents on radiation protection shall also be applicable.

2. SAFETY ORGANISATION

2.1 General

(a) Construction projects have significant health and safety hazards, which need to be managed systematically since the project inception stage to achieve adverse incident free completion. A well-defined safety organisation helps in effective implementation of safety management systems and ensures health and safety of workers.

(b) The safety organisation should assure the management that all the provisions of relevant Acts and Rules are conformed to.

(c) Safety organisation should comply with all the requirements such as safety surveillance, safety training, safety enforcement measures, safety audit etc. related to all works to fulfill the overall safety requirements of this 'guidelines'.

(d) Safety functionaries should be exclusively assigned with the work related to protection of health and safety of workers.

(e) Safety organisation should directly report to the Project Director / Project Manager.

(f) IS: 18001: 2007 gives detailed requirements of health and safety management system requirements. IS: 15793 gives requirements of good practices for managing environment, occupational health and safety legal compliance. This 'guidelines' prescribes requirements in addition to IS: 18001: 2007 and IS: 15793 and gives guidelines on implementing these specific to a construction project.

(g) The requirements prescribed in various central and state regulations including *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and rules framed thereunder with respect to managing health and safety in construction projects, shall be complied with.

2.2 Organisational Structure for Safety Management

(a) Organisational structure depends on the construction project. As an example, a typical organisational chart for safety management in a construction project would be as given in Fig 1.

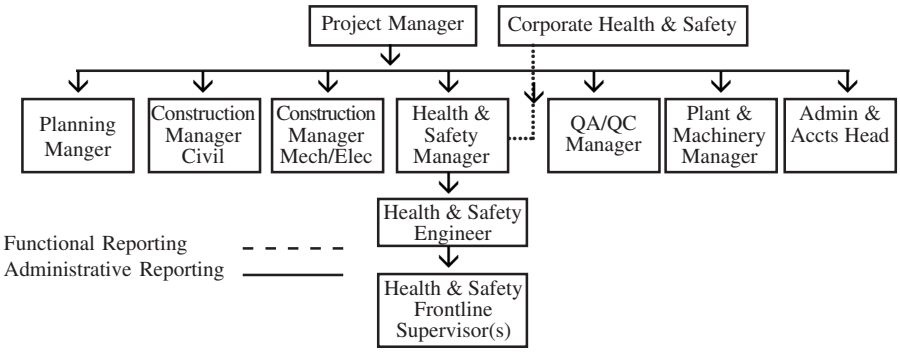

Fig -1 : Typical Organisation Chart

(b) The organisational structure for Health and Safety will vary from project to project. On large and medium projects, it may be necessary to have a separate safety team for each sub-contractor who in turn shall report to safety team of the main construction agency.

(c) The qualification, experience and the minimum number of safety professionals to be deployed should be as per the following table:

TABLE-1 : QUALIFICATION, EXPERIENCE & NUMBER OF SAFETY PROFESSIONALS FOR CONSTRUCTION PROJECTS

Category of safety person	Mandatory requirement	Qualification
Head, industrial safety	One at each site/unit	Degree in engineering/technology and diploma in industrial safety with minimum three years of experience
Safety officer	One in each shift (minimum) up to 1000 workers. If number of workers in a shift (including contractor's workers) exceeds 1000, additionally one safety officer should be deployed for every 1000 workers or part thereof.	Degree in engineering/technology and diploma in industrial safety with minimum two years of experience or Diploma in engineering with diploma in industrial safety with minimum 6 years experience or A recognised degree in physics or chemistry and has practical experience of working in a factory in a supervisory capacity for a period of not less than 5 years.

Category of safety person	Mandatory requirement	Qualification
	One in each shift (minimum) up	Not withstanding the provision contained in the above criteria any person who (i) possesses a recognised degree or diploma in engineering or technology and has had experience of not less than five years in a department of the central or state government which deals with the administration of the Factories Act, 1948 or the Dock Workers (safety, health and welfare) Act, 1986 (54 of 1986) or (ii) Possesses a recognised degree or diploma in engineering or technology and has had experience of not less than 5 years, fulltime on training, education, consultancy, or research in the field of accident prevention in industry or in any institution, shall also be eligible for appointment as a safety officer: Provided that competent authority may, subject to such condition as it may specify, grant exemption from the requirement of this sub rule if in its opinion, a suitable person possessing the necessary qualification and experience is not available for appointment.
Safety supervisor	to 500 workers. If number of persons working in a shift (including the contractors' workers) exceeds 500, additionally one safety supervisor should be deployed for every 500 workers or part thereof.	Diploma in engineering and diploma in industrial safety

3. SAFETY MANAGEMENT

3.1 General

(a) Pre-construction stage activities of the project shall be required to be reviewed before the project management processes are initiated for the construction stage. While the project documents and proposals are reviewed for the adequacy of health and safety measures, it is essential to ascertain timeframes and budgets relating to health and safety measures, including extent of management systems proposed to be employed during construction.

(b) A concise safety management system of the facility shall be established from the pre-construction stage itself. The tender documents of the project shall clearly communicate the health and safety requirements of the project to the prospective contractors. These may include:

(i) Project specific objectives and targets

(ii) Project specific health and safety requirements (technical as well as management systems)

(iii) Requirement of posting safety officers

(iv) Coordination among owner/client, project manager, consultants and facility

(v) Welfare facilities at the project for workmen

(vi) Reward system for good health and safety performance

(vii) Penalty system for non-compliances, violation and adverse incidents

(viii) Health and safety monitoring measures

(ix) Health and safety reports to be submitted and frequency.

(c) The construction agencies (contractors) should be asked to submit a project specific health and safety plan (construction safety management plan) proposing the methodology for managing health and safety and their capability in completing the project in a safe manner.

(d) The proposed construction safety management plans of the construction agencies and their past health and safety performance shall be considered as one of the criteria during pre-qualification and selection of construction agencies.

3.2 Safety Policy

(a) The facility and the construction agency jointly or separately shall have a written statement prescribing the health and safety policy of the organisation. The health and safety policy conveys the management commitment and intent of the organisation towards health and safety, its organisation and arrangements to ensure that the set objectives are met. It also provides a framework for establishing, maintaining and periodically reviewing health and safety objectives and targets.

(b) Health and safety policy shall meet the requirements of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and IS 18001.

(c) The policy shall be communicated to all stakeholders through display and other means. The policy shall be displayed in local language(s) which may be understood by majority of the workmen.

3.3 Safety Plan

(a) A project specific health and safety plan shall be developed by the facility. On approval by the project director, the project health and safety plan shall be reference document for implementation, control and monitoring of health and safety aspects of the project by the facility.

(b) Project health and safety plan shall describe how the project specific health and safety objectives and targets shall be achieved. It shall define the road map for achieving the standards that an organisation lays down for itself so that efforts can be coordinated, synergised and monitored.

(c) Health and safety plan shall explain the means of establishing a positive health and safety culture at the project site. Health and safety plan shall identify and enumerate the control measures to mitigate the risks to the project completion arising out of health and safety issues so that the project is allowed to proceed without interruption and executed as per schedule.

Salient aspects that may be covered in the project health and safety plan are:

(i) Project specific health and safety objectives, targets and programmes in line with health and safety policy

(ii) Hazard identification and risk assessment

(iii) Meeting legal and other requirements

(iv) Health and safety organisation

(v) Resources, roles, responsibility and authority

(vi) General health and safety rules

(vii) Health and safety requirements to be followed by sub-contractors

(viii) Operation control procedure

(ix) Activities requiring work permit system and its procedure

(x) Safe handling of chemicals, explosives, gas cylinders, electrical equipment etc.

(xi) Access control of employees

(xii) Safety of visitors

(xiii) Management of critical activities such as work at height, material handling and working with plant and machinery

(xiv) Ensuring the competency and awareness of the workmen

(xv) Fire prevention and fire fighting plan

(xvi) Emergency preparedness and response plan

(xvii) Traffic management plan

(xviii) Training matrix

(xix) Personal protective equipment matrix

(xx) Health and safety performance monitoring measures such as inspection and audit

(xxi) Incident reporting and investigation procedure

(xxii) Proactive and reactive indicators of health and safety

(xxiii) Reward and reprimand for health and safety performance

(xxiv) Checklist and formats

(xxv) Health monitoring plan for employees/workers enposed to hazardus job.

(d) The risk control measures identified shall meet the provisions of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996, other legislations and provisions of various safety related standards.

(e) Procedures shall be established for timely recording and reporting of information required for continual improvement of health and safety performance. Internal reporting procedures shall cover:

(i) Incident reporting

(ii) Non-conformance reporting

(iii) He alth and safety performance reporting

(iv) Hazard identification reporting

External reporting shall cover

(i) Statutory reporting requirements

The recording of reporting of health and safety performance shall be clearly documented in the project health and safety plan.

3.4 Roles, Responsibility and Authority

(a) Project manager shall define, document and communicate the roles, responsibilities and authorities of all personnel who manage, perform and verify activities having an effect on health and safety risks. It shall also include contractors and visitors.

(b) Ultimate responsibility for health and safety shall rest with top management of the respective organisation.

(c) The line management personnel who are responsible for execution of activities are directly responsible for health and safety in the work under their control.

(d) Health and safety group and health and safety officers are responsible for guiding the top management on health and safety issues and facilitating the implementation of health and safety in the project site. For duties and responsibilities of health and safety officers refer Atomic Energy (Factories) Rules-1996.

(e) Health and safety officers shall administratively report to the project manager and functionally report to the senior health and safety representative of the organisation.

(f) Health and safety officers and health and safety group shall be empowered by the project manager for stopping any unsafe practices which are of imminent danger to employees. Health and safety group shall directly report to no less than the head of the project.

(g) Health and safety supervisors shall be engaged to assist the health and safety officers in performing their duties.

(h) Management shall provide adequate resources essential to effectively manage the health and safety requirements of the project. The resources shall include human resources, organisational infrastructure, technology and financial resources.

3.5 Design and Engineering

(a) Design drawings, construction methodology and plans shall be reviewed to determine whether any additional risks may arise during the construction due to the features in the design or methodology.

Attention shall be paid to:

(i) Providing permanent hooks and loops for tying safety slings of workers

(ii) Providing holes or such arrangements to the structure to which safe working platforms and safety nets can be connected

(iii) Significant risks from construction materials, which cannot be avoided in the design

(iv) Laying permanent slings, grab rails/bars to be used by the workers

(v) Permanent provision for attaching railings

(vi) Provision for alternative access to the trapped or distressed workers

(vii) Provision for communication

(viii) Design facilitating barricading of the area around work site without causing hindrance to building functional activities

(ix) Durability of such safety related permanent design integrated elements

(x) Other safety practices required for the type of woks involved.

(b) Analysis of design and integration of safety measures, as described above, should be undertaken as value engineering through multi-stakeholder consultation, necessarily involving designers, owner/ client, operation/maintenance management and construction agency.

(c) While need for special work methodology and enabling infrastructure is considered to make conditions safe for construction, attention shall also be drawn to the safety during maintenance operations (including inspections which may be necessary before project commissioning as well as maintenance).

(d) It shall also be ascertained whether it would be feasible (within the time and cost considerations) to erect necessary temporary enabling infrastructure. If, in the due assessment by the project manager, it is established that the design, as proposed, would continue to be unsafe during construction and maintenance operations unless special

enabling infrastructure is created and work procedures specifically drawn, the design shall be reviewed.

3.6 Construction Planning

(a) Prior to the start of construction work, detailed planning shall be carried out which may include:

(i) Identifying aspects of design that have bearing on health and safety during construction stage.

(ii) While scheduling the various activities of the construction, allowing adequate time to carry work in accordance with health and safety requirements.

(iii) Reviewing the proposed work method of various activities, identifying health and safety hazards of activities in the project and assessment of the risk level.

(iv) When the risk level is unacceptable, taking additional control measures including revision of the work methodology so that identified risk is at ALARP (as low as reasonably practicable) level.

(v) Planning and establishing the facilities for implementation of health and safety such as workmen training facility, health centre for medical check-up and first aid, access control of employees, etc.

(vi) Ensuring that the temporary establishments at project site such as site offices, workmen camps, toilets, canteens and rest sheds, etc. are created meeting the requirements of the relevant statutes and standards.

(b) Facility shall ensure that the construction agency has understood the challenges and has planned to meet the project specific health and safety requirement through appropriate competencies.

(c) Health and safety measures need proper coordination by the construction agency and such efforts of the construction agency shall be reviewed, monitored and appropriately guided by the facility.

(d) In respect of sub-contractors, project manager of the construction agency shall ensure that the sub-contractors meet the health and safety requirements of the project. Health and safety control and monitoring shall be established specific to the needs of the project.

(e) Past health and safety performance and capability of contractors to complete the job safely shall be given due consideration during selection of contractors. The project specific health and safety

requirements shall be clearly communicated to the contractors and a commitment obtained from them on meeting the requirements.

3.7 Safety Communication

(a) Procedures shall be established to communicate significant hazards and risks to and from employees and other interested parties. The health and safety hazards and risks may be communicated in the following ways:

(i) Sharing of accidents case studies which occurred in the project site as well in other similar projects

(ii) Health and safety posters and displays

(iii) Health and safety campaigns and competition involving the employees

(iv) Sharing of results of the audits, inspections and other monitoring systems

(v) Establishing a system for collecting feedback on health and safety from employees and other interested parties

(vi) Tool box meeting

(vii) Safety signage.

(b) Health and safety communications addressed to workmen shall preferably be in local language(s) understandable by majority of the workmen.

(c) The owner/client, consultant and construction agency shall jointly endeavour to promote a positive health and safety culture at the project. Top management of the organisations should exhibit a visible management commitment and felt leadership towards health and safety. This shall be achieved by participating in health and safety programmes such as,

(i) Project health and safety committee meeting

(ii) Health and safety walk down

(iii) Including health and safety in all performance review meetings

(iv) Exhibiting a safe behaviour while at site.

(d) The top management should clearly communicate that it considers safety as core value and it shall not allow it to get compromised. Such messages when it reaches down the level in the organisation enable to create a positive health and safety culture.

3.8 Safety Monitoring Programme

(a) The objective of the safety surveillance programme should address

assurance of effective implementation of safety measures in execution of works. Following surveillance programme should be in place at sites. The safety organisation should monitor, maintain record and follow up for corrective actions.

(b) The surveillance programme should consist of identification of safety related deficiencies and status of corrections thereof, the implementation of protective measures, the safe work practices, human behavior etc.

(c) Specific surveillance should be ensured with respect to testing of equipment, portable power tools, electrical equipment and tools, hand tools, surveillance of material handling equipment, transport equipment, earth moving equipment, gas cylinders etc. to comply with various statutory requirements.

(d) Surveillance on safety awareness and training compliance including induction training, on the job training and refresher training, job specific pre-job briefing, job hazard analysis, etc. as per facility's guidelines should be ensured.

(e) Safety related deficiencies should be detected by any employee of the facility and communicated by the safety officer to their line managers with a record and corrective measures monitored and recorded. The engineer-in-charge should specifically ensure this. These should be informed to Head, Industrial Safety within the stipulated time period as per the category of safety related deficiencies (SRDs).

(f) Systematic record of safety related deficiencies (SRDs) attended and pending should be made by the facility and other executing agencies.

(g) Head, Industrial Safety should verify periodically, at least once in 15 days that all safety related work permits issued are executed and recorded.

(h) The health and safety performance monitoring and measurement procedures shall provide for:

  (i) Both qualitative and quantitative measures appropriate to the project

  (ii) Monitoring the extent to which project health and safety objectives are met

(iii) Proactive measures of compliance that measures compliance with health and safety plan, operational control procedures and legislation

(iv) Reactive measures of performance to monitor accidents, ill health, near misses and non-conformances

(v) Monitoring dangerous occurrances

(vi) Fire occurrances

(vii) First aid injuries.

(i) Health and safety audit is a systematic and independent examination to estimate if planned arrangements and activities are effectively fulfilling organisation's health and safety policy, plan and objectives. Its purpose is to find out:

(i) Whether the organisation has adequate procedures for identifying specific health and safety requirements

(ii) Whether such laid down procedures are followed and specific health and safety responsibilities are understood

(iii) Whether health and safety policies and risk assessment procedures identify the measures needed to avoid risks to employees and other interested parties

(iv) Whether the company has adequate procedures for devising, reviewing its health and safety standards

(v) Whether the company's health and safety standard identifies measurable targets

(vi) Whether the company has established adequate procedures for planning, implementing, controlling, monitoring and reviewing the health and safety measures.

(j) Project health and safety management audits provide the method for monitoring and controlling health and safety activities and procedures throughout the life of the project. Audits can be internal or external. Internal audit can be conducted by the persons from the same organisation who are not directly connected with the work site to be audited. The external audits are performed through external professional experts.

(k) Health and safety inspections shall be preferably conducted by a team of the concerned engineer, health and safety officer and area in-charge. Project manager and other senior personnel shall also join in some of the health and safety inspections.

(l) The type of inspections that shall be carried out and the frequency shall be decided during the planning stage and documented in the project health and safety plan. The health and safety inspections should include:

(i) General site health and safety inspection

(ii) Electrical safety inspection

(iii) Plant and machinery inspection

(iv) Health and hygiene inspection

(v) Scaffolding safety inspection

(vi) Portable tools and tackles

(vii) Lifting tools and tackles

(viii) Fire equipment inspection

(ix) Illumination level and noise level monitoring

(m) Project health and safety committee shall be constituted with project manager as the chairman, health and safety head as the secretary and representatives from various groups including workmen representatives as the members. The constitution and functioning of the committee shall meet the provisions of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996.

(n) This committee shall review the status of implementation of project health and safety plan, health and safety objectives and targets. Health and safety indicators and findings of the walk down by the committee members shall also be discussed and action plan derived.

(o) Status of health and safety implementation shall be measured and monitored by several proactive indicators which include the following:

(i) Compliance level of project health and safety plan

(ii) Compliance level of health and safety observations with in the target date

(iii) Implementation status of training plan

(iv) Implementation status of corrective and preventive actions

(v) Compliance level of pre-employment medical checks and periodic medical checkups

(vi) Compliance level of legal and other requirements

(vii) Percentage of activities for which detailed project specific risk assessment is conducted.

(p) Procedures shall be established to report, investigate and analyze incidents. The procedures shall involve:

(i) Members of the incident investigation team

(ii) Agencies to be reported in case of incidents

(iii) Time period within which incidents need to be reported

(iv) Methodology for investigation and determining the root cause of accidents.

These procedures shall form a part of the project health and safety plan and monitored on a regular basis for its effectiveness.

(q) All incidents including near miss cases, accidents and dangerous occurrences shall be thoroughly investigated, direct and root causes determined and corrective action planned. Incidents should be analysed covering the following ways to prepare and implement an effective prevention plan:

(i) Body part injured

(ii) Age of the victims

(iii) Time of accidents

(iv) Causes of accidents

(v) Nature of injury.

For detailed guidelines on analysis of incidents and computation of injury rate refer IS 3786.

(r) The following reactive health and safety indicators should be used to measure and monitor the health and safety performance of the project site:

(i) Number of near miss cases

(ii) Number of first aid cases

(iii) Lost time injury frequency rate

(iv) Lost time injury severity rate.

(s) The health and safety performance of contractors shall be monitored on a regular basis and necessary directive and support shall be given to achieve the set health and safety objectives and targets.

(t) All accidents leading to property damage/fatal accidents/personnel injuries/near miss and dangerous occurrence should be reported to the engineer-in-charge immediately.

(u) All 'near-miss' accidents should also be recorded/reported and investigated and recommendations arising out should be implemented on priority.

(v) Facility/Contractor should also submit a monthly statement of accidents to engineer-in-charge/head, industrial safety by 4th of the following month showing details of accident, nature of injury including disability, days lost, treatment required, etc. and the extent of property damage.

3.9 Training/Orientation

(a) It shall be ensured that all employees are competent to perform the assigned work safely on the basis of appropriate education, training or experience. The competency requirements of different categories of employees shall be mapped and procedures shall be implemented to ensure that those deployed meet the competence requirements.

(b) Training needs of the different category of employees shall be identified at the beginning of the project and a training matrix and plan shall be prepared for implementation.

(c) The objective of health and safety training shall be to equip the employee with necessary knowledge and skill to perform the work assigned to him in a safe manner, to foster continual improvement and to imbibe safety culture.

(d) Preferably, the training should be carried out away from the working place of the participants to ensure focused attention on the training for both trainer as well as trainees.

(e) After completion of training due procedure shall be followed for obtaining the feedback from the participants on the effectiveness of the training. Effectiveness of training imparted shall be monitored for continual improvement and necessary corrections in implementation.

(f) The training/orientation programme should be implemented to meet the mandatory requirements. [Rule 43(2) (m) of the Atomic Energy (Factories) Rules 1996]. The training should be phased as follows:

(g) Induction cum orientation training should include the overall safety aspects of the work and give a general overview of the various hazards, the particular activities and the do's and don'ts. As a part of training, workers should also be given demonstrations on use of

personal protective equipment, first aid, fire-fighting equipment, fire mock drills, other emergency preparedness etc.

(h) The line manager along with the safety representative should conduct pre-job briefing on day-to-day basis prior to specific hazardous jobs. This will make the workers aware of the hazards and the precautions to be taken.

(i) Refresher training should be imparted to each worker at least once in a year.

(j) A training schedule should be prepared by the facility for implementation.

(k) Records of training, demonstration and pep talk should be maintained.

3.10 Permit to Work System

(a) Activities requiring permit to work shall be decided before starting the construction and shall be suitably documented in the project health and safety plan. Some of the activities which should require permit to work are:

(i) Excavation

(ii) Entry into confined spaces

(iii) Electrical work (HV/LV)

(iv) Opening manholes, covers and grills

(v) Blasting operation

(vi) Hot work

(vii) Work on plant and machinery & other power driven equipment

(viii) Working at height

(ix) Working at night

(b) The facility should establish a permit to work system for any other hazardous activity, which it feels necessary to be controlled administratively for safe execution.

(c) Record of safety work permit should be maintained in a systematic manner. All the safety conditions and requirements stipulated in the safety work permit should be ensured strictly.

(d) Occupier should ensure that only authorized personnel are deployed for hazardous works/jobs (Refer item 3.11 for hazardous job) and provide facilities for the same.

3.11 Job Hazard Analysis

(a) It should be ensured that a safe work procedure exists for all the hazardous jobs as mentioned hereunder and the requirements of the safety procedures are ensured at the work sites. Job hazard analysis (JHA) should form a part of such safe work procedures. A checklist based on JHA should be prepared. This checklist should be crosschecked by the line managers and verified by safety officer.

Typical list of jobs requiring job hazard analysis (this list is illustrative only and not exhaustive) is as follows:

(i) Excavation

- (a) Blasting including under water blasting
- (b) Earth and stone removal/backfilling/dumping of earth/stones
- (c) Any excavation more than 1.8 m depth.

(ii) Work at height (working beyond 3.5 meters above ground)

- (a) Erection and dismantling of scaffolding, platforms, shuttering/ de-shuttering work
- (b) Dome work, rod bending, construction of chimney and cooling towers
- (c) Working on tower crane.

(iii) Materials and material handling

(A) Critical equipment handling e.g.

- (a) Calandria
- (b) Steam generators
- (c) Turbine generator components
- (d) Diesel generator set
- (e) Generator stator
- (f) End shields
- (g) Fuelling machines components
- (h) Heat transport pumps etc.

(B) Hazardous chemical handling e.g.

- (a) Acids and alkalis
- (b) Chlorine

(c) Hydrazine

(d) Morpholine

(e) Freon

(f) Ammonia

(g) LPG

(C) Movement of heavy material by crane

(D) Movement of tractor trolley on slopes

(E) Manual lifting of heavy material to height

(F) Erection of heavy machinery, equipment.

(iv) Electrical connection

(a) Field connection for electrical installation

(b) Installation of lighting fixtures

(c) Charging of electrical system

(i) Charging of transformer, switch yard, switch gears

(ii) Working near high voltage lines

(iii) Use of portable electrical tools.

(v) Equipment/structural erection work

(a) Material handling

(b) Loading and unloading

(c) Transportation of material from one place to other

(d) Steel fabrication and erection

(e) Cleaning and maintenance of batching plant equipment.

(vi) Finishing/painting work

(a) Painting at height

(b) Painting in confined space.

(vii) Other specific work

(a) Work with pneumatic tools/compressed air

(b) Work on pressure vessels/lines

(c) Work in the vicinity of steam lines

(d) Work in high enthalpy area

(e) Work in high noise area

(f) Work in confined space including tunnels & trenches

(g) Work in isolated area (away from main site)

(h) Radiography work

(i) Work related to welding, gas cutting, grinding

(j) Working near conveyor, rotating machine

(k) Leak detection testing.

3.12 Reward and Reprimand

(a) It is important to acknowledge and encourage good health and safety performance and suitably reprimand repeated violations, non-conformances and poor health and safety performances. Project specific reward and reprimand system shall be prepared as a part of the project health and safety plan.

(b) To motivate the employees and organisation to work safely measures can be implemented based on the suitability. Selection and rewarding for the following categories may be considered on regular basis:

(i) Safest workmen

(ii) Safest supervisor

(iii) Safest area

(iv) Safest contractor, etc.

(v) Contractors and employees may be rewarded when the project achieves significant million man-hours without any lost time injury.

(c) Unsatisfactory health and safety performance in the form of repeated violations, frequent adverse incidents and accidents shall be dealt with firmly. Depending on the seriousness of the violation the following options shall be considered:

(i) Issue of violation memorandum and obtaining written commitment for safe working

(ii) Suspension or termination of the employee from the present work

(iii) Suspension or termination of contract in case of construction agency

(iv) Imposition of penalty to the construction agency.

(d) When penalties are imposed due records shall be maintained in a transparent manner. The main contractor shall be responsible wherever he deploys sub-contractor/petty contractor/piece rate contractor. The funds thus accrued may be spent in the form of rewarding employees for their sincere efforts towards improving the health and safety performance.

4. WORK SPECIFIC SAFETY SAFETY MEASURES

4.1 General

(a) The occupier should ensure that safety precautions are taken during the execution of awarded work and work areas are maintained safe at all times. At the end of each shift and at all times when the work is suspended, it should be ensured that the work area is left safe in such a way that no materials and equipment that can cause damage to existing property, personal injury or interfere with the other works of the project or station are left in an unsafe manner.

(b) The occupier should ensure to provide and maintain all lights, guards, fencing, warning signs, caution boards and other safety measures and provide for vigilance as and when necessary for the protection of workers and for the safety of others. The caution boards should also have appropriate symbols.

(c) Adequate lighting facilities such as floodlights, hand lights and area lighting should be provided at the site of work, storage area of materials and equipment and temporary access roads within the working area.

(d) All works should be planned so as to avoid interference with other facilities, works of other contractors or sub-contractors at the site. In case of any interference, necessary coordination should be ensured for safe and smooth working.

(e) It should be ensured that the instructions given by the safety officer or his designated nominee regarding safety precautions, protective measures, housekeeping requirements, etc. are complied with. The safety officer with due intimation to engineer-in-charge should have the right to stop the work, if in his opinion, proceeding with the work will lead to an unsafe and dangerous condition. Engineer-in-charge should arrange to get the unsafe condition rectified and/ or provide appropriate protective equipment.

(f) Engineer-in-charge should ensure that each job with a hazard whether small or big is intimated to the safety officer of the facility well before it is taken up.

(g) The facility should be fully responsible for non-compliance of any of the safety measures or requirements, implications, injuries, fatalities, dangerous occurrences and compensation arising out of such situations or incidents.

(h) Maximum duty hours of an individual should be as per the Factories Act 1948 or its latest amendment.

(i) Illumination levels should be as per the statutory requirements.

4.2 Rock Blasting

(a) All blasting operations should be carried out on the basis of procedures approved by Head, industrial safety and engineer-in-charge. All works in this connection should be carried out as per BIS specification/code (IS 4081: 1986. Title:- Safety code for blasting and related drilling operations (First Revision)). Barricades, warning signs etc. should be placed on the roads/open area.

(b) Blasting permit should be obtained from Head, industrial safety at least one day before the blasting operation and precautions mentioned there in shall be ensured by the engineer-in-charge before blasting operation.

(c) The blaster should have a licence from competent authority under Explosive Rules, 1983 for blasting work. It should also be ensured that he knows about the risks involved.

(d) Blasting should be done under the supervision of competent engineer/ supervisor.

(e) Blasting in the open site should only be carried out during fixed hours every day/fixed day in the week between sunrise and sunset. Residents of adjacent area should be informed in advance about the blasting schedule.

(f) No blasting should be undertaken during thunderstorm.

(g) Necessary precaution should be taken to ensure the stability/integrity/ safety of the adjacent structure by limiting the peak particle velocity.

(h) No loose material, such as tools, drilling equipment, etc. should be left on the surface to be blasted. Proper muffling arrangement of the blasting area should be ensured to avoid flying of blasted material.

(i) Authorised blaster should personally ensure that all the personnel/ equipment has been removed from the blasting area before the blasting operations.

(j) Blasting area should be free of detonating gas, inflammable objects, sparking or damaged wiring system, stray currents and static electricity.

(k) All electrical lines in blasting area should be de-energised.

(l) Entry of unauthorised personnel should be prevented by displaying warning signs.

(m) In case of misfire, no person should be allowed to approach the blasting site unless it is inspected and cleared by a competent engineer/supervisor.

(n) Explosives and blasting material should be stored only in clean, dry, well-ventilated, suitably constructed bullet/ magazine which should be fire resistant and securely locked. Stock book should be kept accurate and maintained. Licence should be obtained for storage of explosive as per the Explosives Act, 1884.

(o) Blasting caps, electric blasting caps or primers and detonators should not be stored in the same box, container or room with other explosives.

(p) Precautions against lightening should be provided in accordance with Indian Electricity Rules, 1956 (amended in 2000).

(q) The explosives should be transported in specially designed vehicles bearing a special sign or inscription entitled 'DANGER - EXPLOSIVES'. Also detonators separated from other explosive should be transported in a separate compartment.

4.3 Excavation, Trenching and Earth Removal

(a) Before taking up excavation work, necessary permission should be obtained from the engineer-in-charge with reference to existing underground services.

(b) The engineer-in-charge of the works should exercise full care to ensure that no damage is caused by him or his workmen, during the operation/excavation etc., to the existing water supply, sewerages, power or telecommunication lines or any other services or works. He should provide and erect before construction, substantial barricades, guardrails, and warning signs around the work area. He should also furnish, place and maintain adequate warning lights, display board, signals etc., as required.

(c) All trenches 1.2 m or more in depth should at all times be supplied with at least one ladder for every 30 m along the trench. Ladders shall extend from bottom of the trench to at least 1 m above the surface of the ground.

(d) The sides of the trench/pit in soil, which are 1.2 m or more in depth should be stepped back to give suitable slope (angle of repose) or securely held by timber bracing or appropriate shoring/support, to avoid the danger of soil slides from collapsing. The excavated material should not be placed within 1.5 m or half of the depth of the pit whichever is more from edges of the trench/pit. Cutting should be done from top to bottom. Under no circumstances mining or under-cutting should be done.

(e) Workers should not be exposed to the danger of being buried by excavated material or collapse of shoring. Measures to prevent dislodgment of loose or unstable earth, rock or other material from falling into the excavation by proper shoring shall be ensured.

(f) The stability and safety of the excavation, adjacent structures, services and other works should be ensured.

(g) All excavated area should be fenced off by suitable railing and installation of caution board to warn the persons from slipping or/ falling into the excavation pit/ mound.

(h) All excavated areas shall have an illumination level of at least 20 lux for night work and a red danger light shall be displayed at prominent place near the excavation site to warn approaching traffic and men.

(i) For removal of earth from an earth mound/excavated heap a written permission should be obtained from the engineer-in-charge of the work. As far as practical, earth should be removed mechanically. Wherever manual removal of earth is involved, earth should be removed from the top by maintaining a slope equal to the angle of re-pose of the earth. Such work should be constantly supervised to ensure that no under-cutting is done and to ensure that no person is trapped.

(j) Dumping of excavated soil should be done at a specified area under proper supervision with respect to signaling, illumination and safety clearance.

(k) It should be ensured that at a construction site of a building or other construction work, every vehicle or earth moving equipment is equipped with a) silencers, b) tail lights, c) power and hand brakes, d) reversing alarm e) search light for forward and backward movement, which are required for the safe operation of such vehicle or earth moving equipment and f) the cab of the vehicle or earth moving equipment is kept at least one meter from the adjacent face of a ground being excavated. g) indicator etc.

(l) It should be ensured that when a crane or shovel is traveling, the boom of such crane or shovel is in the direction of such travel and the bucket or scoop attached to such crane or shovel is raised and without load, except when it is traveling downhill.

(m) Before loading or unloading power trucks or trailers attached to tractors, the brakes should be applied and if vehicle is on a sloping ground, the wheels should be blocked. Handcart should not be used for the transfer of construction/erection materials in the construction

area. However if the exigency demands urgent transfer of light materials a small handcart may be permitted with the prior approval of the engineer-in-charge.

(n) It should be ensured that at a construction site of a building or other construction work:

(i) All transport or earth moving equipment and vehicles are inspected at least once in a week by responsible persons and in case any defect is noticed in such equipment or vehicle, it is immediately taken out of service.

(ii) Safe gangways are provided for to and fro movement of building workers engaged in loading and unloading of lorries, trucks, trailers and wagons.

(iii) All earth moving equipment, vehicles or other transport equipment be operated only by such persons who are adequately trained and possess such skills as required for safe operation of vehicles or other transport equipment.

(iv) Trucks and other equipment are not loaded beyond their safe carrying capacity, which should be clearly marked on such trucks and other equipment.

(v) No unauthorised person rides the transport equipment employed in such work.

(o) It should be ensured at a construction site of a building or other construction work that:

(i) A shovel or an excavator whether operated by steam or electric or by internal combustion used for such work is constructed, installed, operated, tested and examined as required under any law for the time being in force and the relevant national standards.

(ii) Buckets or grabs of power shovels are propped to restrict the movement of such bucket or grabs while being repaired or while the teeth of such bucket or grabs are being changed.

(p) It should be ensured at a construction site of a building or other construction work that:

(i) An operator of a bulldozer before leaving – applies the brakes, lowers the blade and ripper and puts the shift lever into neutral.

(ii) A bulldozer is parked on level ground at the close of the work.

(iii) The blade of a bulldozer is kept low when such bulldozer is moving uphill.

(iv) Bulldozer blades are not used as brakes except in an emergency.

(q) It should be ensured at a construction site of a building or other construction work that:

(i) A tractor and a scraper are joined safely at the time of its operation

(ii) The scraper bowls are propped while blades of such scraper are being replaced.

(iii) A scraper moving downhill is driven in low gear.

(r) It should be ensured at a construction site of a building or other construction work that:

(i) Before a road roller is used on the ground, such ground is examined for its bearing capacity and general safety, especially at the edges of slopes such as embankments on such grounds.

(ii) A roller is not moved down hill with the engine out of gear.

(s) Vehicle carrying excavated material should have proper cover over the driver's cabin.

4.4 Safe Means of Access/Platforms

(a) Adequate safe means of access and exit should be provided for all work places, at all elevations.

(b) Suitable scaffolds should be provided for workmen for all works that cannot be done safely from the ground, or from solid platform except such short duration work that can be done safely from ladders. Bamboo/wooden scaffolding should not be permitted.

(c) Where the platform for working is more than 3.5 m above ground, the width of the platform should be minimum 1 m.

(d) Ladder should be of rigid construction having sufficient strength for the intended loads. Wooden/bamboo/rope ladders should not be permitted. All ladders should be maintained in good condition. The ladders should be fixed to the ground or rigid platforms. An additional person should be engaged for holding the ladder, if ladder is not securely fixed. Ladder shall be extended from floor to at least one meter above the platform.

(e) A portable ladder should be given an inclination not steeper than 1 in 4 (1 horizontal and 4 vertical). Ladders should not be used for climbing while carrying materials in hands. While climbing both the hands should be free.

(f) Any working platform on scaffolding or staging more than 3.5 m above the ground or floor should have a guard rail attached, bolted, braced at least 1 m high above the floor or platform of such scaffolding or staging along with mid-rail.

(g) The planks used for any working platform should not project beyond the end supports to a distance exceeding four times the thickness of the planks used. The planks should be rigidly fixed at both ends to prevent sliding, slipping or tilting. The thickness of the planks should be adequate to take load of men and materials and should not collapse. Plywood or packing wood should not be used as planks.

(h) The guardrail should extend along the entire exposed length of the scaffolding with only such opening as may be necessary for the delivery of materials. Standard railing should have posts not more than 2 m apart and an intermediate rail halfway between the floor or platform of the scaffolding and the top rail. Such scaffolding or staging should be so fastened as to prevent it from swaying from the building or structure. Scaffolding and ladder should conform to IS 3696 (Part 1): 1987 and (Part II): 1996.

(i) Working platforms of scaffolds should have toe boards at least 15 cm in height to prevent materials from falling down.

(j) A sketch of the scaffolding proposed to be used should be prepared and approval by the engineer-in-charge obtained prior to start of erection of scaffolding. All scaffolds should be examined by engineer-in-charge before use.

(k) Working platform, gangways and stairways should be so constructed that they should not sag unduly or unequally and if the height of the platform or gangway or stairway is more than 3.5 m above ground level or floor level. They should have adequate width for easy movement of persons and materials and should be suitably guarded.

(l) No single portable ladder should be used for access to a height of more than 4.5 m. For ladders up to 3m in length the width between styles (side bars)/width in the ladder should in no case be less than 300 mm. For longer ladders this width should be increased by at least 20 mm for each additional meter of length. Step/rungs spacing should be uniform and should not exceed 300 mm. Portable ladder should be used only for access to work place. In case work place is higher than 4.5 meters, pre-fabricated steel staircase should be used.

4.5 Work at Height

(a) Person to work at height should be medically fit and should have height pass issued by safety section. (Appendix A Part A, B and C). Safety training should be imparted before working at height.

(b) Safety work-permit system for working at height should be obtained from industrial safety section.

(c) At elevated places, secure access and foothold should be provided. Adequate and safe means of access and exit should be provided at all work places for all elevations. Means of access may be portable or fixed ladder, ramp or a stairway. The use of crosses, braces or framework, as a means of access to the working platform should not be permitted.

(d) Linear movement at height should be reduced to minimum. In case of such movement provision for anchoring the safety belt should be made.

(e) Where barricades cannot be installed, a safety net of adequate strength should be installed close to the level at which there is a danger of fall of personnel/fall of objects.

(f) In case where 'work at height' is on asbestos roof, crawling board, roof ladder should be used to walk across the asbestos roof.

4.6 Electrical Safety

(a) All electrical installations shall comply with the appropriate statutory requirements given below and shall be subject to approval of the electrical engineer and safety officer.

(i) The Electricity Act, 2003

(ii) The Indian Electricity Rules 1956 (as amended in 2000)

(iii) The National Electricity Code 2008

(iv) Atomic Energy (Factories) Rules, 1996

(v) Other relevant rules of statutory bodies and power supply authority

(vi) Relevant standards of BIS

In addition to the above statutory provisions, the clauses indicated in this document shall also be complied.

(b) It shall be the responsibility of the user seeking temporary power supply to indicate in writing, if any of the clauses (requirements noted in above regulations and in this document) are conflicting with each other and for which the user cannot decide the course of action regarding safe installation, commissioning, operation, maintenance and decommissioning of the electrical installations.

(c) The electrical engineer and safety officer of the facility providing temporary power supply shall interpret the concerned conflicting clauses and approve in writing the safe course of action.

(d) The Application Form-1 (Form-1A, 1B and 1C) as mentioned in Appendix-B should be submitted by the user for getting the temporary power supply.

(e) After installation of temporary electrical panels, wiring works by the user, certificates as per Form-1D (Appendix-B) should be submitted to the provider.

(f) Certificate of safety officer and authorisation of electrical engineer for energisation of temporary power supply should be filled as per Form-1E (Appendix-B).

4.7 Material Handling and Lifting Machines and Tackles

(a) It should be made compulsory to supervise jobs like lifting/placing/loading/unloading/carrying/transporting etc. of heavy material by qualified supervisor having knowledge about hazards involved and precautions to be taken for such job.

(b) The line managers should ensure that the material handling equipment used is adequate to handle the load.

(c) Manual pulling of heavy equipment and trolley loaded with heavy material is not to be permitted.

(d) Stacking and handling of heavy materials should be done on a firm ground to prevent settlement.

(e) No lifting machine and no chain, rope or lifting tackle, except a fiber rope or fiber rope sling, shall be taken into use in any factory for the first time in that factory unless it has been tested and all parts have been thoroughly examined by a competent person. A certificate of such a test and examination specifying the safe working load or loads and signed by the person making the test and the examination has been obtained and is kept available for inspection.

(f) Use of lifting machines and tackles should conform to relevant BIS requirements [IS 13367 (Part 1): 1992 Reaffirmed 2003, IS 4573: 1982 (Reaffirmed 2000) and IS 13834 (Part 1): 1994 Reaffirmed 2003 etc. The accessories and the attachments, anchorages and supports etc. should be ensured in healthy conditions by regular inspections at defined frequencies.

(g) Every rope used in hoisting or lowering materials or as a means of suspension should be of good quality and adequate strength and free

from any defect. This should be ensured by regular inspection as per IS 2762: 1982- Specification for wire rope slings and sling legs (first revision).

(h) Every crane operator or lifting appliance operator should be authorised. No person under the age of 18 years should be in charge of any hoisting machine or give signal to an operator of such machine.

(i) In case of every lifting machine (and of every chain, ring, hook, shackle, swivel and pulley block used in hoisting or as a means of suspension) the safe working load should be ascertained and clearly marked. In case of a lifting machine having a variable safe working load, each safe working load and the conditions under which it is applicable should be clearly indicated. No part of any machine should be loaded beyond the safe working load except for the purpose of testing. This should be approved by the engineer-in-charge and head, industrial safety.

(j) In case of facilities machines, the safe working load should be notified by the engineer-in-charge. As regards the contractor's machines, the contractor should declare the safe working load of the machine to the engineer-in-charge whenever he brings any machinery to site of work and get it verified by the engineer-in-charge, supported by a valid test certificate by the competent person.

(k) Thorough inspection and load testing of lifting machines and tackles should be done in the presence of competent person at least once in every 12 months and records of such inspections and testing should be maintained.

(l) No mobile crane should be allowed to move under live high-tension power transmission line.

(m) While lifting loads, cranes should be located on level ground.

(n) A thorough load analysis should be carried out before using cranes in tandem.

(o) Motors, gear transmission, couplings, belts, chain drives and other moving parts of hoisting appliances should be provided with adequate safeguards. Hoisting appliances should be provided with such means, which will reduce the risk of any part of a suspended load becoming accidentally displaced or lowered.

(p) It should be ensured that the cabin of the lifting machine in outdoor service:

(i) is made of fire resistant material,

(ii) has a suitable seat, a footrest and protection from vibration,

(iii) affords the operator an adequate view of the area of operation,

(iv) affords the operator adequate protection against the weather, and

(v) is provided with fire extinguisher.

4.8 Welding and Gas Cutting

(a) Welding and gas cutting operations should be done by qualified and authorized persons only.

(b) Safety work permit should be obtained (wherever necessary like presence of flammable or combustible material etc.) before flame cutting/welding is taken up.

(c) Welding and gas cutting should not be carried out in places where flammable or combustible materials are kept and where there is danger of explosion due to presence of gaseous mixtures. In case the requirement cannot be avoided, specific approval and procedure should be ensured and adequate precautions should be taken.

(d) Welding and gas cutting equipment including hoses and cables should be maintained in good condition.

(e) Barriers should be erected to protect other persons from harmful rays from the work. When welding or gas cutting is done in elevated positions, precautions should be taken to prevent sparks or hot metal falling below on persons or combustible materials.

(f) Suitable type of protective clothing consisting of fire resistant gauntlet gloves, leggings, boots and aprons should be provided to workers as protection from heat and hot metal splashes. Face shields with filter glasses of appropriate shade should be worn.

(g) Adequate ventilation should be provided while welding, brazing and cutting the metals like zinc, brass, bronze, galvanised or lead coated material.

(h) Welding and gas cutting on drums, barrels, tanks or other containers should be taken up only after ascertaining that they have been emptied, cleaned thoroughly and made free of flammable material.

(i) Fire safety measures should be available as required near the location of welding/cutting operations.

(j) Flash back arrestor should be provided with gas cutting and gas welding sets.

(k) For electric (Arc) welding the following additional safety precautions should be taken:

(i) When electrical welding is undertaken the return lead of welding machine should be directly connected to the job invariably.

(ii) Provision must be in place in electric welding machine to prevent physical contact with live parts.

(iii) The welding cables and power cables should be routed separately to avoid entanglement.

(iv) The electric welding set should have suitable earth connections. There should be an electrical isolation device in the input power supply side on the welding machine.

(l) Double gauges should be used for all gas cylinders used for cutting/ welding. Pressure gauges/regulators should be in healthy condition.

4.9 Rotary Cutters/Grinders

(a) All portable cutter/grinders should be provided with the wheel guard in position.

(b) Grinding wheels of specified diameter only should be used on all grinders in order to limit the prescribed peripheral speed.

(c) In pedestal grinder, the gap between tool rest and grinding wheel should be maintained less than 3 mm.

(d) Goggle/face shield should be used during grinding operation.

(e) No grinding wheel should be used after its expiry date.

(f) Ear muff/ear plug should be used during the welding/cutting jobs.

(g) Portable appliances, which are powered by single phase AC supply, shall be provided with three-core cable and three pin plug, otherwise the whole body should be double insulated.

(h) Safety work permit should be obtained (wherever necessary like presence of flammable or combustible material etc.) before grinding is taken up.

(i) Fire safety measures should be available as required near the location of grinding operations.

4.10 Concrete Mixing Equipment

(a) Cement bags should be stacked on wooden planks in dry and leak proof area, 150 mm to 200 mm from the floor and 450 mm away

from walls. Height of the stack should not be more than 15 bags or 1.5 meters which ever is lower. Width of the stack should not be more than 4 bags or 3 meters. Lateral loading of the walls of the storage room by stacking should not be permitted. Stacking of the bags should not be used as a working platform.

(b) Shuttering and supporting structures should be of adequate strength and approved by engineer-in-charge. This should be ensured before concrete is poured.

(c) If the mixer has a charging skip the operator should ensure that the workmen are out of danger before the skip is lowered.

(d) Adequate walking platforms (as per the AERB directives) are to be provided in the reinforcement area to ensure safe walking for pouring concrete on the roof.

(e) When workmen are working/cleaning the inside of the drum of mixer, the power of the mixer should be switched off and "Do not operate" tag should be provided. The plant operation and cleaning of mixing pan should be carried out as per equipment supplier's instructions.

(f) Interlocks between the cover and the mixer rotor shall be established to ensure that the agitator does not start when the cover is in open condition.

(g) It should be ensured that moving parts of the elevators, hoists, screens, bunkers, chutes and grouting equipment used for concrete work and of other equipment used for storing and transporting of ingredients of concrete are securely fenced to avoid contact of workers with such moving parts.

(h) It should be ensured that screw conveyors used for cement, lime and other dusty material are completely enclosed.

(i) Workers engaged for handling bulk cement in a confined place should be provided with tight fitting goggle, approved respirators and protective clothing, which will fit snugly around the neck, wrist and ankles.

(j) The following should be ensured for every pipe carrying pumped concrete:

    (i) The scaffolding carrying a pipe for pumped concrete should be strong enough to support such pipe at a time when such pipe is filled with concrete or water or any other liquid and to bear safely all the building workers who may be on such scaffold at such time.

(ii) Securely anchored at its end point and each curve on it.

(iii) Provided with an air release valve near the top of such pipe; and securely attached to a pump nozzle by a bolted collar or other adequate means.

(k) The following should be ensured while using the electric vibrators in concreting work at a construction site of a building or other construction work such that:

(i) Such vibrators are earthed.

(ii) The leads of such vibrators are heavily insulated.

(iii) The current is switched off when such vibrators are not in use.

(l) For obtaining a clearance for first pour of concrete and regular operation of ready mix concrete (RMC) plant, checklist given in Appendix-C shall be submitted to AERB along with the application for clearance.

4.11 Painting

(a) Appropriate breathing air respirators should be provided for use by the workers when paint is applied in the form of spray, or a surface having lead paint is dry rubbed or scraped.

(b) Only the quantity of paint, thinner and polish required for the day's work should be kept at the work spot. Excess storage should not be permitted at the work spot.

(c) Smoking, open flames or sources of ignition should not be allowed in places where paints, varnish, thinner and other flammable substances are stored, mixed or used. A caution board, with the instructions written in national language and regional language, 'SMOKING - STRICTLY PROHIBITED' should be displayed in the vicinity where painting is in progress or where paints are stored. Symbols should also be used on caution boards.

(d) All electrical equipment of paint storage room should be of explosion proof design. Suitable fire extinguishers/sand buckets should be kept available at places where flammable paints are stored, handled or used.

(e) When painting work/hot resin mix is done in a closed room or in a confined space, adequate ventilation should be provided and ensured. In addition, suitable respirators should be provided. No portable electric light or any other electric appliance of voltage exceeding

24 volts should be permitted for use inside any confined space. Walkie-talkie or other means of communication should be provided. Rescue arrangement like full body harness with lifeline, tripod with pulley and extra BA sets should be available.

(f) The workers should use PVC gloves and/or suitable barrier creams to prevent the skin contact with Epoxy resins and their formulations used for painting.

4.12 Demolition

(a) Before any demolition work is commenced and also during the progress of the work, all roads and open area adjacent to the work site should either be closed or suitably cordoned. Appropriate warning signs should be displayed for cautioning approaching persons/ vehicles.

(b) Before demolition operations begin, it should be ensured that all the service lines are de-energized.

(c) Persons handling demolition operations shall use appropriate PPE.

(d) All demolition operations should be carried out with safe and duly approved procedures which shall include following but not limited to:

(i) No masonry/material should be permitted to fall in such masses or volume or weight so as to endanger the structural stability of any floor or structural support.

(ii) No wall, chimney or other structure or part of a structure is left unguarded in such a condition that it may fall, collapse or weaken due to wind pressure or vibration.

(iii) No floor, roof or other part of the building should be overloaded with debris or materials as to render it unsafe.

(e) After the demolition, the debris and other materials collected should be disposed safely and not permitted to be dropped freely.

(f) Entries to the demolition area shall be restricted to authorised persons wearing safety helmets and safety shoes.

4.13 Traffic

(a) All the vehicles moving at sites should conform and comply with the requirements of Motor Vehicles Act, 1988 and the Rules made there under. All the drivers/operators of vehicles should possess valid driving license as per Motor Vehicles Act, 1988 or its latest amendment.

(b) The facility should conduct operations so as to interfere as little as possible with the use of existing roads at or near locations where the work is being performed. When interference to traffic is inevitable such as road cutting or transit unloading of heavy equipment etc. notice of such interference should be given to the engineer-in-charge and safety officer well in advance with the details of start of the work and time required.

(c) A cleaner/assistant must be available for all heavy vehicles whenever vehicles move forward as well as in the reverse direction. All vehicles should be fitted with proper reverse horns, back view mirrors and indicator signals.

(d) Facility should ensure that the assessment of the driver's visual ability is carried out as per Rule 55 of the Atomic Energy (Factories) Rules, 1996/guidelines of advisory committee on occupational health (ACOH), AERB or as per the latest amendments in statutes.

(e) Effective speed breakers with yellow stripes on the roads to regulate the speed at the vulnerable points should be installed. Effective barricading with adequate caution signs should be placed to warn the vehicle drivers whenever the jobs are carried out on the road.

(f) All vehicles moving at the site should have roadworthiness certificate issued by the concerned authority.

(g) Special limit boards and caution boards indicating turns should be installed wherever necessary.

(h) In general, the following maximum speed limits should be specified and implemented. Vehicles speed limits should be as per Motor Vehicle Act or 20 Km/h. Extra precautions and care should be exercised particularly during heavy material/equipment movements.

(i) Safety awareness programmes should be conducted for all the drivers of the light, medium and heavy vehicles.

4.14 Work in Radiation Area

The facility should follow the stipulated procedure under Atomic Energy Radiation Protection Rules, 2004 and AERB safety manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2) regarding work in the radiation area and other works related with radiography.

4.15 Work in and Around Water Bodies

(a) When work is done at a place where there is risk of drowning, all necessary rescue equipment such as life buoys and life jackets should be provided and kept ready for use.

(b) All necessary steps shall be taken for prompt rescue of any person in danger and adequate provision should be made for prompt first-aid treatment of all injuries likely to be sustained during the course of the work. Proper record of entry/exit to and from water bodies shall be maintained on shift basis and search operation shall be conducted as soon as any person is detected to be missing.

(c) Caisson Work

(i) Safe means of access should be provided to the place of work in the caisson and adequate means should be provided to safely reach the top of caisson in the event of inrush of water

(ii) The work relating to construction, positioning, modification or dismantling of caisson shall be done under the supervision of a responsible person

4.16 Fire Safety

(a) All provisions for fire safety shall be complied as per AERB safety standard on 'Fire Protection Systems for Nuclear Facilities' [AERB/NF/SS/FPS (Rev. 1)].

(b) All necessary precautions should be taken to prevent outbreak of fires at the construction site. It should be ensured that all hot work is carried out under valid work permit.

(c) Combustible materials such as wood, cotton waste, oil, coal, paints, chemicals etc., should be segregated and kept to the required bare minimum quantity at work place.

(d) Containers of paints, thinners and allied materials should be stored in a separate room which should be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint should be kept covered or properly fitted with lid and should not be kept open except while using.

(e) Adequate number of trained persons from approved fire training centre required to extend fire safety coverage should be ensured.

(f) Fire extinguishers as approved by the engineer-in-charge/in-charge of fire station/safety-in-charge should be located at the construction site at appropriate places.

(g) Adequate number of trained workmen in fire fighting who can operate fire extinguishers should be ensured.

(h) Portable fire extinguishers with periodic inspection, maintenance and re-filling complying with the mandatory requirements should be ensured.

(i) Availability of adequate water for fire fighting should be ensured.

(j) Implementation of the provisions of various statutory licenses for storing gas cylinders, petroleum products, explosives etc. as per the relevant acts and rules should be ensured wherever required.

4.17 Environmental Safety

Relevant provisions of the state/central statutory authority regarding environment protection should be adhered to.

4.18 Public Protection

The Facility should make necessary provisions to protect the public. He should be bound to bear the expenses in defense of every action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of any precaution required to be taken to protect the public. He should pay for the any such damage and cost which may be awarded in any such suit, action or proceedings to any such person, or the amount, which may be fixed as a compromise by any such person.

4.19 Safety of Visitors

(a) Visitors for the project shall be given health and safety induction before they are allowed in to the construction project. It shall include the minimum PPE to be used, hazards and risks at the work area, restricted areas of entry, emergency response arrangements, etc.

(b) Visitors shall always be accompanied by one of the employees of the project site.

(c) Visitors shall not be allowed in the hazardous areas unless they are competent and trained to work in such areas.

4.20 Housekeeping

(a) It should be recognised that a proper place for everything and everything in its place is maintained for a good housekeeping.

(b) The material required for immediate use only should be brought to the designated workplace and stacked properly and labeled suitably.

(c) All work spots, site office and surroundings should all times be kept clean and free from debris, scrap, concrete muck, surplus materials and unwanted tools and equipment. A day-to-day collection and disposal of scraps/debris should be done safely at designated place.

(d) Electrical cables, leads and hoses should be so routed as to allow safe traffic by all concerned. Cable should be preferably supported on the brackets fixed along the wall to maintain safe access. Wherever

routing on the floor cannot be avoided, care should be taken to ensure mechanical protection of these cables and safe access is not disturbed.

(e) No material on any work place should be so stacked or placed or disposed off as to cause danger, inconvenience or damage to any person or environment.

(f) All unused scaffoldings, surplus/scrap materials and equipment/ systems like temporary electrical panels etc. should not be allowed to accumulate and shall be removed from the premises at the earliest.

(g) Accumulation of water/oil spillages on the floor or any other workplace should be avoided.

(h) Proper aisle space marking should be provided in all workplaces.

4.21 Other Statutory Provisions

Notwithstanding the clauses in the above subsections, there is nothing in these clauses to exempt the Facility from the provisions of any other act or rules in force in the Republic of India. In particular, all operations involving the transport, handling, storage and use of explosives should be as per the standing instructions and conform to the Indian Explosives Act, 1884 and the Explosives Rules, 1983. Handling, transport, storage and use of compressed gas cylinders and pressure vessels should conform to the Gas Cylinder Rules 2004 and Static and Mobile Pressure Vessels (Unfired) Rules 1981. In addition, The Indian Electricity Act 2003 and Indian Electricity Rules 2005, the Atomic Energy Act, 1962, the Radiation Protection Rules, 2004, the Atomic Energy (Factories) Rules, 1996 and AERB safety manual on 'Radiation Protection for Nuclear Facilities' (AERB/NF/SM/O-2) should be complied with.

5. PERSONAL PROTECTIVE EQUIPMENT

5.1 General

Although the primary approach in any safety effort is that the hazard to the workmen should be eliminated or controlled by engineering methods rather than protecting the workman through use of personal protective equipment (PPE). Engineering methods could include design change, substitution, ventilation, mechanical handling, atomisation etc. Under those situations when it is not possible to introduce any effective engineering methods for controlling hazards, it is necessary that workman use appropriate type of PPE. For example, in construction work there is the possibility of a hand tool, a bolt, or some loose material to fall from an elevated level and striking the head of workman working below. It is therefore necessary that construction worker wear a safety helmet. It is for such situations, both the Factories Act 1948 and the Atomic Energy (Factories) Rules, 1996 have provisions for use of appropriate type of PPE.

It is thus recognised that use of PPE is an important and necessary consideration in the development of a safety programme. Once the safety professional decides that PPE is to be used by workmen, it is essential to select right type of PPE and management should ensure that workman uses it and also PPE is correctly maintained.

5.2 Personal Protective Equipment (PPE)

(a) All personal protective equipment as considered necessary should be made available for the use of the persons employed on the site and maintained in a condition suitable for immediate use. Also adequate steps should be taken by engineer-in-charge to ensure proper use of PPE.

(b) All the PPEs in use should be as per relevant IS standards as referred in the AERB safety guidelines on 'Personal Protective Equipment' (AERB/SG/IS-3).

(c) All persons employed at the construction site should use safety helmets. Safety helmet should be with BIS mark and should have its headband with back support and chin strap.

(d) Workers employed on mixing asphaltic materials, cement and lime mortars should use protective goggles, protective foot wears, hand gloves and respirators as required.

(e) Persons engaged in welding and gas-cutting works should use suitable welding face shields. The persons who assist the welders should use suitable goggles. Protective goggles should be worn while chipping and grinding.

(f) Stonebreakers should use protective goggles. They should be seated at sufficiently safe distances from one another.

(g) Safety goggles should be of shatterproof type and with zero power.

(h) Persons engaged in or assisting in shot blasting operations and cleaning the blasting chamber should use suitable gauntlets, overalls, shatterproof and dust-proof goggles and self contained breathing apparatus set.

(i) All persons working at heights more than 3.5 m above ground or floor and exposed to risk of falling down should use full body harness safety belts, unless otherwise protected by cages, guard railings, etc. In places where the use of safety belts is not feasible, suitable net of adequate strength fastened to substantial supports should be used.

(j) When workers are employed in sewers and inside manholes that are in use, it should be ensured that the manholes are opened and are adequately ventilated at least for an hour. After it has been well ventilated, the atmosphere inside the space should be checked for the presence of any toxic gas or oxygen deficiency by a competent person and recorded in the register before the workers are allowed to get into the manholes. A pilot team should enter the area donning self contained breathing apparatus (SCBA). The manholes opened should be cordoned off with suitable railing and provided with warning signals or caution boards to prevent accidents. There should be proper illumination in the night. Depending upon the work situation, the facility should provide PPE including the SCBA as recommended by Head, industrial safety.

6. MEDICAL MANAGEMENT

6.1 General

(a) The facility management/contractor shall make arrangements for the first aid and medical services for the injured or ill persons for prompt attention or aid.

(b) The arrangement can be made by the contractor or an agreement can be in vogue with the facility .

(c) The medical facilities at first-aid centre shall be adequate to immediately cater to the injured based on the hazard potential and probable severe injuries.

(d) The first aid centre shall be provided with the adequate equipment and medicines for catering to the site requirements. The first aid centre shall be manned depending on the working hours/on round the clock shift basis. The services of at least one qualified medical practitioner (medical officer) shall be made available by the Facility management/contractor.

6.2 Medical Facilities

(a) Medical facilities conforming to the provisions of the Atomic Energy (Factories) Rules, 1996 should be provided at all work sites.

(b) The requisite medical facilities in the form of a well-equipped first aid centre manned by qualified nursing personnel should be provided at all work sites. Contractor may avail this facility as per terms and conditions of the contract.

(c) In addition, well-maintained first aid boxes should be kept at each location of the work by the Facility/contractor and availability of the personnel trained in first aid should be ensured.

(d) A manned and equipped ambulance should be available at work site during the working hours/on round-the-clock shift basis.

(e) It should be ensured by the occupier that occupational health monitoring of contract workers is carried out as per provisions of the Factories Act 1948 as per the latest amendment and the stipulations/directions given by Atomic Energy Regulatory Board from time to time.

(f) Display of emergency contact numbers of important persons and hospitals and route map of site shall be maintained at designated places.

6.3 Medical Management of Serious Injuries

(a) In case of serious injuries, the injured should be shifted to the nearest first-aid centre at site immediately. The opinion of medical officer/ certifying surgeon should be sought immediately for medical management.

(b) After providing the first aid treatment the injured should be shifted to designated medical facility of the site/hospital for further medical assistance, in an ambulance along with a nursing attendant.

(c) The doctor at the medical facility of the site/hospital attending the case shall assess the extent of injuries and render immediate medical aid. If the situation warrants trauma/special care the injured shall be shifted to the referral hospital, having all the requisite facilities for specialised treatment in ambulance along with a medical attendant.

(d) A list of such referral hospitals for specialised medical management facilities for the injured persons should be available with the project management/Head, industrial safety and Head, medical services of the site for ready reference.

APPENDIX-A

APPLICATION FOR HEIGHT PASS

PART- A

Group/Section: _____

Agency: _____

1. Applicant's Name : _____
2. Facility address : _____
3. Residential address : _____
4. Age : _____
5. Sex : _____
6. Height : _____
7. Gate Pass No. : _____
8. Name of contractor/agency with whom engaged at present : _____
9. Height pass required for work at _____ m. Height
10. Description of present job : _____
11. Previous experience of working at height :

S.No.	Name of the Employer	Duration of Employment	Work Experience
1.			
2.			

12. Does the applicant suffer from any of the following ailments? (If yes details to be given):

    (a) Blood pressure _____ (b) Epilepsy _____

    (c) Flat foot _____

    (d) Frequent headache or reeling sensation _____

    (e) Mental depression _____ (f) Limping gait _____

    (g) Aerofobia _____

Declaration:

I hereby declare that the above information furnished by me is true and correct. I shall always wear the safety belt and tie the life-line whenever working at unguarded heights of 3 m and above. I shall not misuse the height pass issued to me or transfer it to any other person. I shall never come to duty or work at height/depth under the influence of alcohol/drugs.

Date: Name:

Sign:

(Applicants name and signature or loss time injury (L.T.I) incase he cannot sign. In case of LTI an authorised person shall explain each point/item to the individual and certify on that behalf below the LTI)

I certify that I am satisfied with the above certification of the individual for the application of height pass and request for issue of height pass to him.

Name :

Sign :
(Agency Concerned)

Countersigned by:

Section Head (Facility)

PART- B

MEDICAL FITNESS CERTIFICATE

Certified that I, Dr. _____ have examined Shri _____ _____ aged _____ on (date) _____ who has signed below in my presence. General & physical examinations of Shri. _____ _____ do not reveal any abnormality. He does not suffer from any acute/ chronic skin disease or any contagious or infectious disease. His eye sight is normal with/without glasses. In my opinion, Shri _____ is physically and mentally fit for working at height.

Details of examinations are given below:

Personal attributes:

1. Height: _____
2. Chest: _____
3. Weight: _____
4. Hearing: _____
5. Sight: _____
6. Skin: _____
7. Heart beating: _____

Medical aspects:

1. Urine: _____
2. Blood pressure: _____
3. Epilepsy: _____
4. Flat foot: _____
5. Frequent headache or reeling sensation: _____
6. Mental depression: _____
7. Limping gait: _____
8. Aerophobia: _____

Name:

Sign :

Rubber Stamp of
Medical Practitioner
with Reg. No.

Signature of workman:

PART-C

INDUSTRIAL SAFETY SECTION

(Considering the above medical certificate, the applicant has appeared on the following practical tests conducted by industrial safety section and the results are given below (strike off whichever is in-applicable)

(a) Wearing a safety belt and tying the rope knot : Pass/fail

(b) Walking over a horizontal structure at 3 m. height wearing a safety belt : Pass/fail

(c) General physique (OK/Not OK)

The above applicant's performance in the above tests has been satisfactory/ unsatisfactory due to the following.

So I certify and issue this height pass to Shri _____ with Registration No. _____ in the height pass register. This is valid for one year from the date of issue i.e. up to _____

Date:

Name:

Sign.:
Scientific Assistant (Safety)

Safety Officer

APPENDIX-B

FORM - 1

APPLICATION FOR TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

[Prescribed under clause 4.6(d)]

1.	Name and address of user.	
2.	Reference of tender or work order (if applicable)	:
3.	Name & designation of tender/work order issuing authority.	:
4.	Power supply application number†	:
5.	Name and designation of tender/work order/work supervising authority (engineer-in-charge).	:
6.	Expected date of commencement of temporary supply	:
7.	Expected date of decommissioning of temporary supply	:
8.	Voltage level (LV/MV/HV)	
9.	Type of connection (1Ph/3Ph)	
10.	Connected load (Kw)	
11.	Maximum demand (KVA)/Power factor	
12.	Single line diagram* of proposed power distribution scheme along with equipment data sheet (downstream installation after point of connection).	Enclosed (Form-1A)/Not enclosed
13.	Name of overall supervisor and available qualified Staff	Enclosed (Form-1B)/Not enclosed
14.	Auxiliary equipment data sheet (meters, fire extinguisher, first aid box etc)	Enclosed (Form-1C/Not enclosed
15.	Name and designation of provider's representative to whom the application is addressed.	:
16.	Name and designation of authorized signatory of user, who had submitted this application	:

† Power supply application number shall be different for same user with multiple applications for temporary supply

* All the drawings and tables shall be signed by user's representative indicated against 16 above.

Signature of authorised signatory of user

Signed endorsement of work order supervising authority indicated against 5 above.

FORM - 1A

EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

(Prescribed against item-12 of form-1)

Name and address of user:

Power supply application Number:

Amendment No:-

References:- Single line diagram (SLD) of the power distribution scheme with all equipment details (Attach the SLD)

1. Identity	2. Type	3. Make & model	4. Manufacturer's S.No	5. Fixed/ Portable	6. Size	7. Last used date	8. Last test date	9. Latest test data	10. Rating

Signature of authorised signatory of user

Explanation of column headers:

1. Identity:- Identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/CB/MCB/MCCB/ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- Equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative e.g. length for cables or all dimensions if heavy equipment like transformer.
7. Last used date. date of last use else NEW
8. Last test date. latest test date by user or by manufacturer if NEW
9. Latest test data:- IR, HV, resistance, functional test data depending upon the type of equipment as desired by provider's representative.
10. Rating:- name plate rating of equipment like voltage, current, power (apparent, active, reactive), IP of enclosure, size(cable cross section) etc. depending upon the type of equipment and as desired by provider's representative.

FORM - 1B

STAFF DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-13 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Name	2. Address	3. Tel.No.	4. Responsibility	5. Certification detail	6. Resucitation training	7. Expe-rience	8. Other relevant training	9. Signature

Signature of authorised signatory of user

Explanation of column headers:

1. Name:- Name of agency/person
2. Address:-
3. Tel No:- regular, alternate and emergency telephone numbers
4. Responsibility:- whether responsible for installation, operation, maintenance, overall supervision etc. overall supervisor shall be indicated specifically.
5. Certification detail:- (a) type of certification e.g wire man license, electrical supervisor license, electrical contractor license, diploma in electrical engineering, degree in electrical engineering etc. (b) certifying agency e.g. state PWD, central PWD, CEA, name of college/university etc. (c) certificate/license number with date. (d) valid up to date or next renewal date must for contractor/supervisor license.
6. Artificial resuscitation training:- indicate YES/NO if the staff is trained to apply artificial resuscitation technique.
7. Experience.:- number of years of experience.
8. Other relevant training :- any other training in electrical/safety course. Indicate name of training, duration (days/months), training providing agency.
9. Signature:- original signature of individual.

FORM - 1C

AUXILIARY EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-14 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

Reference:- Layout drawing No. / _____

1. Identity	2. Type	3. Make and model	4. Manufacturer's S. No	5. Fixed/ Portable	6. Size	7. Last used date

Signature of user's representative

Explanation of column headers:

1. Identity:- identification mark/number/tag of equipment in layout drawing.
2. Type:- earthing rod/megger/multi meter/earth resistance meter/fire extinguisher/s and bucket/first aid box/resuscitation chart/rubber mat etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative.
7. Last used date. NEW for new equipment. NA for passive devices like chart/mat etc.

FORM-1D

[Prescribed under clause 4.6(e)]

Name of user agency **Power supply application number:-**

CERTIFICATE BY THE LICENSED ELECTRICAL CONTRACTOR

Certified that subject installations have been carried out by us or checked by us and is in accordance with I.E. Rules. The documents submitted with subject temporary power supply application (Form-1) is verified by us and the complete installation confirms to these documents.

We shall periodically inspect/check the installation so that no unsafe situation arises during use of this temporary power supply system. We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of licensed electrical contractor

Rubber seal of licensed electrical contractor

Date

CERTIFICATE BY THE USER

Certified that my/our installations have been carried out in accordance with the I.E. Rules and that I/We have employed competent agency/staff to handle the installations which is strictly as per the staff data sheet submitted in Form-1B.

We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of user

Name of signatory

Date

FORM -1E

[Prescribed under clause 4.6(f)]

CERTIFICATE BY THE SAFETY OFFICER

Certified that I have inspected the electrical installation referred here in after satisfying myself about the safe condition of the installation, I hereby recommend that the service connection be given to the contractor.

Signature of the safety officer

Name:

Date:

AUTHORISATION BY THE ELECTRICAL ENGINEER

The subject power supply application along with completed installation, necessary certificates (as per Form-1 of Appendix-B) is scrutinised by us. The proposal found to be in order and the installation can be energised on _____ in presence of your designated overall supervisor as indicated in Form-1B. Enclosed herewith the test report data sheet Form-1F. You are requested to carry out the periodic testing of equipment and submit the test report periodically as per this form.

Signature of the electrical engineer
of provider

Name of signatory

Date

FORM - 1F

TEST/MAINTENANCE REPORT DATA SHEET OF EQUIPMENTS OF TEMPORARY POWER SUPPLY SYSTEM AT WORK SITE DURING CONSTRUCTION
(Prescribed against form-1E)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Identity	2. Type	3. Last tested date	4. Next due date of any test	5 Frequency of IR test	6 Frequency of HV test	7. Frequency of earth resistance test	8. Other tests

Signature of electrical engineer of provider

Explanation of column headers:

1. Identity:- identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/ CB/ MCB/ MCCB/ ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Last test date: - latest test date indicated in Form-1A.
4. Next due date of any test:- as worked out by frequency of tests indicated in subsequent columns.
5. Frequency of IR test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
6. Frequency of HV test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
7. Frequency of earth resistance test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
8. Other tests: - name and description of any other essential tests/maintenance activity and required frequency depending upon type of equipment and location of installation. NA if not required after installation.

APPENDIX-C

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

(To be submitted to AERB along with application for construction consent and a copy to be retained by site)

(Verifiable documents like supplementary checklists, work sheets, spread sheets etc. should be maintained for each item of the checklist wherever relevant)

Serial No.	Points to be Checked	Remarks
1. 0	**Prior to Installation of the RMC Plant**	
1.1	Whether acceptance report on healthiness of the pre-identified critical plant equipment like concrete mixer, pumps, programmable logic controllers, conveyors, etc. prior to installation available ?	
1.2	Whether approval for the location of the plant site after evaluation and review by project management available ?	
1.3	Whether review of the vendor documents like operation and maintenance manual, vendor specifications, safety manual, etc. of contractor carried out by project management ?	
1.4	Whether job hazard analysis reports, erection procedures, checklists for critical activities available ? Are the operators aware of it ?	
1.5	Whether adequate number of line managers/supervisors/ operators for carrying out the jobs safely are identified and availability is ensured ?	
1.6	Whether safety surveillance requirements of construction activities both by contractor and facilities clearly spelt out?	
1.7	Whether adequate work control measures like construction permit, safety work permit system, height pass system, etc. for safe job performance are available ?	
1.8	Whether any facilities officer is assigned the responsibility of the RMC Plant ?	
2.0	**Commissioning/Operation of RMC Plant**	
2.1	Whether reports on healthiness of material handling equipment like hoists, belt conveyors, buckets, hoses, including electrical equipment etc. are available ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
2.2	Whether machine guards for pulleys, power shafts, rollers, etc. are available ?	
2.3	Whether availability of safe operating procedures, emergency procedures, process diagrams, power supply diagrams, details of interlocks, operation & maintenance manual (provided by supplier/vendor) ensured ?	
2.4	Whether adequate number of qualified, trained and experienced operators for safe operation of the plant including mechanism/method of operational control and command available ?	
2.5	Whether periodic surveillance programme for equipment, logics, interlocks, process parameters, trips, noise and illumination levels, etc. and measures to take corrective actions are available ?	
2.6	Whether periodic checks are carried out to ensure display of all interlocks and warning signals in PLC monitor ?	
2.7	Whether operations control measures like log sheets, work permits, procedures, instruction sheets, by-passing/jumpering trips, etc. are available ?	
2.8	Whether access to medical first-aid box & fire extinguishers, etc. available ?	
3.0	**Operating/Working Areas**	
3.1	Control Room	
3.1.1	Whether adequate information on process equipment and parameters, logics and control available ?	
3.1.2	Whether clear view of the plant from the control room to check entry of personnel into operating areas is available ?	
3.1.3	Whether availability of distinct window panels to distinguish process parameters, alarms and trips are verified ?	
3.1.4	Whether audio alarm is available in the field to give warning prior to starting of concrete mixer & conveyor belt ?	
3.1.5	Whether relevant operating and maintenance documents available and accessible ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
3.1.6	Whether operational controls preventing re-setting of operational parameters, trips by-passing, logic changes, etc. are available in control room ?	
3.1.7	Whether operational data and information logged chronologically indicating the status of equipment running & shutdown, maintenance works planned and taken up.	
3.1.8	Whether means of communication between operator and control room are available ?	
3.2	**Aggregates Storage/Handling Areas**	
3.2.1	Whether aggregates/materials stored separately in suitable weatherproof enclosures ?	
3.2.2	Whether routes for movement of vehicles clearly defined ?	
3.2.3	Whether reverse horns, rear view mirror, etc. on all dumpers/ trailers/trucks are provided ?	
3.2.4	Whether machine guards for rotating/moving/conveying machines available in place ?	
3.2.5	Whether engineered noise control measures available in the crushing areas ?	
3.2.6	Whether usage of ear muffs for ear protection in noisy areas enforced ?	
3.2.7	Whether trip/emergency stop switch/pull cord mechanisms, etc. to the moving/rotating equipment like belt conveyors, crushers etc. are available and healthy ?	
3.2.8	Whether adequate dust control measures in working areas available ?	
3.2.9	Whether adequate illumination is provided in the working areas ?	
3.2.10	Whether safety/warning sign boards available to prevent persons approaching operating crushers/belt conveyors etc ?	
3.3	**Storage Hoppers/Silos**	
3.3.1	Whether suitable access with handrails to reach to the top of hoppers/silos provided ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
3.3.2	Whether proper walk ways with guard railing to access to different storage areas available ?	
3.3.3	Whether measures to prevent clogging of equipment like air fluidiser, etc. are available ?	
3.3.4	Whether controls and safety measures for feeders like belt conveyors to the silos/hoppers, etc. is available ?	
3.3.5	Whether dust suppression and noise control measures are in place ?	
3.3.6	Whether safety measures to enter into silos/hoppers for operation/maintenance requirements.	
3.3.7	Whether safe access for sampling locations/areas and procedure for collecting the samples are available ?	
3.4	**Concrete Mixer Areas**	
3.4.1	Whether safe access and working platform in mixing area provided ?	
3.4.2	Whether safe condition of the mixers, pumps, etc. used in the areas is ensured ?	
3.4.3	Whether proper identification tags for equipment, pipelines etc. are available ?	
3.4.4	Whether safe condition of the electrical equipment like local push buttons, panels, cables etc. ensured ?	
3.4.5	Whether adequate illumination in the working areas is ensured ?	
3.4.6	Whether interlocks of Mixers are in healthy state ?	
3.4.7	Whether sand bin is provided with electro-mechanical vibrator for easy material flow ?	
3.4.8	Whether warning signals to prevent persons approaching operating mixers in place ?	
3.4.9	Whether proper storage of admixtures to prevent freezing and availability of material safety data sheets for admixtures and other chemicals are ensured ?	
3.4.10	Whether collection trays have been provided under overhead conveyor belt to prevent fall of material ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
3.4.11	Whether the mixing cylinder/drum has emergency manual discharge facility ?	
4.0	**Electrical Safety**	
4.1	Whether proper isolating switches/isolators are provided for all equipment in the field as well as in control room ?	
4.2	Whether proper grounding/earthing arrangement for all electrical installations metallic structures and panel boards provided and recording of earth pit resistance values planned ?	
4.3	Whether fuses of adequate rating are available to limit overloading of circuits ?	
4.4	Whether earth leakage circuit breakers in all circuits are provided and tested periodically to ensure their healthiness ?	
5.0	**Particulate Emissions**	
5.1	Whether provisions of measurement of particulate emissions are available ?	
5.2	Whether actions to be taken in case of more visual emissions are available ?	
5.3	Whether methods to prevent/control spread of dust in working areas available ?	
6.0	**General Requirements**	
6.1	Whether emergency services like fire station, first aid, hospital etc accessible ?	
6.2	Whether specific line staff/supervisors for carrying out routine, special and emergency works with certain instructions and communications identified and trained ?	
6.3	Whether do's and don'ts while handling refrigerants like ammonia and admixtures used in concrete mixing displayed promptly ?	
6.4	Whether the use of personal protective equipment like helmet, safety belt, self contained breathing apparatus/canister, hand gloves, apron, face shield, safety shoes, gumboots etc. has been ensured ?	

APPENDIX-C (CONTD.)

CHECKLIST FOR OPERATION OF READY MIX CONCRETE (RMC) PLANT

Serial No.	Points to be Checked	Remarks
6.5	Whether emergency procedures to be followed during ammonia leaks, fires, etc. are available ?	
6.6	Whether fire extinguishers are available at various critical locations ?	

PART-B

CONTROL OF WORKS
(CONTRACTORS)

7. INTRODUCTION

7.1 General

The Department of Atomic Energy(DAE) through its constituent units execute various site works either by their own manpower or by manpower of various outside agencies. The nature of contracts with outside agencies can be works contracts, engineering procurement contracts, purchase contracts, minor fabrication contracts etc. These site works involve entire gamut of conventional industrial activities like excavation, rock blasting, earth handling, construction, material handling, fabrication, installation, operation, maintenance etc. of nuclear or conventional plants/facilities. This is a challenging responsibility for the contractor due to the complexity of problems like quality of workforce (which may be unskilled, illiterate, migratory) available for labor-intensive jobs, lack of coordination among agencies at site, lack of safety awareness among concerned authorities, time schedules of project etc. As a principal employer, facility management shall be responsible to ensure health and safety of all personnel engaged for the work. In this process, the contractor through his established measures shall ensure that the guidelines are implemented. However the facility management shall monitor the compliance with the provisions outlined in the guidelines through periodic supervision and review. Any accidental injury or loss of life is detrimental to the facility as well as the society. This 'guidelines' covers the safety organisation and the safety management system requirements in sections two and three. The work specific safety precautions are covered in section four. The requirements relating to personal protective equipment and medical management are covered in sections 5 and 6.

7.2 Objective

This 'guidelines' has a basic framework of industrial safety organisation, safety management systems, safe work procedures to maintain a safe working environment for all personnel and to prevent any unsafe condition/act endangering the life of personnel engaged for industrial activities. The major objectives of this 'guidelines' are:

(i) To create awareness among workers about industrial hazards and safe working procedures.

(ii) To lay down safe work procedures and systems to be followed for different type of industrial activities.

(iii) To establish a robust safety management system.

(iv) To protect the health and ensure the safety of the workers from industrial activities.

7.3 Scope

This ‘guidelines’ is essential for implementation and assurance of conventional safety in areas such as industrial, chemical, electrical, fire, environmental and is applicable for all works executed through contracts, like engineering procurement contract, minor fabrication contract etc. Where the execution of work is envisaged in radiation controlled area or involves handling and fabrication of any nuclear material, additional precautions noted in relevant AERB safety documents on radiation protection shall also be applicable.

8. SAFETY ORGANISATION

8.1 General

(a) Construction projects have significant health and safety hazards, which need to be managed systematically since the project inception stage to achieve incident- free completion of jobs. Contractor should have well-defined safety organisation which helps in effective implementation of safety management systems and ensures health and safety of workers.

(b) The top management of contractor should assure that all the provisions of relevant Acts & Rules are conformed to.

(c) Safety organisation should carry out safety surveillance, safety training, safety enforcement measures, safety audit etc. related to all works to fulfill the overall safety requirements of this 'guidelines'.

(d) Safety functionaries should be exclusively assigned with the work related to protection of health and safety of workers.

(e) IS: 18001: 2007 gives detailed requirements of health and safety management system requirements. IS: 15793 gives requirements of good practices for managing environment, occupational health and safety legal compliance. This 'guidelines' prescribes requirements in addition to IS: 18001:2007 and IS: 15793 and gives guidelines on implementing these specific to a construction project.

(f) The requirements prescribed in various central and state regulations including *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and rules framed thereunder with respect to managing health and safety in construction projects, shall be complied with.

8.2 Organisational Structure for Safety Management

(a) The Contractor shall deploy qualified and experienced line management personnel for supervising the jobs to be carried out safely by workers. In order to oversee the industrial and fire safety aspects during execution of hazardous jobs (listed out in para 9.11) by the contractors, at least one safety supervisor with the qualifications and experience mentioned in Table -2 shall be in place irrespective of the man power deployed by the contractor.

(b) The qualification, experience and the minimum number of safety professionals to be deployed by contractor shall be as per the following table:

TABLE-2 : QUALIFICATION, EXPERIENCE AND NUMBER OF SAFETY PROFESSIONALS FOR CONSTRUCTION PROJECTS

Category of safety person	Mandatory requirement	Qualification
Safety officer	One in each shift (minimum) up to 1000 workers. If number of workers in a shift (including contractor's workers) exceeds 1000, additionally one safety officer should be deployed for every 1000 workers or part thereof.	Degree in engineering/ technology and diploma in industrial safety with minimum two years of experience or Diploma in engineering with diploma in industrial safety with minimum 6 years experience or A recognised degree in physics or chemistry and has practical experience of working in a factory in a supervisory capacity for a period of not less than 5 years. Not withstanding the provision contained in the above criteria any person who (i) possesses a recognised degree or diploma in engineering or technology and has had experience of not less than five years in a department of the central or state government which deals with the administration of the Factories Act, 1948 or the Dock Workers (safety, health and welfare) Act, 1986 (54 of 1986) or (ii) Possesses a recognised degree or diploma in engineering or technology and has had experience of not less than 5 years, fulltime on training, education, consultancy, or research in the field of accident prevention in industry or in any institution, shall also be eligible for appointment as a safety officer:

TABLE-2 : QUALIFICATION, EXPERIENCE AND NUMBER OF SAFETY PROFESSIONALS FOR CONSTRUCTION PROJECTS (CONTD.)

Category of safety person	Mandatory requirement	Qualification
		Provided that competent authority may, subject to such condition as it may specify, grant exemption from the requirement of this sub rule if in its opinion, a suitable person possessing the necessary qualification and experience is not available for appointment.
Safety supervisor	One in each shift (minimum) up to 500 workers or One Supervisor for any hazardous job (listed in para 9.11) if, carried out by Contractor irrespective of number of workers. If number of persons working in a shift (including the contractors' workers) exceeds 500, additionally one safety supervisor should be deployed for every 500 workers or part thereof.	Diploma in engineering and diploma in industrial safety

9. SAFETY MANAGEMENT

9.1 General

The construction agencies (contractors) shall be asked to submit a project specific health and safety plan (construction safety management plan) proposing the methodology for managing health and safety and their capability in completing the project in a safe manner.

9.2 Safety Policy

(a) The facility and the construction agency jointly or separately shall have a written statement prescribing the health and safety policy of the organisation. The health and safety policy conveys the management commitment and intent of the organisation towards health and safety, its organisation and arrangements to ensure that the set objectives are met. It also provides a framework for establishing, maintaining and periodically reviewing health and safety objectives and targets.

(b) Health and safety policy shall meet the requirements of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996 and IS 18001.

(c) The policy shall be communicated to all stakeholders through display and other means. The policy shall be displayed in local language(s) which may be understood by majority of the workmen.

9.3 Safety Plan

(a) A project specific health and safety plan shall be developed by the contractor and approved by the facility. On approval by the facility, health and safety plan shall be reference document for implementation, control and monitoring of health and safety aspects of the project by the Contractor.

(b) Project health and safety plan shall describe how the project specific health and safety objectives and targets shall be achieved. It shall define the road map for achieving the standards that an organisation lays down for itself so that efforts can be coordinated, synergized and monitored.

(c) Health and safety plan shall explain the means of establishing a positive health and safety culture at the project site. Health and safety plan shall identify and enumerate the control measures to mitigate the risks to the project completion arising out of health and safety issues so that the project is allowed to proceed without interruption and executed as per schedule.

Salient aspects that may be covered in the project health and safety plan are:

(i) Project specific health and safety objectives, targets and programmes in line with health and safety policy.

(ii) Hazard identification and risk assessment

(iii) Meeting legal and other requirements

(iv) Health and safety organisation

(v) Resources, roles, responsibility and authority

(vi) General health and safety rules

(vii) Health and safety requirements to be followed by sub-contractors

(viii) Operation control procedure

(ix) Activities requiring work permit system and its procedure

(x) Management of traffic safety inside the project

(xi) Access control of employees

(xii) Safety of visitors

(xiii) Management of critical activities such as work at height, material handling, working with plant and machinery, etc.

(xiv) Safe handling of chemicals, explosives, gas cylinders, electrical equipment etc.

(xv) Ensuring the competency and awareness of the workmen

(xvi) Fire prevention and fire fighting plan

(xvii) Emergency preparedness and response plan

(xviii) Traffic management plan

(xix) Training matrix

(xx) Personal protective equipment matrix

(xxi) Health and safety performance monitoring measures such as inspection and audit

(xxii) Incident reporting and investigation procedure

(xxiii) Proactive and reactive indicators of health and safety

(xxiv) Reward and reprimand for health and safety performance

(xxv) Checklist and formats.

(xxvi) Health monitoring plan for employees/workers exposed to hazardous jobs.

(d) The risk control measures identified shall meet the provisions of *Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act*, 1996, other legislations and provisions of various safety related standards.

(e) Procedures shall be established for timely recording and reporting of information required for continual improvement of health and safety performance.

Internal reporting procedures shall cover:

(i) Incident reporting

(ii) Non-conformance reporting

(iii) Health and safety performance reporting

(iv) Hazard identification reporting

External reporting shall cover

(i) Statutory reporting requirements

The recording of reporting of health and safety performance shall be clearly documented in the health and safety plan.

9.4 Roles, Responsibility and Authority

(a) Contractor shall define, document and communicate the roles, responsibilities and authorities of all personnel who manage, perform and verify activities having an effect on health and safety risks. It shall also include subcontractors and visitors.

(b) The line management personnel who are responsible for execution of activities are directly responsible for health and safety in the work under their control.

(c) Health and safety group and health and safety officers are responsible for guiding the top management of their own organisation on health and safety issues and facilitating the implementation of health and safety in the project site. For duties and responsibilities of health and safety officers refer Atomic Energy (Factories) Rules-1996.

(d) Health and safety supervisors shall be engaged to assist the health and safety officers in performing their duties.

(e) Management shall provide adequate resources essential to effectively manage the health and safety management system requirements of the project.

9.5 Design and Engineering

(a) Design drawings, construction methodology and plans shall be reviewed to determine whether any additional risks may arise during the construction due to the features in the design or methodology.

Attention shall be paid to:

(i) Providing permanent hooks and loops for tying safety slings of workers

(ii) Providing holes or such arrangements to the structure to which safe working platforms and safety nets can be connected

(iii) Laying permanent slings, grab rails/bars to be used by the workers

(iv) Permanent provision for attaching railings

(v) Provision for alternative access to the trapped or distressed workers

(vi) Provision for communication

(vii) Design facilitating barricading of the area around work site without causing hindrance to building functional activities

(viii) Durability of such safety related permanent design integrated elements

(ix) Other safety practices required for the type of woks involved

(x) Significant risks from construction materials, which cannot be avoided in the design.

(b) Analysis of design and integration of safety measures, as described above, should be undertaken as value engineering through multi-stakeholder consultation, necessarily involving designers, owner/ client, operation/maintenance management and construction agency.

(c) While need for special work methodology and enabling infrastructure is considered to make conditions safe for construction, attention shall also be drawn to the safety during maintenance operations (including inspections which may be necessary before project commissioning as well as maintenance).

(d) It shall also be ascertained whether it would be feasible (within the time and cost considerations) to erect necessary temporary enabling infrastructure. If, in the due assessment by the project manager, it is established that the design, as proposed, would continue to be unsafe during construction and maintenance operations unless special enabling infrastructure is created and work procedures specifically drawn, the design shall be reviewed.

9.6 Construction Planning

(a) Prior to the start of construction work, detailed planning shall be carried out which may include:

(i) Identifying aspects of design that have bearing on health and safety during construction stage.

(ii) While scheduling the various activities of the construction, allowing adequate time to carry work in accordance with health and safety requirements.

(iii) Reviewing the proposed work method of various activities, identifying health and safety hazards of activities in the project and assessment of the risk level.

(iv) When the risk level is unacceptable, taking additional control measures including revision of the work methodology so that identified risk is at ALARP (As Low as Reasonably Practicable) level.

(v) Planning and establishing the facilities for implementation of health and safety such as workmen training facility, health centre for medical check-up and first aid, access control of employees, etc.

(vi) Ensuring that the temporary establishments at project site such as site offices, workmen camps, toilets, canteens and rest sheds, etc. are created meeting the requirements of the relevant statutes and standards.

(b) Facility shall ensure that the construction agency has understood the challenges and has planned to meet the project specific health and safety requirement through appropriate competencies.

(c) Health and safety measures need proper coordination by the construction agency and such efforts of the construction agency shall be reviewed, monitored and appropriately guided by the facility.

(d) In respect of sub-contractors, project manager of the construction agency shall ensure that the sub-contractors meet the health and safety requirements of the project. Health and safety control and monitoring shall be established specific to the needs of the project.

9.7 Safety Communication

(a) Procedures shall be established to communicate significant hazards and risks to and from employees and other interested parties. The health and safety hazards and risks may be communicated in the following ways:

(i) Sharing of accidents case studies which occurred in the project site as well in other similar projects

(ii) Safety induction and orientation training

(iii) Health and safety posters and displays

(iv) Health and safety campaigns and competition involving the employees

(v) Sharing of results of the audits, inspections and other monitoring systems

(vi) Establishing a system for collecting feedback on health and safety from employees and other interested parties

(vii) Tool box meeting

(vii) Safety signage.

(b) Health and safety communications addressed to workmen shall preferably be in local language(s) understandable by majority of the workmen.

(c) The facility and construction agency shall jointly endeavour to promote a positive health and safety culture at the project. Top management of the organisations should exhibit a visible management commitment and felt leadership towards health and safety. This shall be achieved by participating in health and safety programmes such as:

(i) Project health and safety committee meeting

(ii) Health and safety walk down

(iii) Including health and safety in all performance review meetings

(iv) Exhibiting a safe behaviour while at site.

(d) The top management should clearly communicate that it considers safety as core value and it shall not allow it to get compromised. Such messages when it reaches down the level in the organisation enable to create a positive health and safety culture.

9.8 Safety Monitoring Programme

(a) The objective of the safety surveillance programme should address assurance of effective implementation of safety measures in execution of works. Following surveillance programme should be in place at sites. The safety organisation should monitor, maintain record and follow up for corrective actions.

(b) The surveillance programme should consist of identification of safety related deficiencies and status of corrections thereof, the implementation of protective measures, the safe work practices, human behavior etc.

(c) Specific surveillance should be ensured with respect to testing of equipment, portable power tools, electrical equipment and tools, hand tools, surveillance of material handling equipment, transport equipment, earth moving equipment, gas cylinders, stores, etc. to comply with various statutory requirements.

(d) Surveillance on safety awareness and training compliance including induction training, on the job training and refresher training, job specific pre-job briefing, job hazard analysis, etc. as per facility's guidelines should be ensured.

(e) Safety related deficiencies (SRDs) shall be detected by any employees/worker of construction agency and communicated to the line manager for corrective actions. The corrective action shall be monitored and records shall be maintained.

(f) Systematic updating of SRDs attended and pending should be made available by the contractor for verification of facility.

(g) The health and safety performance monitoring and measurement procedures shall provide for:

  (i) Both qualitative and quantitative measures appropriate to the project

  (ii) Monitoring the extent to which project health and safety objectives are met

  (iii) Proactive measures of compliance that measures compliance with health and safety plan, operational control procedures and legislation

  (iv) Reactive measures of performance to monitor accidents, ill health, near misses and non-conformances

  (v) Monitoring dangerous occurrences

  (vi) Fire occurrences

  (vii) First aid injuries.

(h) Health and safety inspections shall be preferably conducted by a team of the concerned engineer, health and safety officer and area in-charge of the contractor.

(i) The type of inspections that shall be carried out and the frequency shall be decided during the planning stage and documented in the project health and safety plan. The health and safety inspections should include:

(i) General site health and safety inspection

(ii) Electrical safety inspection

(iii) Plant and machinery inspection

(iv) Health and hygiene inspection

(v) Scaffolding safety inspection.

(vi) Portable tools and tackles

(vii) Lifting tools and tackles

(viii) Fire equipment inspections

(ix) Illumination level and noise level monitoring

(j) Status of health and safety implementation shall be measured and monitored by several proactive indicators which include the following:

(i) Compliance level of project health and safety plan

(ii) Compliance level of health and safety observations with in the target date

(iii) Implementation status of training plan

(iv) Implementation status of corrective and preventive actions

(v) Compliance level of pre-employment medical checks and periodic medical checkups

(vi) Compliance level of legal and other requirements

(vii) Percentage of activities for which detailed project specific risk assessment is conducted.

(k) Procedures shall be established to report, investigate and analyze incidents. The procedures shall involve:

(i) Members of the incident investigation team

(ii) Agencies to be reported in case of incidents

(iii) Time period within which incidents need to be reported

(iv) Methodology for investigation and determining the root cause of accidents.

These procedures shall form a part of the project health and safety plan and monitored on a regular basis for its effectiveness.

(l) All incidents including near miss cases, accidents and dangerous occurrences shall be thoroughly investigated, direct and root causes determined and corrective action planned. Incidents may be analysed covering the following ways to prepare and implement an effective prevention plan:

(i) Body part injured

(ii) Age of the victims

(iii) Time of accidents

(iv) Causes of accidents

(v) Nature of injury.

For detailed guidelines on analysis of incidents and computation of injury rate refer IS 3786.

(m) The following reactive health and safety indicators should be used to measure and monitor the health and safety performance of the project site:

(i) Number of near miss cases

(ii) Number of first aid cases

(iii) Lost time injury frequency rate

(iv) Lost time injury severity rate.

(n) The health and safety performance of subcontractors shall be monitored on a regular basis and necessary directive and support shall be given to achieve the set health and safety objectives and targets.

(o) All accidents leading to property damage/personnel injuries/fatal accident/near miss and dangerous occurrence should be reported to the facility's engineer-in-charge immediately

(p) All 'near-miss' accidents should also be recorded/reported and investigated and recommendations arising out should be implemented on priority.

9.9 Training/Orientation

(a) It shall be ensured that all employees are competent to perform the assigned work safely on the basis of appropriate education, training or experience. The competency requirements of different categories of employees shall be mapped and procedures shall be implemented to ensure that those deployed meet the competence requirements.

(b) The objective of health and safety training shall be to equip the employee with necessary knowledge and skill to perform the work assigned to him in a safe manner, to foster continual improvement and to imbibe safety culture.

(c) Preferably, the training should be carried out away from the working place of the participants to ensure focused attention on the training for both trainer as well as trainees.

(d) After completion of training due procedure shall be followed for obtaining the feedback from the participants on the effectiveness of the training. Effectiveness of training imparted shall be monitored for continual improvement and necessary corrections in implementation.

(e) The training/orientation programme should be implemented to meet the mandatory requirements. [Rule 43(2) (m) of the Atomic Energy (Factories) Rules 1996]. The training should be phased as follows:

(f) Induction cum orientation training should include the overall safety aspects of the work and give a general overview of the various hazards, the particular activities and the do's and don'ts. As a part of training, workers should also be given demonstrations on use of personal protective equipment, first aid and fire-fighting equipment, fire mock drills, other emergency preparedness etc.

(g) The line manager along with the safety representative should conduct pre-job briefing on day-to-day basis prior to specific hazardous jobs. This will make the workers aware of the hazards and the precautions to be taken.

(h) Refresher training should be imparted to each worker at least once in a year.

(i) A training schedule should be prepared by the construction agency and communicated to facility for concurrence.

(j) Records of training, demonstration and pep talk should be maintained.

9.10 Permit to Work System

(a) Activities requiring permit to work shall be decided before starting the construction and shall be suitably documented in the project health and safety plan. Some of the activities which shall require permit to work are:

(i) Excavation

(ii) Entry into confined spaces

(iii) Electrical work (HV/LV)

(iv) Opening manholes, covers and grills

(v) Blasting operation

(vi) Hot work

(vii) Work on plant and machinery and other power driven equipment

(viii) Working at height

(ix) Working at night

(b) The contractor should establish a permit to work system for any other hazardous activity, which it feels necessary to be controlled administratively for safe execution.

(c) Contractor should obtain valid safety work permit before carrying out any hazardous job and shall maintain a copy of it with him through out the period of his work. Record of safety work permit should be maintained in a systematic manner. All the safety conditions and requirements stipulated in the safety work permit should be ensured strictly.

(d) Contractor should ensure that only authorized personnel are deployed for hazardous works/jobs (refer item 3.11 for hazardous job) and provide facilities for the same.

9.11 Job Hazard Analysis

(a) It should be ensured by contractor that a safe work procedure exists for all the hazardous jobs as mentioned hereunder and the requirements of the safety procedures are ensured at the work sites. Job hazard analysis (JHA) should form a part of such safe work procedures. A checklist based on JHA should be prepared. This checklist should be crosschecked by the line managers and verified by safety officer.

Typical list of jobs requiring job hazard analysis (This list is illustrative only and not exhaustive) is as follows:

(i) Excavation

(a) Blasting including under water blasting

(b) Earth and stone removal/backfilling/dumping of earth/ stones

(c) Any excavation more than 1.8 m depth.

(ii) Work at height (working beyond 3.5 meters above ground)

(a) Erection and dismantling of scaffolding, platforms, shuttering/de-shuttering work

(b) Dome work, rod bending, construction of chimney and cooling towers

(c) Working on tower crane.

(iii) Materials and material handling

(A) Critical equipment handling e.g.

(a) Calandria

(b) Steam generators

(c) Turbine generator components

(d) Diesel generator set

(e) Generator stator

(f) End shields

(g) Fuelling machines components

(h) Heat transport pumps etc.

(B) Hazardous chemical handling e.g.

(a) Acids and alkalis

(b) Ammonia

(c) Chlorine

(d) Freon

(e) Hydrazine

(f) Hydrogen sulphide

(g) LPG

(h) Morpholine

(C) Movement of heavy material by crane

(D) Movement of tractor trolley on slopes

(E) Manual lifting of heavy material to height

(F) Erection of heavy machinery, equipment.

(iv) Electrical connection

(a) Field connection for electrical installation

(b) Installation of lighting fixtures

(c) Charging of electrical system

(d) Charging of transformer, switch yard, switch gears

(e) Working near high voltage lines

(f) Use of portable electrical tools.

(v) Equipment/structural erection work

(a) Material handling

(b) Loading and unloading

(c) Transportation of material from one place to other

(d) Steel fabrication and erection

(e) Cleaning and maintenance of batching plant equipment.

(vi) Finishing/painting work

(a) Painting at height

(b) Painting in confined space.

(viii) Other specific work

(a) Work with pneumatic tools/compressed air

(b) Work on pressure vessels/lines

(c) Work in the vicinity of steam lines

(d) Work in high enthalpy area

(e) Work in high noise area

(f) Work in confined space including tunnels and trenches

(g) Work in isolated area (away from main site)

(h) Radiography work

(i) Work related to welding, gas cutting, grinding

(j) Working near conveyor, rotating machine

(k) Leak detection testing.

9.12 Reward

(a) To motivate the employees and organisation to work safely measures can be implemented based on the suitability. Selection and rewarding for the following categories may be considered on regular basis:

(i) Safest workmen

(ii) Safest supervisor

(iii) Safest area

(iv) Safest sub-contractor, etc.

(v) Sub-contractors and employees may be rewarded when the project achieves significant million man-hours without any lost time injury.

10. WORK SPECIFIC SAFETY MEASURES

10.1 General

(a) The contractor should ensure that safety precautions are taken during the execution of awarded work and work areas are maintained safe at all times. At the end of each shift and at all times when the work is suspended, it should be ensured that the work area is left safe in such a way that no materials and equipment that can cause damage to existing property, personal injury or interfere with the other works of the project or station are left in an unsafe manner.

(b) The contractor should ensure to provide and maintain all lights, guards, fencing, warning signs, caution boards and other safety measures and provide for vigilance as and when necessary for the protection of workers and for the safety of others. The caution boards should also have appropriate symbols.

(c) Adequate lighting facilities such as floodlights, hand lights and area lighting should be provided at the site of work, storage area of materials and equipment and temporary access roads within the working area.

(d) All works should be planned so as to avoid interference with other facilities, works of other contractors or sub-contractors at the site. In case of any interference, necessary coordination should be ensured for safe and smooth working.

(e) It should be ensured that the instructions given by the safety officer or his designated nominee regarding safety precautions, protective measures, housekeeping requirements, etc. are complied with. The safety officer with due intimation to line manager should have the right to stop the work, if in his opinion, proceeding with the work will lead to an unsafe and dangerous condition. Line manager should arrange to get the unsafe condition rectified and/or provide appropriate protective equipment.

(f) Contractor should ensure that each job with a hazard whether small or big is intimated to the Head, industrial safety of the facility well before it is taken up.

(g) The contractor should be fully responsible for non-compliance of any of the safety measures or requirements, implications, injuries, fatalities, dangerous occurrences and compensation arising out of such situations or incidents.

(h) Maximum duty hours of an individual should be as per the Factories Act 1948 or its latest amendment.

(i) Illumination levels should be as per the statutory requirements.

10.2 Rock Blasting

(a) All blasting operations should be carried out on the basis of procedures approved by Head, industrial safety and engineer-in-charge. All works in this connection should be carried out as per BIS specification/code (IS 4081: 1986. Title:- Safety code for blasting and related drilling operations (First Revision)). Barricades, warning signs etc. should be placed on the roads/open area.

(b) Blasting permit should be obtained from Head, Industrial Safety at least one day before the blasting operation and precautions mentioned there in shall be ensured by the engineer-in-charge before blasting operation.

(c) The blaster should have a licence from competent authority under Explosive Rules, 1983 for blasting work. It should also be ensured that he knows about the risks involved.

(d) Blasting should be done under the supervision of competent engineer/ supervisor.

(e) Blasting in the open site should only be carried out during fixed hours every day/fixed day in the week between sunrise and sunset. Residents of adjacent area should be informed in advance about the blasting schedule.

(f) No blasting should be undertaken during thunderstorm.

(g) Necessary precaution should be taken to ensure the stability/integrity/ safety of the adjacent structure by limiting the peak particle velocity.

(h) No loose material, such as tools, drilling equipment, etc. should be left on the surface to be blasted. Proper muffling arrangement of the blasting area should be ensured to avoid flying of blasted material.

(i) Authorized blaster should personally ensure that all the personnel/ equipment has been removed from the blasting area before the blasting operations.

(j) Blasting area should be free of detonating gas, inflammable objects, sparking or damaged wiring system, stray currents and static electricity.

(k) All electrical lines in blasting area should be de-energised.

(l) Entry of unauthorized personnel should be prevented by displaying warning signs.

(m) In case of misfire, no person should be allowed to approach the blasting site unless it is inspected and cleared by a competent engineer/supervisor.

(n) Explosives and blasting material should be stored only in clean, dry, well-ventilated, suitably constructed bullet/magazine which should be fire resistant and securely locked. Stock book should be kept accurate and maintained. Licence should be obtained for storage of explosive as per the Explosives Act, 1884.

(o) Blasting caps, electric blasting caps or primers and detonators should not be stored in the same box, container or room with other explosives.

(p) Precautions against lightening should be provided in accordance with Indian Electricity Rules, 1956 (amended in 2000).

(q) The explosives should be transported in specially designed vehicles bearing a special sign or inscription entitled 'DANGER-EXPLOSIVES'. Also detonators separated from other explosive should be transported in a separate compartment.

10.3 Excavation, Trenching and Earth Removal

(a) Before taking up excavation work, necessary permission should be obtained from the engineer-in-charge with reference to existing underground services.

(b) The Line manager of the works should exercise full care to ensure that no damage is caused by him or his workmen, during the operation/excavation etc., to the existing water supply, sewerages, power or telecommunication lines or any other services or works. He should provide and erect before construction, substantial barricades, guardrails, and warning signs around the work area. He should also furnish, place and maintain adequate warning lights, display board, signals etc., as required.

(c) All trenches 1.2 m or more in depth should at all times be supplied with at least one ladder for every 30 m along the trench. Ladders shall extend from bottom of the trench to at least 1 m above the surface of the ground.

(d) The sides of the trench/pit in soil, which are 1.2 m or more in depth should be stepped back to give suitable slope (angle of repose) or securely held by timber bracing or appropriate shoring/support, to avoid the danger of soil slides from collapsing. The excavated material should not be placed within 1.5 m or half of the depth of the pit whichever is more from edges of the trench/pit. Cutting should

be done from top to bottom. Under no circumstances mining or under-cutting should be done.

(e) Workers should not be exposed to the danger of being buried by excavated material or collapse of shoring. Measures to prevent dislodgment of loose or unstable earth, rock or other material from falling into the excavation by proper shoring shall be ensured.

(f) The stability and safety of the excavation, adjacent structures, services and other works should be ensured.

(g) All excavated area should be fenced off by suitable railing and installation of caution board to warn the persons from slipping or/ falling into the excavation pit/ mound.

(h) All excavated areas shall have an illumination level of at least 20 lux for night work and a red danger light shall be displayed at prominent place near the excavation site to warn approaching traffic and men.

(i) For removal of earth from an earth mound/excavated heap a written permission should be obtained from the engineer-in-charge of the work. As far as practical, earth should be removed mechanically. Wherever manual removal of earth is involved, earth should be removed from the top by maintaining a slope equal to the angle of re-pose of the earth. Such work should be constantly supervised to ensure that no under-cutting is done and to ensure that no person is trapped.

(j) Dumping of excavated soil should be done at a specified area under proper supervision with respect to signaling, illumination and safety clearance.

(k) It should be ensured that at a construction site of a building or other construction work, every vehicle or earth moving equipment is equipped with (a) silencers, (b) tail lights, (c) power and hand brakes, (d) reversing alarm (e) search light for forward and backward movement, which are required for the safe operation of such vehicle or earth moving equipment and (f) the cab of the vehicle or earth moving equipment is kept at least one meter from the adjacent face of a ground being excavated. (g) indicator etc.

(l) It should be ensured that when a crane or shovel is traveling, the boom of such crane or shovel is in the direction of such travel and the bucket or scoop attached to such crane or shovel is raised and without load, except when it is traveling downhill.

(m) Before loading or unloading power trucks or trailers attached to tractors, the brakes should be applied and if vehicle is on a sloping

ground, the wheels should be blocked. Handcart should not be used for the transfer of construction/erection materials in the construction area. However if the exigency demands urgent transfer of light materials a small handcart may be permitted with the prior approval of the Engineer-in-charge.

(n) It should be ensured that at a construction site of a building or other construction work:

(i) All transport or earth moving equipment and vehicles are inspected at least once in a week by responsible persons and in case any defect is noticed in such equipment or vehicle, it is immediately taken out of service.

(ii) Safe gangways are provided for to and fro movement of building workers engaged in loading and unloading of lorries, trucks, trailers and wagons.

(iii) All earth moving equipment, vehicles or other transport equipment be operated only by such persons who are adequately trained and possess such skills as required for safe operation of vehicles or other transport equipment.

(iv) Trucks and other equipment are not loaded beyond their safe carrying capacity, which should be clearly marked on such trucks and other equipment.

(v) No unauthorised person rides the transport equipment employed in such work.

(o) It should be ensured at a construction site of a building or other construction work that:

(i) A shovel or an excavator whether operated by steam or electric or by internal combustion used for such work is constructed, installed, operated, tested and examined as required under any law for the time being in force and the relevant national standards.

(ii) Buckets or grabs of power shovels are propped to restrict the movement of such bucket or grabs while being repaired or while the teeth of such bucket or grabs are being changed.

(p) It should be ensured at a construction site of a building or other construction work that:

(i) An operator of a bulldozer before leaving - applies the brakes, lowers the blade and ripper and puts the shift lever into neutral.

(ii) A bulldozer is parked on level ground at the close of the work.

(iii) The blade of a bulldozer is kept low when such bulldozer is moving uphill.

(iv) Bulldozer blades are not used as brakes except in an emergency.

(q) It should be ensured at a construction site of a building or other construction work that:

(i) A tractor and a scraper are joined safely at the time of its operation

(ii) The scraper bowls are propped while blades of such scraper are being replaced.

(iii) A scraper moving downhill is driven in low gear.

(r) It should be ensured at a construction site of a building or other construction work that:

(i) Before a road roller is used on the ground, such ground is examined for its bearing capacity and general safety, especially at the edges of slopes such as embankments on such grounds.

(ii) A roller is not moved down hill with the engine out of gear.

(s) Vehicle carrying excavated material should have proper cover over the driver's cabin.

10.4 Safe Means of Access/Platforms

(a) Adequate safe means of access and exit should be provided for all work places, at all elevations.

(b) Suitable scaffolds should be provided for workmen for all works that cannot be done safely from the ground, or from solid platform except such short duration work that can be done safely from ladders. Bamboo/wooden scaffolding should not be permitted.

(c) Where the platform for working is more than 3.5 m above ground, the width of the platform should be minimum 1 m.

(d) Ladder should be of rigid construction having sufficient strength for the intended loads. Wooden/bamboo/rope ladders should not be permitted. All ladders should be maintained in good condition. The ladders should be fixed to the ground or rigid platforms. An additional person should be engaged for holding the ladder, if ladder is not securely fixed. Ladder shall be extended from floor to at least one meter above the platform.

(e) A portable ladder should be given an inclination not steeper than 1 in 4 (1 horizontal and 4 vertical). Ladders should not be used for climbing while carrying materials in hands. While climbing both the hands should be free.

(f) Any working platform on scaffolding or staging more than 3.5 m above the ground or floor should have a guard rail attached, bolted, braced at least 1.0 m high above the floor or platform of such scaffolding or staging along with mid-rail.

(g) The planks used for any working platform should not project beyond the end supports to a distance exceeding four times the thickness of the planks used. The planks should be rigidly fixed at both ends to prevent sliding, slipping or tilting. The thickness of the planks should be adequate to take load of men and materials and should not collapse. Plywood or packing wood should not be used as planks.

(h) The guardrail should extend along the entire exposed length of the scaffolding with only such opening as may be necessary for the delivery of materials. Standard railing should have posts not more than 2 m apart and an intermediate rail halfway between the floor or platform of the scaffolding and the top rail. Such scaffolding or staging should be so fastened as to prevent it from swaying from the building or structure. Scaffolding and ladder should conform to IS 3696 (Part I): 1987 and (Part II): 1996.

(i) Working platforms of scaffolds should have toe boards at least 15 cm in height to prevent materials from falling down.

(j) A sketch of the scaffolding proposed to be used should be prepared and approval by the engineer-in-charge obtained prior to start of erection of scaffolding. All scaffolds should be examined by engineer-in-charge before use.

(k) Working platform, gangways and stairways should be so constructed that they should not sag unduly or unequally and if the height of the platform or gangway or stairway is more than 3.5 m above ground level or floor level, they should have adequate width for easy movement of persons and materials and should be suitably guarded.

(l) No single portable ladder should be used for access to a height of more than 4.5 m. For ladders up to 3m in length the width between styles (side bars)/width in the ladder should in no case be less than 300 mm. For longer ladders this width should be increased by at least 20 mm for each additional meter of length. Step/rungs spacing should be uniform and should not exceed 300 mm. Portable ladder should be used only for access to work place. In case work place is higher than 4.5 meters, pre-fabricated steel staircase should be used.

10.5 Work at Height

(a) Person to work at height should be medically fit and should have height pass issued by safety section. (Appendix-D Part A, B and C). Safety training should be imparted before working at height.

(b) Safety work-permit system for working at height should be obtained from industrial safety section.

(c) At elevated places, secure access and foothold should be provided. Adequate and safe means of access and exit should be provided at all work places for all elevations. Means of access may be portable or fixed ladder, ramp or a stairway. The use of crosses, braces or framework, as a means of access to the working platform should not be permitted.

(d) Linear movement at height should be reduced to minimum. In case of such movement provision for anchoring the safety belt should be made.

(e) Where barricades cannot be installed, a safety net of adequate strength should be installed close to the level at which there is a danger of fall of personnel/fall of objects.

(f) In case where 'work at height' is on asbestos roof, crawling board/ roof ladder should be used to walk across the asbestos roof.

10.6 Electrical Safety

(a) All electrical installations shall comply with the appropriate statutory requirements given below and shall be subject to approval of the Electrical Engineer and Safety Officer.

(i) The Electricity Act, 2003

(ii) The Indian Electricity Rules 1956 (as amended in 2000)

(iii) The National Electricity Code 2008

(iv) Atomic Energy (Factories) Rules, 1996

(v) Other relevant rules of Statutory Bodies and power supply authority

(vi) Relevant standards of BIS

In addition to the above statutory provisions, the clauses indicated in this document shall also be complied.

(b) It shall be the responsibility of the user seeking temporary power supply to indicate in writing, if any of the clauses (requirements

noted in above regulations and in this document) are conflicting with each other and for which the user cannot decide the course of action regarding safe installation, commissioning, operation, maintenance and decommissioning of the electrical installations.

(c) The electrical engineer and safety officer of the agency providing temporary power supply shall interpret the concerned conflicting clauses and approve in writing the safe course of action.

(d) The application Form-1 (Form-1A, 1B and 1C) as mentioned in Appendix-E should be submitted by the user for getting the temporary power supply.

(e) After installation of temporary electrical panels, wiring works by the user, Certificates as per Form-1D (Appendix-E) should be submitted to the provider.

(f) Certificate of safety officer and authorization of electrical engineer for energisation of temporary power supply should be filled as per Form-1E (Appendix-E).

10.7 Material Handling and Lifting Machines and Tackles

(a) It should be made compulsory to supervise jobs like lifting/placing/ loading/unloading/carrying/transporting etc. of heavy material by qualified supervisor having knowledge about hazards involved and precautions to be taken for such job.

(b) The line managers should ensure that the material handling equipment used is adequate to handle the load.

(c) Manual pulling of heavy equipment and trolley loaded with heavy material is not to be permitted.

(d) Stacking and handling of heavy materials should be done on a firm ground to prevent settlement.

(e) No lifting machine and no chain, rope or lifting tackle, except a fiber rope or fiber rope sling, shall be taken into use for the first time in that factory unless it has been tested and all parts have been thoroughly examined by a competent person. A certificate of such a test and examination specifying the safe working load or loads and signed by the person making the test and the examination has been obtained and is kept available for inspection.

(f) Use of lifting machines and tackles should conform to relevant BIS requirements [IS 13367 (Part 1): 1992 Reaffirmed 2003, IS 4573: 1982 (Reaffirmed 2000) and IS 13834 (Part 1): 1994 Reaffirmed 2003 etc. The accessories and the attachments, anchorages and

supports etc. should be ensured in healthy conditions by regular inspections at defined frequencies.

(g) Every rope used in hoisting or lowering materials or as a means of suspension should be of good quality and adequate strength and free from any defect. This should be ensured by regular inspection as per IS 2762: 1982- Specification for wire rope slings and sling legs (first revision).

(h) Every crane operator or lifting appliance operator should be authorized. No person under the age of 18 years should be in charge of any hoisting machine or give signal to an operator of such machine.

(i) In case of every lifting machine (and of every chain, ring, hook, shackle, swivel and pulley block used in hoisting or as a means of suspension) the safe working load should be ascertained and clearly marked. In case of a lifting machine having a variable safe working load, each safe working load and the conditions under which it is applicable should be clearly indicated. No part of any machine should be loaded beyond the safe working load except for the purpose of testing. This should be approved by the engineer-in-charge and Head, Industrial Safety.

(j) In case of facilities machines, the safety of the machines shall be ensured by the Engineer-in-charge. As regards the Contractor's machines, the contractor should declare the safety of the machine to the Engineer-in-charge whenever he brings any machinery to site of work and get it verified by the engineer-in-charge, supported by a valid test certificate by the competent person.

(k) Thorough inspection and load testing of lifting machines and tackles should be done in the presence of competent person at least once in every 12 months and records of such inspections and testing should be maintained.

(l) No mobile crane should be allowed to move under live high-tension power transmission line.

(m) While lifting loads, cranes should be located on level ground.

(n) A thorough load analysis should be carried out before using cranes in tandem.

(o) Motors, gear transmission, couplings, belts, chain drives and other moving parts of hoisting appliances should be provided with adequate safeguards. Hoisting appliances should be provided with such means, which will reduce the risk of any part of a suspended load becoming accidentally displaced or lowered.

(p) It should be ensured that the cabin of the lifting machine in outdoor service:

(i) is made of fire resistant material,

(ii) has a suitable seat, a footrest and protection from vibration,

(iii) affords the operator an adequate view of the area of operation,

(iv) affords the operator adequate protection against the weather, and

(v) is provided with fire extinguisher.

10.8 Welding and Gas Cutting

(a) Welding and gas cutting operations should be done by qualified and authorized persons only.

(b) Safety work permit shall be obtained (wherever necessary like presence of flammable or combustible material etc.) before flame cutting/welding is taken up.

(c) Welding and gas cutting should not be carried out in places where flammable or combustible materials are kept and where there is danger of explosion due to presence of gaseous mixtures. In case the requirement cannot be avoided, specific approval and procedure should be ensured and adequate precautions should be taken.

(d) Welding and gas cutting equipment including hoses and cables should be maintained in good condition.

(e) Barriers should be erected to protect other persons from harmful rays from the work. When welding or gas cutting is done in elevated positions, precautions should be taken to prevent sparks or hot metal falling below on persons or combustible materials.

(f) Suitable type of protective clothing consisting of fire resistant gauntlet gloves, leggings, boots and aprons should be provided to workers as protection from heat and hot metal splashes. Face shields with filter glasses of appropriate shade should be worn.

(g) Adequate ventilation should be provided while welding, brazing and cutting the metals like zinc, brass, bronze, galvanised or lead coated material.

(h) Welding and gas cutting on drums, barrels, tanks or other containers should be taken up only after ascertaining that they have been emptied, cleaned thoroughly and made free of flammable material.

(i) Fire safety measures should be available as required near the location of welding/cutting operations.

(j) Flash back arrestor should be provided with gas cutting and gas welding sets.

(k) For electric (Arc) welding the following additional safety precautions should be taken:

(i) When electrical welding is undertaken the return lead of welding machine should be directly connected to the job invariably.

(ii) Provision must be in place in electric welding machine to prevent physical contact with live parts.

(iii) The welding cables and power cables should be routed separately to avoid entanglement.

(iv) The electric welding set should have suitable earth connections. There should be an electrical isolation device in the input power supply side on the welding machine.

(l) Double gauges should be used for all gas cylinders used for cutting/ welding. Pressure gauges/regulators should be in healthy condition.

10.9 Rotary Cutters/Grinders

(a) All portable cutter/grinders should be provided with the wheel guard in position.

(b) Grinding wheels of specified diameter only should be used on all grinders in order to limit the prescribed peripheral speed.

(c) In pedestal grinder, the gap between tool rest and grinding wheel should be maintained less than 3 mm.

(d) Goggle/face shield should be used during grinding operation.

(e) No grinding wheel should be used after its expiry date.

(f) Ear muff/ear plug should be used during the welding /cutting jobs.

(g) Portable appliances, which are powered by single phase AC supply, shall be provided with three-core cable and three pin plug, otherwise the whole body should be double insulated.

(h) Safety work permit should be obtained (wherever necessary like presence of flammable or combustible material etc.) before grinding is taken up.

(i) Fire safety measures should be available as required near the location of grinding operations.

10.10 Concrete Mixing Equipment

(a) Cement bags should be stacked on wooden planks in dry and leak proof area, 150 mm to 200 mm from the floor and 450 mm away from walls. Height of the stack should not be more than 15 bags or 1.5 meters which ever is lower. Width of the stack should not be more than 4 bags or 3 meters. Lateral loading of the walls of the storage room by stacking should not be permitted. Stacking of the bags should not be used as a working platform.

(b) Shuttering and supporting structures should be of adequate strength and approved by engineer-in-charge. This should be ensured before concrete is poured.

(c) If the mixer has a charging skip the operator should ensure that the workmen are out of danger before the skip is lowered.

(d) Adequate walking platforms are to be provided in the reinforcement area to ensure safe walking for pouring concrete on the roof.

(e) When workmen are working/cleaning the inside of the drum of mixer, the power of the mixer should be switched off and 'Do not operate' tag should be provided. The plant operation and cleaning of mixing pan should be carried out as per equipment supplier's instructions.

(f) Interlocks between the cover and the mixer rotor shall be established to ensure that the agitator does not start when the cover is in open condition.

(g) It should be ensured that moving parts of the elevators, hoists, screens, bunkers, chutes and grouting equipment used for concrete work and of other equipment used for storing and transporting of ingredients of concrete are securely fenced to avoid contact of workers with such moving parts.

(h) It should be ensured that screw conveyors used for cement, lime and other dusty material are completely enclosed.

(i) Workers engaged for handling bulk cement in a confined place should be provided with tight fitting goggle, approved respirators and protective clothing, which will fit snugly around the neck, wrist and ankles.

(j) The following should be ensured for every pipe carrying pumped concrete:

  (i) The scaffolding carrying a pipe for pumped concrete should be strong enough to support such pipe at a time when such pipe is filled with concrete or water or any other liquid and to bear safely all the building workers who may be on such scaffold at such time.

(ii) Securely anchored at its end point and each curve on it.

(iii) Provided with an air release valve near the top of such pipe; and securely attached to a pump nozzle by a bolted collar or other adequate means.

(k) The following should be ensured while using the electric vibrators in concreting work at a construction site of a building or other construction work such that:

(i) Such vibrators are earthed.

(ii) The leads of such vibrators are heavily insulated.

(iii) The current is switched off when such vibrators are not in use.

10.11 Painting

(a) Appropriate breathing air respirators should be provided for use by the workers when paint is applied in the form of spray, or a surface having lead paint is dry rubbed or scraped.

(b) Only the quantity of paint, thinner and polish required for the day's work should be kept at the work spot. Excess storage should not be permitted at the work spot.

(c) Smoking, open flames or sources of ignition should not be allowed in places where paints, varnish, thinner and other flammable substances are stored, mixed or used. A caution board, with the instructions written in national language and regional language, 'SMOKING - STRICTLY PROHIBITED' should be displayed in the vicinity where painting is in progress or where paints are stored. Symbols should also be used on caution boards.

(d) All electrical equipment of paint storage room should be of explosion proof design. Suitable fire extinguishers / sand buckets should be kept available at places where flammable paints are stored, handled or used.

(e) When painting work/hot resin mix is done in a closed room or in a confined space, adequate ventilation should be provided and ensured. In addition, suitable respirators should be provided. No portable electric light or any other electric appliance of voltage exceeding 24 volts should be permitted for use inside any confined space. Walkie-talkie or other means of communication should be provided. Rescue arrangement like full body harness with lifeline, tripod with pulley and extra BA sets should be available.

(f) The workers should use PVC gloves and/or suitable barrier creams to prevent the skin contact with Epoxy resins and their formulations used for painting.

10.12 Demolition

(a) Before any demolition work is commenced and also during the progress of the work, all roads and open area adjacent to the work site should either be closed or suitably cordoned. Appropriate warning signs should be displayed for cautioning approaching persons/ vehicles.

(b) Before demolition operations begin, it should be ensured that all the service lines are de-energized.

(c) Persons handling demolition operations shall use appropriate PPE.

(d) All demolition operations should be carried out with safe and duly approved procedures which shall include following but not limited to:

(i) No masonry/material should be permitted to fall in such masses or volume or weight so as to endanger the structural stability of any floor or structural support.

(ii) No wall, chimney or other structure or part of a structure is left unguarded in such a condition that it may fall, collapse or weaken due to wind pressure or vibration.

(iii) No floor roof or other part of the building should be overloaded with debris or materials as to render it unsafe.

(e) After the demolition, the debris and other materials collected should be disposed safely and not permitted to be dropped freely.

(f) Entries to the demolition area shall be restricted to authorized persons wearing safety helmets and safety shoes.

10.13 Traffic

(a) All the vehicles moving at sites should conform and comply with the requirements of Motor Vehicles Act, 1988 and the Rules made thereunder. All the drivers /operators of vehicles should possess valid driving license as per Motor Vehicles Act, 1988 or its latest amendment.

(b) When the construction work causes interference with traffic such as road cutting or transit unloading of heavy equipment etc. notice of such interference should be given to the engineer-in-charge and Head, industrial safety well in advance with the details of start of the work and time required.

(c) A cleaner/assistant must be available for all heavy vehicles whenever vehicles move forward as well as in the reverse direction. All vehicles should be fitted with proper reverse horns, back view mirrors and indicator signals.

(d) Facility shall ensure that the assessment of the driver's visual ability is carried out as per Rule 55 of the Atomic Energy (Factories) Rules, 1996/guidelines of advisory committee on occupational health (ACOH), AERB or as per the latest amendments in statutes.

(e) Effective speed breakers with yellow stripes on the roads to regulate the speed at the vulnerable points should be installed. Effective barricading with adequate caution signs should be placed to warn the vehicle drivers whenever the jobs are carried out on the road.

(f) All vehicles moving at the site should have roadworthiness certificate issued by the concerned authority.

(g) Special limit boards and caution boards indicating turns should be installed wherever necessary.

(h) In general, the following maximum speed limits should be specified and implemented. Vehicles speed limits should be as per Motor Vehicle Act or 20 Km/h. Extra precautions and care should be exercised particularly during heavy material/equipment movements.

(i) Safety awareness programmes should be conducted for all the drivers of the light, medium and heavy vehicles.

10.14 Work in Radiation Area

The facility shall follow the stipulations under Atomic Energy (Radiation Protection) Rules, 2004 and AERB Safety Manual on 'Radiation Protection for Nuclear Facilities'[AERB/NF/SM/O-2 (Rev.4)] with regard to work in the radiation area and other works related with radiography, etc.

10.15 Work in and Around Water Bodies

(a) When work is done at a place where there is risk of drowning, all necessary rescue equipment such as life buoys and life jackets should be provided and kept ready for use.

(b) All necessary steps shall be taken for prompt rescue of any person in danger and adequate provision should be made for prompt first-aid treatment of all injuries likely to be sustained during the course of the work. Proper record of entry/exit to and from water bodies shall be maintained on shift basis and search operation shall be conducted as soon as any person is detected to be missing.

(c) Caisson Work

(i) Safe means of access should be provided to the place of work in the caisson and adequate means should be provided to safely reach the top of caisson in the event of inrush of water.

(ii) The work relating to construction, positioning, modification or dismantling of caisson shall be done under the supervision of a responsible person.

10.16 Fire Safety

(a) Provisions prescribed in the AERB safety standard on 'Fire Protection Systems for Nuclear Facilities', [AERB/NF/SS/FPS (Rev. 1)] shall be complied.

(b) All necessary precautions should be taken to prevent outbreak of fires at the construction site. It should be ensured that all hot works are carried out under valid work permit.

(c) Combustible materials such as wood, cotton waste, oil, coal, paints, chemicals etc., should be segregated and kept to the required bare minimum quantity at work place.

(d) Containers of paints, thinners and allied materials should be stored in a separate room which should be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint should be kept covered or properly fitted with lid and should not be kept open except while using.

(e) Adequate number of trained persons from approved fire training centre required to extend fire safety coverage should be ensured.

(f) Fire extinguishers as approved by the engineer-in-charge/in-charge of fire station/safety in-charge should be located at the construction site at appropriate places.

(g) Adequate number of trained workmen in fire fighting who can operate fire extinguishers should be ensured.

(h) Portable fire extinguishers with periodic inspection, maintenance and re-filling complying with the mandatory requirements should be ensured.

(i) Availability of adequate water for fire fighting should be ensured.

(j) Implementation of the provisions of various statutory licenses for storing gas cylinders, petroleum products, explosives etc. as per the relevant Acts and Rules should be ensured wherever required.

10.17 Environmental Safety

Relevant provisions of the state/central statutory authority regarding environment protection should be adhered to.

10.18 Public Protection

The Contractor should make necessary provisions to protect the public. He should be bound to bear the expenses in defense of every action or other proceedings at law that may be brought by any person for injury sustained owing to neglect of any precaution required to be taken to protect the public. He should pay for the any such damage and cost which may be awarded in any such suit, action or proceedings to any such person, or the amount, which may be fixed as a compromise by any such person.

10.19 Safety of Visitors

(a) Visitors for the project shall be given health and safety induction before they are allowed in to the construction project. It shall include the minimum PPE to be used, hazards and risks at the work area, restricted areas of entry, emergency response arrangements, etc.

(b) Visitors shall always be accompanied by one of the employees of the project site.

(c) Visitors shall not be allowed in the hazardous areas unless they are competent and trained to work in such areas.

10.20 Housekeeping

(a) It should be recognized that a proper place for everything and everything in its place is maintained for a good housekeeping.

(b) The material required for immediate use only should be brought to the designated workplace and stacked properly and labeled suitably.

(c) All work spots, site office and surroundings should all times be kept clean and free from debris, scrap, concrete muck, surplus materials and unwanted tools and equipment. A day-to-day collection and disposal of scraps/debris should be done safely at designated place.

(d) Electrical cables should be so routed as to allow safe traffic by all concerned. Cable should be preferably supported on the brackets fixed along the wall to maintain safe access. Wherever routing on the floor cannot be avoided, care should be taken to ensure mechanical protection of these cables and safe access is not disturbed.

(e) No material at any work place should be so stacked or placed or disposed off as to cause danger, inconvenience or damage to any person or environment.

(f) All unused scaffoldings, surplus/scrap materials and equipment/ systems like temporary electrical panels etc. should not be allowed to accumulate and shall be removed from the premises at the earliest.

(g) Accumulation of water /oil spillages on the floor or any other workplace should be avoided.

(h) Proper aisle space marking should be provided in all workplaces.

10.21 Other Statutory Provisions

Notwithstanding the clauses in the above subsections, there is nothing in these clauses to exempt the contractor from the provisions of any other Act or Rules in force in the Republic of India. In particular, all operations involving the transport, handling, storage and use of explosives should be as per the standing instructions and conform to the Indian Explosives Act, 1884 and the Explosives Rules, 1983. Handling, transport, storage and use of compressed gas cylinders and pressure vessels should conform to the Gas Cylinder Rules 2004 and Static and Mobile Pressure Vessels (Unfired) Rules 1981. In addition, The Indian Electricity Act 2003 and Indian Electricity Rules 2005, the Atomic Energy Act, 1962, the Radiation Protection Rules, 2004, the Atomic Energy (Factories) Rules, 1996 and AERB safety manual on 'Radiation Protection for Nuclear Facilities' [AERB/NF/SM/O-2 (Rev.4)] should be complied with.

11. PERSONAL PROTECTIVE EQUIPMENT

11.1 General

Although the primary approach in any safety effort is that the hazard to the workmen should be eliminated or controlled by engineering methods rather than protecting the workman through use of personal protective equipment (PPE). Engineering methods could include design change, substitution, ventilation, mechanical handling, atomization etc. Under those situations when it is not possible to introduce any effective engineering methods for controlling hazards, it is necessary that workman use appropriate type of PPE. For example, in construction work there is the possibility of a hand tool, a bolt, or some loose material to fall from an elevated level and striking the head of workman working below. It is therefore necessary that construction worker wear a safety helmet. It is for such situations, both the Factories Act 1948 and the Atomic Energy (Factories) Rules, 1996 have provisions for use of appropriate type of PPE.

It is thus recognized that use of PPE is an important and necessary consideration in the development of a safety programme. Once the safety professional decides that PPE is to be used by workmen, it is essential to select right type of PPE and construction agency should ensure that workman uses it and also PPE is correctly maintained.

11.2 Personal Protective Equipment (PPE)

(a) All personal protective equipment as considered necessary should be made available for the use of the persons employed on the site and maintained in a condition suitable for immediate use. Also adequate steps should be taken by line manager to ensure proper use of PPE.

(b) All the PPEs in use should be as per relevant IS standards as referred in the AERB safety guidelines on 'Personal Protective Equipment' (AERB/SG/IS-3).

(c) All persons employed at the construction site should use safety helmets. Safety helmet should be with BIS mark and should have its headband with back support and chin strap.

(d) Workers employed on mixing asphaltic materials, cement and lime mortars should use protective goggles, protective foot wears, hand gloves and respirators as required.

(e) Persons engaged in welding and gas-cutting works should use suitable welding face shields. The persons who assist the welders should use suitable goggles. Protective goggles should be worn while chipping and grinding.

(f) Stonebreakers should use protective goggles. They should be seated at sufficiently safe distances from one another.

(g) Safety goggles should be of shatterproof type and with zero power.

(h) Persons engaged in or assisting in shot blasting operations and cleaning the blasting chamber should use suitable gauntlets, overalls, shatterproof and dust-proof goggles and self contained breathing apparatus set.

(i) All persons working at heights more than 3.5 m above ground or floor and exposed to risk of falling down should use full body harness safety belts, unless otherwise protected by cages, guard railings, etc. In places where the use of safety belts is not feasible, suitable net of adequate strength fastened to substantial supports should be used.

(j) When workers are employed in sewers and inside manholes that are in use, it should be ensured that the manholes are opened and are adequately ventilated at least for an hour. After it has been well ventilated, the atmosphere inside the space should be checked for the presence of any toxic gas or oxygen deficiency by a competent person and recorded in the register before the workers are allowed to get into the manholes. A pilot team should enter the area donning self contained breathing apparatus (SCBA). The manholes opened should be cordoned off with suitable railing and provided with warning signals or caution boards to prevent accidents. There should be proper illumination in the night. Depending upon the work situation, the contractor should provide PPE including the SCBA as recommended by Head, industrial safety.

12. MEDICAL MANAGEMENT

12.1 General

(a) The contractor shall make arrangements for the first aid and medical services for the injured or ill persons for prompt attention or aid.

(b) The arrangement can be made by the contractor or an agreement can be in vogue with the facility.

(c) The medical facilities at first-aid centre shall be adequate to immediately cater to the injured based on the hazard potential and probable severe injuries.

(d) The first-aid centre shall be provided with the adequate equipment and medicines for catering to the site requirements. The first-aid centre shall be manned depending on the working hours / on round the clock shift basis. The services of at least one qualified medical practitioner (medical officer) shall be made available by the contractor.

12.2 Medical Facilities

(a) Medical facilities conforming to the provisions of the Atomic Energy (Factories) Rules, 1996 should be provided at all work sites.

(b) The requisite medical facilities in the form of a well-equipped first aid centre manned by qualified nursing personnel should be provided at all work sites. Contractor may avail this facility as per terms and conditions of the contract.

(c) In addition, well-maintained first-aid boxes should be kept at each location of the work by the contractor and availability of the personnel trained in first aid should be ensured.

(d) A manned and equipped ambulance should be available at work site during the working hours/on round-the-clock shift basis.

(e) It should be ensured by the facility that occupational health monitoring of contract workers is carried out as per provisions of the Factories Act 1948 as per the latest amendment and the stipulations/directives given by Atomic Energy Regulatory Board from time to time.

(f) Display of emergency contact numbers of important persons and hospitals and route map of site shall be maintained at designated places.

12.3 Medical Management of Serious Injuries

(a) In case of serious injuries, the injured should be shifted to the nearest first-aid centre at site immediately. The opinion of medical officer/ certifying surgeon should be sought immediately for medical management.

(b) After providing the first aid treatment the injured should be shifted to designated medical facility of the site/hospital for further medical assistance, in an ambulance along with a nursing attendant.

(c) The doctor at the medical facility of the site/hospital attending the case shall assess the extent of injuries and render immediate medical aid. If the situation warrants trauma/special care the injured shall be shifted to the referral hospital, having all the requisite facilities for specialized treatment in ambulance along with a medical attendant.

(d) A list of such referral hospitals for specialised medical management facilities for the injured persons should be available with the project management/Head, industrial safety and Head, medical services of the site for ready reference.

APPENDIX-D

APPLICATION FOR HEIGHT PASS

PART- A

Group/Section: _____

Agency: _____

1. Applicant's name : _____
2. Facility address : _____
3. Residential address : _____
4. Age : _____
5. Sex : _____
6. Height : _____
7. Gate Pass No. : _____
8. Name of contractor/agency with whom engaged at present : _____
9. Height pass required for work at _____ m. Height
10. Description of present job : _____
11. Previous experience of working at height : _____

S.No.	Name of the employer	Duration of employment	Work experience
1.			
2.			

12. Does the applicant suffer from any of the following ailments ? (If yes details to be given):

    (a) Blood pressure _____ (b) Epilepsy _____

    (c) Flat foot _____

    (d) Frequent headache or reeling sensation _____

    (e) Mental depression _____ (f) Limping gait _____

    (g) Aerofobia _____

Declaration:

I hereby declare that the above information furnished by me is true and correct. I shall always wear the safety belt and tie the life-line whenever working at unguarded heights of 3 m and above. I shall not misuse the height pass issued to me or transfer it to any other person. I shall never come to duty or work at height/depth under the influence of alcohol/drugs.

Date: Name:

Sign:

(Applicants Name and Signature or loss time injury (L.T.I) in case he cannot sign. In case of LTI an authorised person shall explain each point/item to the individual and certify on that behalf below the LTI)

I certify that I am satisfied with the above certification of the individual for the application of height pass and request for issue of height pass to him.

Name :

Sign:
(Agency Concerned)

Countersigned by:

Section Head (Facility)

PART-B

MEDICAL FITNESS CERTIFICATE

Certified that I, Dr. _____ have examined Shri._____ _____ aged _____ on (date) _____ who has signed below in my presence. General and physical examinations of Shri._____ do not reveal any abnormality. He does not suffer from any acute/chronic skin disease or any contagious or infectious disease. His eye sight is normal with/without glasses. In my opinion, Shri._____ is physically and mentally fit for working at height.

Details of examinations are given below:

Personal attributes:			**Medical aspects:**		
1.	Height	: _____	1.	Urine	: _____
2.	Chest	: _____	2.	Blood pressure	: _____
3.	Weight	: _____	3.	Epilepsy	: _____
4.	Hearing	: _____	4.	Flat foot	: _____
5.	Sight	: _____	5.	Frequent headache or reeling sensation:	_____
6.	Skin	: _____	6.	Mental depression:	_____
7.	Heart beating:	_____	7.	Limping gait	: _____
			8.	Aerophobia	: _____

Name:

Signature of workman

Signature and Rubber Stamp of Medical Practitioner with Reg. No.

PART-C

INDUSTRIAL SAFETY SECTION

(Considering the above medical certificate, the applicant has appeared on the following practical tests conducted by industrial safety section and the results are given below (strike off whichever is in-applicable)

(a) Wearing a safety belt and tying the rope knot : Pass/fail

(b) Walking over a horizontal structure at 3 m. height wearing a safety belt : Pass/fail

(c) General physique (OK/Not OK)

The above applicant's performance in the above tests has been satisfactory/ unsatisfactory due to the following.

So I certify and issue this height pass to Shri. _____ with Registration No. _____ in the height pass register. This is valid for one year from the date of issue i.e. up to .....

Date:

Name:

Signature

Scientific Assistant (Safety)

Safety Officer

APPENDIX-E

FORM - 1

APPLICATION FOR TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

[Prescribed under clause 10.6(d)]

1.	Name and address of user.	
2.	Reference of tender or work order (if applicable)	:
3.	Name and designation of tender/work order issuing authority.	:
4.	Power supply application number†	:
5.	Name and designation of tender/work order/work supervising authority (engineer-in-charge).	:
6.	Expected date of commencement of temporary supply	:
7.	Expected date of decommissioning of temporary supply	:
8.	Voltage level (LV/MV/HV)	
9.	Type of connection (1Ph/3Ph)	
10.	Connected load (Kw)	
11.	Maximum demand(KVA)/Power factor	
12.	Single line diagram* of proposed power distribution scheme along with equipment data sheet (downstream installation after point of connection).	Enclosed (Form-1A)/Not enclosed
13.	Name of overall supervisor and available qualified Staff	Enclosed (Form-1B)/Not enclosed
14.	Auxiliary equipment data sheet (meters, fire extinguisher, first aid box etc)	Enclosed (Form-1C/Not enclosed
15.	Name and designation of provider's representative to whom the application is addressed.	:
16.	Name and designation of authorised signatory of user, who had submitted this application	:

† Power supply application number shall be different for same user with multiple applications for temporary supply

* All the drawings and tables shall be signed by user's representative indicated against 16 above.

Signature of authorised signatory of user

Signed endorsement of work order supervising authority indicated against 5 above.

FORM - 1A

EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION

(Prescribed against item-12 of form-1)

Name and address of user:

Power supply application Number:

Amendment No:

References:- Single line diagram (SLD) of the power distribution scheme with all equipment details (attach the SLD)

1. Identity	2. Type	3. Make and model	4. Manufacturer's S.No	5. Fixed/ Portable	6. Size	7. Last used date	8. Last test date	9. Latest test data	10. Rating

Signature of authorised signatory of user

Explanation of column headers:

1. Identity:- Identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/CB/MCB/MCCB/ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- Equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative e.g. length for cables or all dimensions if heavy equipment like transformer.
7. Last used date. date of last use else NEW
8. Last test date. latest test date by user or by manufacturer if NEW
9. Latest test data:- IR, HV, resistance, functional test data depending upon the type of equipment as desired by provider's representative.
10. Rating:- name plate rating of equipment like voltage, current, power (apparent, active, reactive), IP of enclosure, size (cable cross section) etc. depending upon the type of equipment and as desired by provider's representative.

FORM - 1B

STAFF DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-13 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Name	2. Address	3. Tel.No.	4. Responsibility	5. Certification detail	6. Resucitation training	7. Expe-rience	8. Other relevant training	9. Signature

Signature of authorised signatory of user

Explanation of column headers:

1. Name:- Name of agency/person
2. Address:-
3. Tel No:- regular, alternate and emergency telephone numbers
4. Responsibility:- whether responsible for installation, operation, maintenance, overall supervision etc. overall supervisor shall be indicated specifically.
5. Certification detail:- (a) type of certification e.g wire man license, electrical supervisor license, electrical contractor license, diploma in electrical engineering, degree in electrical engineering etc. (b) certifying agency e.g. state PWD, central PWD, CEA, name of college/university etc. (c) certificate/license number with date. (d) valid up to date or next renewal date must for contractor/supervisor license.
6. Artificial resuscitation training:- indicate YES/NO if the staff is trained to apply artificial resuscitation technique.
7. Experience.:- number of years of experience.
8. Other relevant training :- any other training in electrical/ safety course. Indicate name of training, duration (days/months), training providing agency.
9. Signature:- original signature of individual.

FORM - 1C

AUXILIARY EQUIPMENT DATA SHEET FOR OBTAINING TEMPORARY POWER SUPPLY AND USE OF ELECTRICITY AT WORK SITE DURING CONSTRUCTION
(Prescribed against item-14 of form-1)

Name and address of user:

Power supply application Number:
Amendment No:-

Reference:- Layout drawing No. / _____

1. Identity	2. Type	3. Make and model	4. Manufacturer's S. No	5. Fixed/ Portable	6. Size	7. Last used date

Signature of user's representative

Explanation of column headers:

1. Identity:- identification mark/number/tag of equipment in layout drawing.
2. Type:- earthing rod/megger/multi meter/earth resistance meter/fire extinguisher/s and bucket/first aid box/resuscitation chart/rubber mat etc.
3. Make and model:- manufacturer's name and corresponding model no.
4. Manufacturer's S. No:- serial number and date in name plate if available. Else NA
5. Fixed/portable:- equipment is installed/laid/anchored to surface or portable.
6. Size:- depending upon type of equipment and as desired by provider representative.
7. Last used date. NEW for new equipment. NA for passive devices like chart/mat etc.

FORM -1D

(Prescribed under clause 4.6(e)]

Name of user agency **Power supply application number:-**

CERTIFICATE BY THE LICENSED ELECTRICAL CONTRACTOR

Certified that subject installations have been carried out by us or checked by us and is in accordance with I.E. Rules. The documents submitted with subject temporary power supply application (Form-1) is verified by us and the complete installation confirms to these documents.

We shall periodically inspect/check the installation so that no unsafe situation arises during use of this temporary power supply system. We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of licensed electrical contractor

Rubber seal of licensed electrical contractor

Date

CERTIFICATE BY THE USER

Certified that my/our installations have been carried out in accordance with the I.E. Rules and that I/We have employed competent agency/staff to handle the installations which is strictly as per the staff data sheet submitted in Form-1B.

We understand that for the entire duration of existence of this temporary power supply system we shall be responsible for any unsafe installation, operation, maintenance, testing of the same which results into any loss of life or material. We shall immediately report to the provider's representative and ensure de-energisation of supply if any unsafe situation arises during use of this temporary power supply system.

Signature of the authorised signatory of user

Name of signatory

Date

FORM -1E

[Prescribed under clause 10.6(f)]

CERTIFICATE BY THE SAFETY OFFICER

Certified that I have inspected the electrical installation referred here in after satisfying myself about the safe condition of the installation, I hereby recommend that the service connection be given to the contractor.

Signature of the safety officer

Name:

Date:

AUTHORISATION BY THE ELECTRICAL ENGINEER

The subject power supply application along with completed installation, necessary certificates (as per Form-1 of Appendix-E) is scrutinised by us. The proposal found to be in order and the installation can be energised on _____ in presence of your designated overall supervisor as indicated in Form-1B. Enclosed herewith the test report data sheet Form-1F. You are requested to carry out the periodic testing of equipment and submit the test report periodically as per this form.

Signature of the electrical engineer
of provider

Name of signatory

Date

FORM - 1F

TEST/MAINTENANCE REPORT DATA SHEET OF EQUIPMENTS OF TEMPORARY POWER SUPPLY SYSTEM AT WORK SITE DURING CONSTRUCTION
(Prescribed against form-1E)

Name and address of user:

Power supply application Number:
Amendment No:-

1. Identity	2. Type	3. Last tested date	4. Next due date of any test	5 Frequency of IR test	6 Frequency of HV test	7. Frequency of earth resistance test	8. Other tests

Signature of electrical engineer of provider

Explanation of column headers:

1. Identity:- Identification mark/number/tag of equipment in single line drawing and layout drawing. Every equipment in single line drawing and layout drawing shall have suitable identification mark/number/tag.
2. Type:- Cable/CB/MCB/MCCB/ELCB/transformer/lightning arrestor/earthing station/ earthing connection/motor/lighting fixture/switch/fuse/switch, socket box etc.
3. Last test date: - latest test date indicated in Form-1A.
4. Next due date of any test:- as worked out by frequency of tests indicated in subsequent columns.
5. Frequency of IR test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
6. Frequency of HV test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
7. Frequency of earth resistance test:- required frequency depending upon type of equipment and location of installation. NA if not required after installation.
8. Other tests:- name and description of any other essential tests/maintenance activity and required frequency depending upon type of equipment and location of installation. NA if not required after installation.

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25. Indian Standard 13416(Part 4), Recommendations for preventive measures against hazards at workplaces: Part 4 Timber structure, 1994

26. Indian Standard 13416(Part 5), Recommendations for preventive measures against hazards at workplaces: Part 5 Fire protection, 1994

27. Indian Standard 13430, Code of practice for safety during additional construction and alteration to existing buildings, 1992

LIST OF PARTICIPANTS

EXPERT COMMITTEE FOR REVIEW OF 'GUIDELINES' ON CONTROL OF WORKS

Dates of meeting:	July 9, 2007	July 23, 2007
	September 3, 2007	October 3, 2007
	October 17, 2007	February 22, 2008
	April 4, 2008	April 23, 2008
	May 6, 2008	May 13, 2008
	June 18 & 19, 2008	August 4, 2008
	May 12, 2010	

Members of Sub Committee:

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Shri Sushil Kumar	:	DGFASLI
Shri D.K. Jain	:	NPCIL
Shri N. Nagaich	:	NPCIL
Shri P. Lahiri	:	BARC
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ADVISORY COMMITTEE ON INDUSTRIAL AND FIRE SAFETY (ACIFS)

Dates of meeting	:	July 6, 2009 August 4, 2009 November 30, 2009 February 22, 2010 March 26, 2010 April 29, 2010 July 30, 2010 September 21, 2010

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Shri R. Bhattacharya	:	AERB
Shri K. Ramprasad (Member-Secretary)	:	AERB

PROVISIONAL LIST OF REGULATORY DOCUMENTS ON INDUSTRIAL AND FIRE SAFETY

Reference No.	Title	Year of Publication
AERB/NF/FPS (Rev. 1)	Fire Protection Systems for Nuclear Facilities	2010
AERB/NRF/SG/ IS-1 (Rev. 1)	Control of Works	2012
AERB/SG/IS-2	Preparation of Safety Report of Industrial Plants other than Nuclear Power Plants in the Department of Atomic Energy	2001
AERB/SG/IS-3	Personal Protective Equipment	004
AERB/SG/IS-4	Guidelines for Pre-employment Medical Examination and fitness for Special Assignment	2005
AERB/SG/EP-3	Preparation of Site Emergency Preparedness Plans for Non-nuclear Installations.	2000
AERB/SG/EP-4	Preparation of Off-site Emergency Preparedness Plans for Non-nuclear Installations.	2000
AERB/SG/D-4	Fire Protection in Pressurised Heavy Water Reactor Based Nuclear Power Plants	1999
AERB/SM/IS-1	Manual on Database Management for Accidents/ Diseases Happening due to Occupation and Implementation of the same in the Department of Atomic Energy	1991

AERB SAFETY GUIDELINES NO. AERB/NRF/SG/IS-1 (Rev. 1)

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BCS

VOLUME: II

SECTION – C

SPECIFIC TECHNICAL REQUIREMENTS

BORED CAST-IN-SITU RCC PILES

SPECIFICATION NO: PE-TS-486-607-C001

Bharat Heavy Electricals Limited
Power Sector - Project Engineering Management
PPEI Building, Plot No. 25
Sector – 16A, NOIDA (U.P.) - 201301

SPECIFIC REQUIREMENTS

Section-C covers Specific Technical Requirements of the Contract and shall be read in conjunction with Schedule of Quantities (SOQ), Section-D and other sections of the contract. In case of any conflict between the contents of SOQ and Section-C, SOQ will prevail over Section-C. In case of any conflict between Section-C and Section-D, Section-C will prevail over Section-D.

GHAVP-1&2/40000/PROCUREMENT SPECIFICATION/MS-1

REVISION No. – R0, AUGUST-2018

VOLUME-II –
Section-C
PART-2

C-2: SPECIFIC TECHNICAL REQUIREMENTS

C-2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

NUCLEAR POWER CORPORATION OF INDIA LIMITED

(A Government of India Enterprises)

PROCUREMENT SPECIFICATION NUMBER : GHAVP- 1&2/40000/ PROCUREMENT SPECIFICATION/ MS-1
PROCUREMENT SPECIFICATION
FOR
TURBINE ISLAND PACKAGE

SECTION C -2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

Revision No	R0			
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Prepared By	SUDHANSHU PANDEY, Sr. EE (Civil)	08/08/2018	08/08/2018
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Reviewed By	N.M.RAO, CE (Civil)	08/08/18	08/08/2018
Approved By	ARVIND SHRIVASTAVA AD (Civil) & Head (Civil Engineering Group)		08/08/2018
	(Name & Designation)	(Signature)	(Date)

REVISION CONTROL SHEET

PROCUREMENT SPECIFICATION NUMBER : GHAVP- 1&2/40000/ PROCUREMENT SPECIFICATION/ MS-1

PROCUREMENT SPECIFICATION FOR TURBINE ISLAND

SECTION C -2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

REV. NO. / DATE	DESCRIPTION	PREPARED BY	CHECKED BY	REVIEWED BY	APPROVED BY

1. GENERAL

1.0.1 PROJECT

The proposed project of GHAVP-1&2 consists of two units of 700 MWe PHWR type Nuclear Reactors.

1.0.2 LOCATION

The site is situated on the left bank of the Fatehabad Branch of Bhakra canal, near running distance (RD) of 48159 m (158000 ft.), in Fatehabad District of Haryana State. The nearest village to the site is Gorakhpur.

1.0.3 ACCESSIBILITY

Chandigarh, the State capital is about 218 km away from the site by road. The site can be accessed by following ways:

By Road

National Highway No. 10 passes about 6 km away from site. The project site can be approached from NH-10 by turning-off at village Kharakheri, via. the Kharakheri-Gorakhpur road. From Delhi the road to site via NH-10 passes through Rohtak, Hansi and Hisar. The entire route from Delhi to Hissar and further upto Kharakheri is a black-topped national highway.

By Rail

The nearest rail head is Adampur at a distance of 22 km south-western of the site. Adampur station is on the Hisar-Sirsa Borad-Gauge section of Northern Railway. Jakhal Junction is located on the Delhi-Bhatinda sections of the Northern Railway. The road from Adampur station to the site is a good road. Narwana or Jakhal junction / railway station can be used by personnel coming from places like Mumbai, by train.

By Air

The nearest major airport is at Delhi (about 208 kms from project site).

1.1 GEOLOGY OF THE SITE

The site area lies on the western part of Indogangetic alluvial plain on the Punjab side, adjoining the Rajasthan shelf, separated underneath by the alluvium, by the NW-SE trending Lahore-Saharsa Ridge. The site is located on alluvial soil made up of both older and newer alluvium with a thickness estimated to be of the order of about 320 m, below which hard rock formation of the Lahore-Sahara Ridge is reported to occur.

Preliminary investigations at site indicate that the substrata consist of alternate layers of sandy silt/silty sand and silty clay/sandy clay (each layer being of approx. 4m thickness) upto approximate 110 M depth from EGL.

The water table is varying between 0-3 m below the existing ground level. It is likely that the water table may rise to a higher level during rainy seasons. Ground water variation is reported to be quite minimal thereby causing water saturation and water logging in the region during monsoon times.

The existing ground level of the site in the area around TI package is varying from RL 213.5 m to 215.0 m.

1.2 METEOROLOGICAL DATA

The maximum and mean wind speed observed at Hisar during the period 1969-2013 was 48km/hr and 3.6 km/hr respectively.

The other meteorological parameters at Hisar are as follows:

		Max.	Min.
1.	Air temperature (1969-2013)	48.8	-1.5
2.	Average annual Wet Bulb Temperature ^{o}C (1969-2013)	21.4	17.3

The annual average rainfall is about 450 mm with maximum of 793.6 mm (1976) and minimum of 145.2 mm (2000). Relative humidity of maximum 100 % & minimum 5 % has been observed.

Occasionally dust storms are experienced during summer months and hail storms during Feb-April. Fog and dew prevail generally during Dec-Jan. Thunder storm also occurs during post monsoon season and summer months.

1.3 SEISMOLOGY

The site falls under zone III as per the seismic zoning map of India (IS: 1893-Part-1).

1.4 SITE INSPECTION

Intending bidders should visit the site to familiarize themselves thoroughly with the site conditions before submitting their tender. Non-familiarity with site conditions will not be considered a reason either for extra claims or for not carrying out the work in strict conformity with the drawings, time schedule and specifications. For any information on site visit, the bidders may contact NPCIL site office, Village-Gorakhpur, District-Fatehabad, Haryana.

1.5 SITE CONDITIONS

The bore hole location drawing (Drawing No. GHAVP-1&2/10120/2001/DD) is enclosed along with the tender document. Typical details of a relevant Bore log data are given at the end of this section in Annexure-1 for general guidance to the Bidders. Seven Boreholes BH103, RBH-104,RBH-109, BH-110, RBH-111, BH-115 and BH-116 were drilled covering Turbine Building-1. Seven Boreholes BH105, RBH-112,BH-113, BH-106, RBH-114, BH-117 and RBH-118 were drilled covering Turbine Building-2. The bore hole no RBH107 & RBH108 covers the transformer yard area of unit 1 & 2 respectively.

The bidders are advised to study the bore log data for information. The details of other bore log data in balance area of plant is available in the office of the Engineer for reference of the bidders, if needed.

The finished grade level of EL 99.7m corresponds to RL 219.300m.

For detailed geology around Turbine Building & other structures, para 2.1.1 may be referred.

1.6 BUILDING DESCRIPTION

Description of Main structures covered in the scope of this tender are as follows:

1.6.1 TURBINE BUILDING :

The Turbine buildings are located to the East of Control building. The Structure of the Turbine building shall be of reinforced concrete and shall be supported on Raft Foundation. Wherever required, piles shall also be provided under the raft foundation. For wall/cladding , Concrete Block Masonry is to be provided unless approved otherwise by the engineer. The roof shall be made without any internal support, in order to avoid any interference in work being carried below the roof. The roof shall be provided with water proofing with thermal insulation as per specifications. All the fire rating & other technical requirements shall be considered while selection of material & sizing of the members. Each turbine building shall be accommodated within the allocated maximum plan size as shown in the main plant layout drawing. The location of buildings in the main plant lay out is shown in Drg No. GHAVP 1&2/10000/5001/GA enclosed along with the tender. A portion below condenser shall be lowered appropriately for cooling water inlet and outlet pipes.

The turbine building shall have floors and mezzanine floors at various elevations, housing the turbo generator and other components like HP Turbine, LP Turbine, Generator, Moisture Separator & Reheater, Deaerator, HP and LP feed water heaters, Condensate Extraction Pumps, Boiler Feed Pumps, Storage tanks, Vacuum pumps, Generator Circuit Breaker, Bus Ducts etc. The description given above is brief only . For detailed description relevant chapters of the tender may be followed.

For industrial & fire safety requirements relevant AERB & other statutory guidelines

as applicable shall be strictly adhered.(Refer C-1-3)

The Turbine Generator(TG) shall be supported on a separate RCC pedestal and Reinforcing Concrete Raft foundation. Wherever required, piles shall also be provided below TG raft. The TG foundation shall be isolated from the main turbine building, so as to avoid transmission of vibrations or any other kind of forces to the main building.

Inside the building, EOT cranes with suitable crane girders shall be provided, to handle the heaviest load within the building for maintenance & erection of Turbo Generator & other equipments except Turbo Generator Stator. During maintenance provision to facilitate the removal of Turbo Generator Stator , proper removable leak-tight opening shall be made in the roof of Turbine Building. The building shall have necessary cable & Pipe trenches / tunnels, racks, pipes, hangers & anchor supports. The lifts as well as stair cases shall be provided to access from one floor to another floor of the building.

The access to Turbine building from Control Building at various floors shall also be provided through proper connecting walkways, landing, Staircase etc. Floor levels & entry location from control building are enclosed in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, along with this tender. ***The connecting structure (Access Bridge) shall be planned & designed in such a way that it does not transfer any load to control building as the same is not considered in the design of control building.***

In addition to above, condensate storage area & ventilation buildings, are to be provided by the side of Turbine buildings as indicated in the Drawing No. GHAVP 1&2/10000/5001/GA enclosed along-with the tender.

Annex Buildings are located by the side of both the Turbine Buildings. One of the Annex Building houses the Workshop alongwith other facilities, whereas other Annex Building houses the Laboratory with other facilities. For details of various facilities in the Annex Buildings Chapter C-1-3 of the Tender may be referred. The Annex building may be designed by the bidder as standalone structure or could be a part of the Turbine Building.

The construction of a local Control center inside turbine building with noise barrier/acoustic insulation as specified is also included in the scope of bidder, The detailed requirements of same which are indicated C&I specifications in chapter C-2-4 are also to be met .

1.6.2 **Pipe Cable Bridge (PCB):**

The Pipe and Cable Bridge (PCB) connecting Control building to Turbine Building shall have RCC Structure with suitable foundation and the same is included in the scope of this tender . The intermediate floors & roof of PCB shall be of RCC. The roof shall be provided with water proofing with insulation as per specifications.. ***The structure of PCB shall be planned in such a manner that it does not interfere with***

the vehicular and equipment movement on 10 m wide (7m carriage bay and 1.5m wide shoulder on either side of road) road , as well as tunnels & trenches laid under the road. The tunnel & trenches in this area are indicated in drawing no GHAVP-1&2-29700-5002-GA.The PCB foundations should not transfer any load on tunnels & trenches.

The floor elevations of Turbine Building shall preferably match with Control building floor levels. (Floor levels of control building are enclosed in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, along with this tender). The width of PCB shall match with the PCB opening at control building end as shown in above mentioned drawings ,however the length of PCB will depend on the size of Turbine building as finalized by the bidder and approved by the purchaser. ***The PCB structure shall be planned & designed in such a way that it does not transfer any load to control building.***

1.6.3 **Electrical Bays:**

The electrical bays shall be provided adjoining to main turbine buildings. The electrical bay houses switchgears and Motor Control Centers. The size , layout & equipment arrangement of electrical bay shall be as specified in section C-2-3 of the Tender. The Structure of the Electrical bay shall be of RCC with raft foundation. Piles shall also be provided, wherever required. The roof shall be provided with water proofing with thermal insulation as per specifications. All the fire rating & other technical requirements shall be considered while selection of material & sizing of the members. ***The engineering of the Electrical Bay shall be carried out on the basis of equipment layout and other input as finalized by the Purchaser & given in the electrical specifications in section C-2-3.***

The present layout of Electrical bays is finalized based on the structural configuration and sizing of various columns, beams etc. as per drawings attached in section C-2-3. It is expected that bidder shall maintain the same while design of Electrical Bay Buildings . In case, it is found to be essential to change the given dimension and same is approved by Engineer, the Purchaser may modify the equipment layout, opening arrangement etc, to meet the design, construction and maintenance requirements. In such situation, Bidder shall carry out the necessary design changes based on modified layout by the purchaser without any extra cost to Purchaser.

1.6.4 **Access Bridge:**

The Access bridge for both the units needs to be provided to connect the turbine building from control building from each floor of Control building. This structure shall have landing at each floor of Turbine Building connected to nearest available Control building floor. It shall also have provision of lift, to access the Turbine Building & control building. The floor elevations of Control building at which turbine building to be connected with control building are given in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, attached with this tender. The Access Bridge structure shall be RCC. The roof shall be provided with water proofing with insulation as per specifications. Lift shall open at all floor levels of CB & TB.

1.6.5 **CCW Inlet & Outlet Pipes / Conduit**

The detailed requirement for CCW Inlet & Outlet Pipes/ Conduits given in Section C-2-5 shall be met. Suitable arrangement viz. culvert etc. shall be made to ensure that no loads are transferred by other Structures & Systems under this package on CCW Pipes/ Conduits.

1.6.6 **Transformer Yard:**

All the civil works for transformer yard (adjoining to turbine buildings & electrical bay) to accommodate SUT, UT, GT, Oil Separation Pit, Bus Duct, Rail Track (including rails) for maintenance upto Turbine building, spare GT area, fire barrier walls etc. are included in the scope of the bidder as shown in the relevant tender drawing. **The supply and erection of rail on road towards western side of grid X-2 is also included in the scope of bidder**. For detailed scope Section C-2-3 shall be referred. The transformer yard is open to sky. An area reserved for Transformer Yard is shown in main plant layout drawing attached with the tender. ***The engineering of this area shall be done on the basis of input data and equipment layout provided by the Purchaser as given in the electrical specifications in Section C-2-3.The foundation for all the equipment & structures shall be Raft or Pile- Raft foundation, unless approved otherwise by the Purchaser. The founding level for SUTs, UTs, GTs, Burnt Oil Pit and Fire wall etc. shall be kept at EL 95.4m or lower as required (unless specifically approved by the engineer).*** The equipment foundations shall be structurally isolated from the grade slab to avoid any transfer of load.

1.6.7 **Tunnels & Trenches around Turbine Building & Transformer Yard (Other than CCW Pipes/conduits) & other area:**

The engineering & construction of all the tunnel trenches within the road edges between grid (8&9), Grid (26-27), grid (r2- q2) & grid (x2-y2)is included in the scope of bidder. The terminal points are specified in Sketch No.GHAVP-1&2/29700/2001/SK. The end of the RCC tunnels shall be provided with proper construction joint & dowels of adequate length which can be used by other agency for further construction. (The load being transferred, if any, at terminal point and is to be accounted for during design by TI package contractor to be specified.) The tunnels / trenches shall be aligned & engineered properly considering the road crossing etc, if any as per overall layout of the plant. The Tunnel trenches included in the scope are:

- PTL 26, 33(upto terminal point),53,96,97
- PTR 26A , 26B & 68
- CTR 72,74, 74A,75, 77,78,79, 80
- CTL 73, 73A(upto terminal point), 73B, 94 (upto terminal point), 95, 95A
- ASW tunnels upto terminal points in East & West direction.
- Any additional tunnel / trenches / pipes required within the terminal points as given in above para. are also included in the scope of bidder. The portion of the tunnels/

trenches which is excluded from the scope of this package are specifically mentioned in the Sketch No . GHAVP-1&2/29700/2001/SK given with the tender.

- Tentative layout of Surface drain is given in Drawing No GHAVP-1&2/15300/5001/GA. Design and construction of down comer pipes & additional internal drains connecting to the Surface drains shown in above drawing is in the scope of bidder. Construction of Surface drains between nodes A26 to A29, A29 to A30, A30 to A45, A39 to A45, B2 to B5, B5 to B6 and B1to B6 are in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant.
- Tentative layout of Plant drain is given in Drawing No. GHAVP-1&2/15200/5101/GA. Design and construction of additional internal plant drains connecting to the nearest available plant drains shown in above drawing is in the scope of bidder. Design & Construction of plant drains from building to the terminal point (PDC-22, PDC-23, PDC-30, PDC-31, PDC-32, PDC-33 and PDC-34) are in the scope of the bidder. Construction of Plant drains between M62 to M67, PDC-31 to M67, M43 to M46 and PDC-33 to M46 is in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the boundary limit.
- Tentative layout of Roof drain is given in Drawing No. GHAVP-1&2/15200/5001/GA and Drawing No. GHAVP-1&2/15200/5002/GA. Design & Construction of roof down comers to the terminal points (RWE-16 to RWE-23, RM-18 and RM-19) are in the scope of the bidder. Construction of Roof drains between RWE-16 to RWE-23 and RM-18 to RM-19 is in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the battery limit.
- The tentative layout of sewer lines is given in Drawing No GHAVP-1&2/15200/5201/SK. Design & construction of sewer line from building to the nearest manhole is in the scope of bidder. The construction of Manhole no MH 338 to MH 340 and connecting sewer lines to these manhole as shown in the above drawing is in the scope of the bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the boundary limit.
- The construction of 10 m wide road between grid 17- 18 within terminal point is excluded from the scope of the bidder. However the bidder shall fill the area up to subgrade i.e. EL 98.0m , with soil cement mix as per the specification. The typical cross section to be followed for the road is given in Sketch No. GHAVP

1&2/15600/5001/SK attached with the tender .

1.6.8 The Hard Stand "C" is excluded from the scope of this tender. However, the area below the Hard stand within terminal point shall be graded upto EL 98.00 with soil cement mix as per detailed technical specifications.

1.6.9 **Area grading within the terminal points:**

The area grading within the terminal point within the road edges between grid (8-9), Grid (26-27), grid (r2- q2) & grid (x2-y2) , upto EL 99.7M (RL 219.3M) is within the scope of bidder. For area grading backfilling upto EL 98.7M shall be done using soil cement mix as per the specifications, unless specified in the approved drawing otherwise . The portion above EL 98.7M shall be backfilled using compacted soil as per technical specifications provided.

1.7 SCOPE OF CIVIL WORK

1.7.1 **General:**

The works proposed to be performed under this contract are for Engineering, procurement, fabrication, construction, commissioning and handover of two 700 MWe units of Gorakhpur Haryana Anu Vidhyut Pariyojana - 1&2 (GHAVP- 1&2) and shall include all the facilities required for power production utilizing the steam produced in secondary cycle. ***The facilities shall be established within the allocated area satisfying all the statutory, technical and performance requirements specified in the tender.*** The work shall generally include but not limited to following:

Finalization of equipment layout, general arrangement, loading, analysis , design , drawings, procurement, fabrication, construction & commissioning of :

- Turbine Building including BFP, CEP and Vaccum Pumps.
- Turbo Generator Foundations
- Foundation of all other equipments
- Annex Building ,Turbine Oil storage tank
- Condensate storage tank and its storage area
- Pipe and Cable Bridge (PCB) structure connecting Control building to Turbine Building
- Electrical bay (The engineering of the building is to be carried out on the basis of equipment layout and other input finalized by the Purchaser or his consultant as given in the Electrical Specification.).
- All other Tunnels , Trenches & pipes within the terminal points except those are specifically mentioned as excluded in the sketch No. GHAVP-1&2/29700/2001/SK.
- Transformer yard accommodating SUT, UT, GT, Oil Separation Pit, Bus Duct, Rail yard for maintenance upto Turbine building including rails in transformer yard to & within the turbine building unloading bay, spare GT area . The supply and erection of rail on road towards western side of grid X-2 is also included in the scope of bidder.
- Embedded parts / Penetrations,
- Access bridge to connect the turbine building from control building from each floor

of Control building (The floor elevations of Control building at which turbine building to be connected with control building are given in drawing Nos GHAVP 1&2/24200/ 2011 TO 2018/ GA, attached with this tender) .

- Surface drains, Plant drains, Roof drains and Sewer lines (Based on the engineering input provided by the purchaser)within the terminal point as specified in Para 1.6.7.
- Internal & External Finishes, cladding , plastering , flooring & painting etc.
- Fabrication & erection of all structural steel works like trusses , crane girders etc.
- Area Grading & temporary access roads within the terminal point
- All the civil, structural & architectural works as necessary for completion of the system.

1.7.2 **Detailed:**

The scope of work shall include engineering, procurement, supply & construction necessary for functional requirements. The work shall generally include but not limited to the following :

(a) Based on the geotechnical study carried out at site, the soil is found to be susceptible to liquefaction in varying depth. In order to mitigate the possibility of liquefaction the soil is to be treated up to a depth susceptible for liquefaction, by mixing the soil (at OMC) with 5% cement (by weight of dry soil) and compacting the same in a specific manner. The area within the battery limits of TI package shall be treated by the Purchaser up to the various levels specified in the attached Drawing GHAVP-1&2/16000/2003 &2004/DD. However, as per the layout and structural arrangement opted by the bidder or system requirements , if the founding levels are fixed at a higher elevation than the levels indicated in Drawing no GHAVP-1&2/16000/2003&2004/DD, the area shall be raised by treating it using soil cement mix (cement content 5% by weight of dry soil) by the bidder at his own cost, as specified in the relevant part of technical specifications. The area may also be raised by filling PCC, only if approved by the Engineer . ***It is preferred to take up the foundation of various structures from the level up to which Ground Improvement is carried out by the Purchaser and as indicated in the Drawing No*** GHAVP-1&2/16000/2003& 2004/DD**.** Wherever, the founding levels are lower than the levels specified in above drawing the ground shall be lowered by bidder at his own cost using appropriate cutting tool like chisel etc. which does not disturb and damage the improved soil below founding level. The damaged improved ground, if any, shall be made good by the bidder at his own cost. Additional excavation or backfilling, wherever required shall be carried out by bidder on priority avoiding any adverse effect on the existing works or the works being executed by other contractors in adjoining areas. Schedule of the additional excavation and backfilling shall be finalized in consultation with PURCHASER. Bidder must schedule his excavation and other activities considering the status of construction & schedule of construction of adjoining structure.

(b) Analysis ,Design and Detailed Engineering of all the structures i.e. covered in the scope of this tender and as detailed above.

(c) Preparation of Design Basis Reports (DBR), Static and dynamic analysis reports and other design reports as applicable and suggested by the engineer.

(d) Preparation of general arrangement, loading, Architectural , concrete forming, EP location, EP fabrication and Reinforcement drawings etc. The reinforcement detailing has to be as per Indian Standards/ ACI/ AERB code as directed by the engineer

(e) Complete analysis , design, procurement ,fabrication and erection of structural /Miscellaneous Steel works & EP including preparation of all necessary drawings within the terminal points &within the scope of this tender.

(f) Preparation of composite drawings including details of Civil, Electrical, Mechanical, Instrumentation etc.

(g) Preparation of Bar bending schedule and Bill of materials.

(h) Design , fabrication and erection of formwork and supporting system required for concreting of the various elements of the structure.

(i) All Reinforced concrete work in pile, raft, isolated footings, columns, equipment foundations, slabs, beams, underground tunnels/trenches, sumps, basement structures, ducts, precast covers and allied structures etc

(j) All RCC work required for equipment machinery, tanks, tunnels , trenches etc, supply & installation of EPs.

(k) Supplying and Fixing water stops, expansion joint.

(l) Supplying & Construction of brick, concrete block walls along with plastering , glazed walls, Metal sheet cladding & roofing as per the drawings .

(m) Providing & fixing the Metal Doors/ Fire proof doors, Windows, Ventilators & Louvers with glass & glazing along with all the necessary fixtures wherever required or as specified by the Purchaser. Wherever required, suitable sound insulation measures shall be provided.

(n) Providing and laying of plant drain, storm water drains, sewer lines, roof drains, UPVC pipe down comers and different pipes and other plumbing and sanitary works and connecting the sewer lines to nearest manhole outside the area within this contract or as required.

(o) F3 & U3 finishes to the concrete.

(p) Hardonate flooring by vacuum de-watering method and other types of flooring as specified in the specifications, including specific requirements given in other sections of the tender.

(q) Painting over concrete , structural steel , wall, ceiling, Doors , Windows & Ventilators etc. wherever required as specified in the tender or else as directed by

Purchaser.

(r) Water proofing work in basement, sump, wall and roof etc as specified in the tender specifications or approved by the Purchaser.

(s) Providing facilities throughout the contract period for sampling and testing of various construction materials as specified and as directed by Purchaser.

(t) Providing proper storage facilities for construction materials such as cement, steel, aggregate, admixture, Structural Steel, water stop, paints etc.

(u) Construction of temporary Access Roads & storm water drains within the terminal points .

(v) General area grading and drainage within the terminal points upto EL 99.7M unless specified otherwise, with proper retaining walls / sheet piles (wherever required) .

(w)Finishing works for above mentioned structures, partition walls. plastering, flooring, painting, false ceiling wherever specified & approved in the drawings, erection of doors, windows & rolling shutters, P.H. Works, waterproofing, construction joints, fire proofing, painting of equipment, structures and piping etc.

(x) Preparation of quality assurance plan, quality assurance manual, testing methodologies Inspection and testing plan, and acceptance criteria for material qualification.

(y) Preparation of construction methodology, safety manual, job hazard analysis, work procedures, etc.

(z) Submission & obtaining the purchaser approval on Construction Completion Certificate & system transfer docket containing necessary documents like Test Certificates, Pour Cards, As Built Drawings & Inspection reports etc.

(aa) Attending meetings with purchaser, AERB, wherever & whenever required, at own cost.

1.8 MATERIAL AND SERVICES BY NPC

Land, water and power etc. will be given by NPCIL on chargeable basis on conditions mentioned elsewhere in the relevant documents.

The supply of all the materials , required to execute the work covered under this contract, is in the scope of contractor.

1.9 DRAWINGS

Drawings being issued with bid are for ***guidance*** only. All the construction/ as-built drawings are to be prepared by bidder on suitable integrated engineering environment or AutoCAD (latest version) as per relevant standards and as specified by purchaser .

Drawings in Compatible AutoCAD version shall also be provided to the purchaser. Contractor should have adequate knowledge of prevailing codes and practices for reinforcement detailing .

3 number of prints (full scale) of each drawing shall be submitted to Purchaser for every revision/correction. Drawings /Documents preparation, checking and Approval of drawings shall be done by the EPC contractor as well as design consultant (if appointed) and same shall also be approved by Proof consultant. Before submission to Purchaser all documents should bear the signatures and names of persons preparing, checking and approving the documents/drawings as well as of Proof consultant .After the approval from Proof consultant the Drawings /Documents shall be submitted for final acceptance of Purchaser. Purchaser comments if any shall be incorporated in the relevant final drawings/ documents prior to execution.

Supporting design calculations (wherever applicable) shall also be submitted by EPC contractor prior to submission of related drawings. Two copies of the approved prints and one set soft copy shall be submitted to the Purchaser. The final soft copy of all the documents and drawings will be registered in Purchaser's document management system (PLM) in the format attached with the tender, progressively with the work progress. Execution shall be done only after proper registration of the documents/ drawings.

Submission of DVD/ CDs (2 copies) of all approved drawings, DBR, Mathematical model, software input and output files, post processors , static and dynamic analysis reports, Design Manual etc , along with soft copy of executable file of programme, excel sheets used in the process of analysis and design are also included in the scope of bidder.

The documents/drawings furnished by Purchaser and/or generated by the EPC contractor shall not be used by the contractor anywhere else without prior written approval of the purchaser. All the generated documents/ drawings will be property of the purchaser.

The bidder has to prepare the following drawings:

(a) General arrangement, loading, Architectural , Concrete forming, EP location, EP fabrication, Reinforcement drawings etc for all the structure covered in the scope of this contract. The reinforcement detailing has to be carried out as per Indian Standards/ ACI code as directed by the purchaser .

(b) Design of Joints, preparation & issue of fabrication drawings for Structural Steel works& other Miscellaneous Steel Structures.

(c) Preparation of Bar bending schedule and Bill of materials (BOQ).

(d) Preparation of composite drawings including details of Civil, Electrical, Mechanical, Instrumentation etc.

(e) Preparation of EP list

The bidder has to prepare all the drawings/ Report as per the approved format of the Purchaser. A period of minimum 15 working days shall be considered for obtaining the Purchaser's comments after submission of drawing / Document by the Contractor.

1.10 SPECIFICATIONS

The specifications given in this document cover the general description, quality and workmanship of materials and finished work. They are not intended to cover minute details. The work shall be executed in accordance with best modern practices.

For all the Civil works these specifications shall have precedence in case anything contrary to this is stated anywhere in the contract document, unless specifically mentioned in this document or approved by the engineer. The Purchaser's decision shall be final, on any issue arising out of such discrepancies.

1.11 PARTICULARS OF THE MATERIALS TO BE USED BY THE BIDDER:

The bidder has to use the following materials for civil construction unless otherwise specified /approved by the Engineer in writing

- **Backfilling:**

A) AREA GRADING:

i) Upto EL 98.70m : Using soil (at OMC) with 5% cement (by weight of dry soil) and compacting the same as per relevant specifications for Backfilling /ground improvement unless approved otherwise. PCC may be used , only if specifically approved by the engineer without financial implication.

ii) Above EL 98.70m: Soil suitable for land escaping/ Soil Cement mix as approved by the Engineer.

B) Within Foot Print of structure/ equipment Foundation:

PCC shall be used, unless specifically approved by the Engineer. The properties of the back fill material used shall be suitably accounted in the design.

- **CONCRETE : M 35 Grade**

- **PCC: M15 Grade**

- **STRUCTURE-**

Foundation Type : RCC Raft or RCC Raft with Piles

Structure above Raft: Reinforced Cement Concrete (RCC), unless approved otherwise by the Purchaser. *RCC slabs and roofs shall be constructed using Galvanized deck sheets as left in shuttering,* unless specifically approved otherwise.

- **WALLS :**All external walls shall be of Concrete Block Masonry, unless approved otherwise by the Engineer . Wherever required, proper glass partitions shall also be provided.

- **ROOFING :**

  The roof of Turbine buildings shall be cast in situ RCC (with water proofing and required thermal insulation as per specifications) over Steel Deck Span Sheets, unless specifically approved by the Engineer. The roof of Turbine Buildings shall be laid over steel roof trusses and purlins. The roof shall be made without any internal support from slab below in order to avoid any interference in work being carried below the roof.

  The floors & roofs for Electrical Bay, Annex Portion of Turbine Building, PCB and AB shall be cast in situ RCC (with water proofing and required thermal insulation on roofs) .

- **PLASTERING : On masonry works**

  A)EXTERNAL: 20 mm thick rough cast plaster / sand faced plaster wherever masonry is used for cladding and as approved by purchaser.
  B) INTERNAL: 15 mm thick cement mortar

- **FLOORING :**

  40 mm thick Hardonate flooring in cement concrete 1: 1.5: 3 or alternative flooring or as functionally required & approved by the purchaser.

  The areas used for handling the chemicals and battery rooms shall be provided with acid & alkali resistant lining .

  In case, if specific flooring requirements are specified in other sections of the tender the same shall be followed unless otherwise agreed by the engineer.

- **WATER STOP :**

  PVC type as required & approved by the purchaser.

- **WATER PROOFING:**

  FOR ROOF :

  Spray Applied 2 component Polyurethene Membrane as per specifications on all RCC roofs . Wherever required, proper thermal insulation shall also be provided .

  FOR BASMENT / TUNNELS/ TRENCHES /SUMPS:.

PVC Membrane as per the technical specifications. PVC membrane shall also be provided all around CEP foundation external surfaces.

❖ **PAINTING**

A) INSIDE SURFACE :
On masanory walls upto 2 m height 250 micron thick epoxy paint & for balance height acrylic emulsion paint of shade to be approved by purchaser.

B) OUTSIDE SURFACE:
Anti-Carbonation, Anti-Corrosive and Waterproof Coating on plastered/ concrete surface of shade as approved by the purchaser.

C) STEEL STRUCTURE:
Epoxy paint as specified in clause 19.18.5.5, unless specified otherwise.

D) FLOOR :
1200micron thick Self-Leveling Epoxy coating on Turbine operating floor. On all other floors except for Turbine operating floor, 500 micron thick epoxy paint shall be used.

In areas where any other specific type of flooring like Acid Alkali Resistant Lining etc (other than Hardonate flooring) is specified, epoxy coating need not be provided.

E) FIRE PROOFING OF STEEL STRUCTURE:
Using Intumescent Paint for desired fire rating or encasing in concrete as specified in the drawing and approved by the Engineer.

❖ **DOORS/ WINDOWS :**

Anodised aluminum doors / steel rolling shutters and anodised aluminum windows as approved by the purchaser .Wherever required, fireproof doors shall also be provided of adequate fire rating.

❖ The false ceiling shall be provided, wherever specified in the tender (inclusive of other sections).

1.12 GENERAL & ARCHITECTURAL REQUIREMENTS

1.12.1 *Grade of concrete*

All the cement concrete works involved in the Turbine Building& other associated structures shall meet the requirements for relevant IS standards.

Grade of concrete shall be M35 for sub-structure and for super-structure. The RCPT value of the concrete used for the construction shall not be more than 2000 columbs at 56 days.

1.12.2 *Types of cement*

The cement shall be OPC 43 grade confirming to IS 8112 or OPC 53grade confirming to IS 12269 as well as the additional requirements of technical specifications . To meet the durability requirement, mineral admixture like flyash may be used with proper mix proportioning . The quality of fly ash shall meet the relevant technical specifications.

1.12.3 *Reinforcement*

The reinforcement shall be HYSD TMT bars of grade Fe 500 as well as the additional requirements of relevant technical specifications shall be used.

1.12.4 *General Architectural Requirements*

Powder coated aluminum panel of minimum 0.5mm thick lined ceiling (closed type pattern) fixed to R.C. beams shall be provided for all air-conditioned areas. The illumination and duct grills in these areas shall match the overall aesthetics.

All the buildings shall be provided with minimum 1.0m wide concrete paving all round as plinth protection. Paving shall be slopped outward to provide a rapid run off rainwater away from building.

Doors, windows and rolling shutters on external walls of buildings shall be provided with sunshade with side projections .Sunshade from walls shall be minimum 750 mm over windows & doors and 1500 mm over rolling shutters.

All stairs shall have a maximum riser height of 175mm and a minimum thread width of 250mm with Aluminum nosing. Minimum width of stairs of in all building shall be 1200mm.

Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 3.0m and number of riser shall not exceed 12 for a single flight.

Hand railing minimum 1100mm high shall be provided around all floors/roof openings, projections, balconies, walkways, platforms, etc. ***All hand rails, toe guard, balustrades, vertical posts& horizontal rails of RCC staircases connecting the floors& railings around openings in RCC floors shall be of Stainless steel*** . Other hand rails shall be 32mm nominal bores MS medium quality pipes and shall be coated with 2 coats of high build epoxy paints with suitable primer. Vertical spacing of landings shall not exceed 1.5m center to center. Minimum 2 numbers 32NB GI pipe shall be provided for horizontal rails and toe guard shall be provided. All rungs for ladder shall also be coated with 2 coats of high build epoxy paints with suitable primer as per specifications.

All steel platforms above grade shall be constructed with 150 wide kick plates at edge of platform to prevent tools or materials from falling off platform.

Doors shall be provided at appropriate location to prevent dust ingress from outside.

Rolling shutter size and its operating system shall be decided based on the equipment handling for erection and maintenance with a side clearance.

All windows/louvers shall be of anodized aluminum .

External cage ladder shall be provided for access to Turbine building roof. Internal cage ladder 2 nos. shall be provided to access crane walkway .

All the edge protection angles shall be coated with 2 coats of high build epoxy paints with suitable primer.

1.12.5 *Glazing*

Glazing partition wall shall be provided in areas wherever required and as approved by the Engineer.

Glazing shall be in double toughened glass with glass of minimum 6mm thickness for effective thermal insulation. Vision panel shall be minimum 4mm thick.

Windows & ventilators located on external walls above operating floors levels and those located in fire prone areas shall be provided with wired glass of minimum 6mm thickness. Windows in other areas shall be finished with 6mm thick clear glass.

1.12.6 *Flooring*

The nominal total thickness of floor finish shall be 40mm. The areas used for handing of chemicals shall be provided with Acid & Alkali resistant Lining. Wherever, special type of flooring is required due to functional requirements or mentioned in other sections, the same shall be provided.

Skirting shall match with floor finish.

1.12.7 *Roof Drainage System*

A system shall be provided for removal of water from roof surface to avoid damage to the roof structure of all buildings and shall consist of the following:

Roof Drain Heads
Rainwater down comers
Fixtures

IS:1742 code of practice for buildings drainage shall be followed for this purpose.

Multiple drains (min.2nos.) shall be provided for all roof areas. System will be designed to handle rainfall at a rate of 125mm per hour and in accordance with

stipulations of IS:1742

Roof drains will be connected to main roof drain arrangement as given in Drawing No. GHAVP-1&2/15200/5001/GA and Drawing No. GHAVP-1&2/15200/5002/GA.

1.12.8 ***Plant Drain, Surface Drain & Sewer Line:***

Construction shall be done as per the system engineered by Purchaser as specified in clause 1.6.7 above . Wherever additional lines are to be laid to connect the system engineered by Purchaser, shall be designed and constructed by Bidder.

1.12.9 ***External Painting***

The building shall be provided with paint on external surface matching with the plant aesthetics as specified in clause 1.11 above.

1.13 LAYOUT

Only two main centre lines and one permanent bench mark would be furnished and all other lay out, fixing levels etc. shall be done by the Contractor at his own cost. The Contractor shall protect and maintain, during the course of execution of the work, the main centre lines and bench marks, so that they are left undisturbed even after completion of his work.

1.14 ACTIVITY SCHEDULE

The successful bidder has to prepare the detailed schedule and construction procedures for all major activities and submit the same for approval before commencement of work.

The work shall commence and completed in accordance with the Construction Schedule specified elsewhere. The various phases of work shall be completed within the periods as specified in the approved construction schedule, to be submitted by the bidder. The total completion period for this contract will be as given in the tender notice attached with this tender document.

2. DESIGN SPECIFICATIONS

2.1 PROJECT SITE FEATURES

2.1.1. LOCAL GEOLOGY

Seven Boreholes BH103, RBH-104,RBH-109, BH-110, RBH-111, BH-115 and BH-116 were drilled covering Turbine Building-1.

Seven Boreholes BH105, RBH-112, BH-113, BH-106, RBH-114, BH-117 and RBH-118 were drilled covering Turbine Building-2.

Boreholes RBH-107 & RBH -108 covers Transformer Yard of both the units.

The soil samples from these boreholes have been tested . The location of bore holes & relevant data are enclosed in Annexure-1.

Subsurface profile at Turbine building -1 & 2 areas generally consists of alluvial deposits for full depth of exploration. Alluvium soils, consisting mostly of clayey silt and silty sand, were encountered from the ground surface in the boreholes. Based on Standard Penetration Tests (SPT) conducted in this layer, consistencies of the cohesive soil (clayey silt) ranged between medium stiff to hard Clay Silt, while relative densities of the granular soil (silty sand) derived from SPT values, ranged between Medium dense to Dense silty sand. Boreholes were terminated in this layer at depths between 51.6m and 54.0m below existing ground surface and details are given in the Annexure - 1.Groundwater level was observed at depths between 2.3 m and 3.0 m below existing ground surface in the boreholes.

2.1.2. SITE GRADING

The site selected for general layout of Turbine Building and other associated structure are located in a relatively flat terrain. This area will be excavated and ground improvement will be carried out by the Purchaser up to the levels as indicated in drawing No GHAVP 1&2-/16000/2003 &2004 /DD. However, on completion of construction, this area will have to be graded to Finished Grade Level of RL 219.3 m. i.e. EL 99.7 M and the same is included within the scope of this tender.

The finished floor level of all the structures is fixed at EL 100 000 i.e RL 219.6 M . The site will be graded to EL 99700.

2.1.3. SEISMIC, SAFETY, QUALITY & DESIGN CLASSIFICATION

The site lies in Zone-III, as per the zoning map of India [IS-1893-2002, Part-1]. The structures within the scope of this tender are seismically classified category 3, safety class NINS (Not important from Nuclear Safety) & Design Class DC-4(Non Safety class structure.

2.1.4. METEOROLOGICAL CONDITIONS

Following meteorological data should be considered for design.

a) Annual average Rainfall: 450 mm
Maximum Intensity /Hr for 1 Hr duration: 125 mm/hr
(for design of roof drainage)

b) Wind pressures : Following wind speed shall be followed in the design.

Height	V_b	k_1 values for	Values of	3-sec averaged extreme wind

(m)	(m/s)	different return periods						speed for different return periods			
		50	100	1000	10000	k_2	k_3	50	100	1000	10000
10	47	1.00	1.07	1.35	1.63	0.99	1.00	46.5	49.8	62.8	75.8
20	47	1.00	1.07	1.35	1.63	1.06	1.00	49.8	53.3	67.3	81.2
30	47	1.00	1.07	1.35	1.63	1.09	1.00	51.2	54.8	69.2	83.5
40	47	1.00	1.07	1.35	1.63	1.12	1.00	52.6	56.3	71.1	85.8
50	47	1.00	1.07	1.35	1.63	1.14	1.00	53.6	57.3	72.3	87.3
60	47	1.00	1.07	1.35	1.63	1.15	1.00	54.1	57.8	73.0	88.1
70	47	1.00	1.07	1.35	1.63	1.16	1.00	54.5	58.3	73.6	88.9
80	47	1.00	1.07	1.35	1.63	1.18	1.00	55.5	59.3	74.9	90.4
90	47	1.00	1.07	1.35	1.63	1.19	1.00	55.9	59.8	75.5	91.2
100	47	1.00	1.07	1.35	1.63	1.20	1.00	56.4	60.3	76.1	91.9

Note: (i) Design wind speed obtained by multiplying basic wind speed by different factors of k_1, k_2 and k_3; and (ii) Values of k_2 at different heights are computed under assumption of terrain category 1, Class C

c) Max Dry Bulb Temp : 50.8 ^{0} C (1000 year return period)
d) minimum Dry Bulb temp : -6.9 ^{0} C (1000 year return period)
e) Relative Humidity
i) Max. during monsoon : 100%
ii) Min. during Dec to Jan : 5%

2.2 DESIGN

The design of the structures (unless specified otherwise) given in clause 1.6 &1.7 is in the scope of the Bidder. The design of the structures shall be done by the Bidder or his design consultant as approved by the purchaser .**The designer should have experience to design of similar structures i.e minimum one Turbine Building with Turbo generator Foundation of a power plant of minimum 500 MWe capacity of any Nuclear or Thermal Power Plant in soil sites**. ***The designer shall be acceptable & approved by the purchaser. The credentials of Designer shall also be provided along with technical bid.***

The bidder has to follow the procedure for preparation and approval of design documents given in flow chart as Annexure-2 of this tender.

2.2.1 PROOF CONSULTANT

The successful bidder shall appoint a proof consultant(s) with the approval of the purchaser for independent checking of the analysis, design and drawing works carried out by the bidder or his design consultant. The bidder shall provide the names of his prospective design consultants (if appointed) and proof consultants along with his bid.

It is preferred that proof checking consultants are from institutions like IIT's or

any other premier organizations / experienced professionals. The proof consultant shall have experience of analysis & design of machine foundation & framed structures. The proof consultant shall be acceptable & approved by the purchaser. The credentials of Consultant (if appointed) & Proof consultant shall also be provided along with technical bid.

All design related deliverables by bidder shall bear the certification by proof check consultant regarding conformance to codal provisions and technical specifications.

2.2.2 GUARANTEE FOR DESIGN

The bidder shall furnish guarantee against fault in the design (even though it might have been accepted by the Purchaser)of the structures covered under his scope of work. Further he shall also carry out at his cost all necessary rectification/improvements in the design of structures covered under the contract so as to make good any inadequacy arising out of above factors. The approval of Purchaser does not absolve the bidder from the overall responsibility of satisfactory performance of design & construction of the works within his scope.

2.3 DESIGN PARAMETERS AND METHODOLOGY

The following design parameters and methodology shall be followed for structural/civil engineering design of Turbine building and other structures within this contract. ***The fundamental principle controlling the design and construction of all the structures is to ensure that functional performance is maintained at all times upto earthquake level of zone III of IS 1893 and structural integrity against collapse is also to be maintained under the extreme loading including Safe Shutdown Earthquake condition*** to ensure safety of the adjacent safety related buildings viz. Control Building, SAB etc.
In principle this shall be achieved through a combination of using the best quality control standards for material and workmanship during construction and designing for all severe load combinations, whilst imparting a high level of redundancy within the structural system.

2.3.1 DESIGN PARAMETERS

2.3.1.1 SAFE BEARING CAPACITY, FOUNDING LEVEL & OTHER GEOTECHNICAL PARAMETERS:

The safe bearing capacity at founding level of any structure shall be computed based on standard codal approach/ practices considering the geotechnical parameters of the influence zone, based on dimension of structure and maximum intensity of pressure. For finalization of influence zone, the soil profile up to a depth, where net increase in vertical pressure becomes less than 10% of the initial overburden pressure from founding level of the structure shall be considered in the analysis.

The various geotechnical parameters to be considered for evaluation of engineering parameters are given in Annexure 1.

The geotechnical parameters given in Annexure-1, are evaluated based on bore hole data obtained on original ground prior to excavation. Subsequently, the ground improvement is carried out to mitigate liquefaction, in varying depth below the founding level using Soil Cement mix. Therefore the properties of the improved soil as given Annexure-1A shall be considered instead of soil properties for the relevant improved portion of ground.

The foundation of all major equipments of transformer yard (SUT, UT, GT etc.) & oil separation pit, CCW Inlet & hot water tunnel, PCB & Electrical bay, Turbine Building and Turbo-generator etc. shall be taken from EL 95.4 or below, unless required otherwise functionally or approved by the engineer. All other tunnel / trenches may be engineered & founded on PCC / Soil Cement mix, unless approved otherwise and as accepted by the Engineer.

2.3.1.2 MODULUS OF SUBGRADE REACTION :

The value of subgrade reaction for both static and dynamic analysis shall be worked out as per detailed soil structure analysis using ABAQUS or equivalent software. The detailed approach for the same is given in clause 2.4 below.

2.3.1.3 GROUND WATER

From the recording of ground water table observed in various bore holes during site investigation, it has been established that the bore holes and trial pit water level variation within the main plant area is quite erratic. The ground water table varies from 0m to 3m from the existing ground level. The Coefficient of permeability based on pump-out test is 1.2 x 10-5 m/sec. This value is recommended for the design of dewatering system in this area. The design, operation & maintinance of dewatering system for the TI package area is in the scope of NPCIL. The details of the same will be provided to the successful bidder. The bidder has to schedule his work plan in coordination with dewatering contractor engaged by NPCIL. However, if any water accumulates within the building same shall be dewatered by the bidder at his own cost.

As the foundations are below the ground water table, de-watering will be required during construction. Suitable de-watering system will be adopted during construction stage to maintain the water level 1 m below the founding level. All the foundations, retaining walls etc. will be designed taking into account worst conditions of ground water hydrostatic pressure. As per the current practice for design and stability check purpose, ground water level will be taken upto finished grade level/EL 95.4M as approved by the engineer. The structural integrity of the basement raft and walls shall be ensured by designing them for full hydrostatic head upto ground level/ EL 95.4M as approved by the engineer.

2.3.1.4 EARTHQUAKE INDUCED LIQUEFACTION

The phenomena of Landslides, Collapse, Subsidence and Liquefaction depend on the nature of ground and prevailing sub-soil water conditions. The soil is found to be susceptible for Liquefaction and same is being treated upto the expected founding level of structures as indicated in the Drawing No GHAVP-1&2/16000/2003 &2004/DD by the purchaser.

2.3.1.5 LOADS & LOAD COMBINATIONS

The following loads shall be considered in their worse combinations as appropriate for the design of the Turbine Buildings, Ventilation Buildings, Electrical Bay, Pipe & Cable Bridge , Transformer Yard area& CCW Tunnels etc

a) Dead Loads (D)

Dead loads comprise of the self-weight of all permanent construction, including walls, floors, roofs, ceilings, columns, stairways, cable shafts and fixed service equipments. While estimating dead loads for the purpose of design, the unit weight specified in IS: 875 Part-1 shall be used.

b) Equipment Loads (EL)

The buildings shall house a number of equipment on various floors. The loads from these equipments shall be specified as per vendor details.

c) Live Loads (L)

Live loads on floors shall be considered as per the following sub-sections:

d) Uniformly distributed loads

The uniformly distributed live loads assumed shall be the highest values likely to be produced. The uniformly distributed loads are static loads on the plan area and provide for normal effects of impact but do not take into consideration special concentrated loads, which are been dealt below.

e) Concentrated loads

Except for offices, toilet blocks etc. all floor slabs, secondary beams and girders etc. (other than the operating platforms near the equipments) shall be designed for a concentrated load of 10000 N acting simultaneously with the uniform live load as given in (i) to take care of any unforeseen exigent loads. This load shall be assumed to act at points so as to result in maximum moment and/or maximum shear. However, this load shall not be considered concurrently along with any actual concentrated load given to be carried over to the main beams, columns and foundations. For floor slabs, unless otherwise specified, this load shall be assumed to act as distributed uniformly over an area of 750mm square and shall be located so as to produce the maximum

stress condition in the floor slab.

f) Live load on roof (LR)

Live load on roof shall be considered, as the roof is provided with access. The following provisions as per BIS 875 Part-2 shall be followed. The minimum live load on roof that shall be considered for design is 1500 N/sq m. but not less than 3750N uniformly distributed over any span of one meter width of roof slab or 9000N uniformly distributed over the span in the case of beams or truss or wall.

g) Loads on purlins supporting the RCC roof

Every purlin shall be designed to carry the more severe of the two loads indicated below:

- The loads transmitted to the member RCC roof in accordance with (f) and
- An incidental concentrated load of 10000N placed at the most unfavorable position on the member.

h) Loading on handrails, parapets etc

Stairway railings, hand rails, parapets and balustrades, both exterior and interior shall be designed to resist horizontal thrust of 750 N/m applied at the top of the railing.

i) Loads due to impact and vibration

Structures carrying live loads, which induce impact or vibration, shall be designed for increased live load as follows:

Structures	**Min. Impact Factor**	**R e f e r e n c e**
a) For light machinery, shaft or motor units.	20%	BIS:875
b) For reciprocating machinery or power units.	50%	BIS:875
c)Transformer roller loads	10%	Assumed
d)Truck wheel load	30%	Assumed

Impact and vibration load for gantry girders, monorails etc

For crane gantry girders and supporting columns, the following allowances shall be deemed to cover all forces set up by vibration, shock from slipping of slings, kinetic action of acceleration and retardation and impact of wheel loads –

Type of load	Additional load
a) Vertical loads for electrical overhead crane (EOT)/monorails	25% of maximum static wheel loads.
b) Vertical loads for hand operated cranes/monorails (HOT)	10% of maximum wheel loads.
c) Horizontal forces transverse to the rails for electric overhead cranes.	5% of weight of the crab and the weight lifted on the crane.
d) Horizontal forces along the rails for EOT cranes.	5% of the static wheel loads.

The horizontal forces specified in (c) & (d) shall be considered as acting at the rail level.

For monorails no horizontal surge shall be considered.

j) Construction Live Load (CL)

These are the superimposed loads, which may come on a member during construction or after construction as erection loads.

k) Soil/Earth Pressure (Sp)

Turbine building with C.W. Pit basement walls shall be subjected to lateral earth pressure for the portion where sides of the wall are back-filled. The walls shall be subjected to earth pressure at rest derived as per standard formulae.

l) Hydrostatic Pressure (F2)

The basement walls shall be designed considering the subsurface water pressure rising up to finished grade level/ El 95.4m, as approved by the engineer , under normal and severe environmental load combinations including Earthquake. Computation shall be based on the buoyant unit weight of the soil plus full hydrostatic pressure. The value of δ shall be taken as half the value of δ for dry backfill. The full upward pressure of water below basement floors shall be taken over the entire area.

m) Rain Loads (RL)

Design maximum intensity of rainfall for the roof is 125 mm/hr. The flat roofs shall be designed to sustain the load of rainwater that could accumulate on it during any unlikely event of roof drain blockage. The maximum accumulated height of water shall be assumed as 300mm over roof drain and 150mm over roof slab. Rain load and live load on roof shall not be considered to act simultaneously and more critical of the two shall be adopted in the design.

n) Wind Loads (WC)

The design wind speed (Vz) shall be computed in accordance with BIS:875 (Part-3).

The relevant normal loadings to be considered in combination with wind load as stated above shall comprise of the full dead load and the reduced percentage of live loads as applicable, together with live loads on roof. For structural design 100 year return period of wind shall be considered.

o) Seismic Loads (EO/ES)

Since no safety related systems are located in turbine building and other associated structures, but due to provision of MSIV on PCB, the seismic classification has been kept as NINS and structure design is to be done as per codal provisions of IS 1893.However, the structural integrity against collapse is also to be maintained for all the structures under the extreme loading (SSE) condition to ensure safety of the adjacent safety related buildings viz. Control Building, SAB etc.

The elements of the structures shall be checked considering the SRSS values of responses due to all the three ground motions acting concurrently.

At GHAVP- 1&2 site, in SSE condition the digital value of Response spectra is given in Annexure-3 corresponds to the peak free field ground acceleration .

The relevant normal loadings to be considered in combination with seismic load (SSE) shall comprise of the full dead load and the following percentages of live loads:

Load Class	Percentage of Design Live Load
Staircase & balconies	25%
Uniformly distributed live loads 4000 N/sq.m. and above	50%

Under earthquake conditions the structure shall be assumed as loaded with the above-reduced percentages of live loads and the roof with no live load . Self wt. of EOT cranes shall be considered without any lift load.

Active earth pressure distribution due to submerged backfill on the basement walls during an earthquake shall be as per the provisions of BIS:1893. Also active pressure due to uniform surcharge over backfill behind basement walls shall be obtained as per BIS:1893. For saturated earthfill, the saturated unit weight of the backfilled soil shall be adopted. For submerged earthfill, the dynamic increment in active earth pressure during earthquakes shall be found using Mononobe-Okabe formulae which has been furnished in of BIS:1893and also recommended in ASCE 4-16.

p) Crane Load:

The maximum load while lifting the test load shall be considered . However this shall

not be considered during the seismic condition.

q) Surcharge:

A suitable surcharge (Minimum 2 T/SQM) shall be considered in the design on account of movement of equipment, traffic, stacking of material , crane etc on the ground adjacent to structures .

r) Internal Pressure (In case of Pressure Tunnels)

The internal water pressure in the tunnels including the surge & shut off condition shall be considered in the design appropriately as specified in Section C-2-5.

***s)* Any Other Load:**

As applicable the load due to temperature, creep, shrinkage etc shall be considered in the design following the relevant codal provisions.

t) Combination Of Loads

The turbine buildings and other structures shall be designed for worst combination of the loads specified above and any other loads as applicable. The suitability of the design shall be checked for load combinations to satisfy the Limit state of serviceability & Limit state of strength / Collapse as defined below:

i) Limit state of Serviceability :

Load combinations under this category are unfactored (or as given in Table-18 , BIS:456 for Limit State of Serviceability) and shall be used to ensure the requirements of limit state of serviceability of the structure. For CCW Tunnels relevant requirements specified in the AWWA standards and requirements specified in C-2-5 shall be met.

ii) Limit State of strength/ Collapse:

Load combinations for design under this category are factored and shall be used to ensure that no applicable limit state of failure is exceeded and stresses in the structure are well within its permissible limits . The structural elements to grouped into a number of groups and the basic loading combinations applicable to each of these groups shall be applied . The load factors applicable for the various load combinations shall be based on the combination philosophy of BIS:456, except for the Extreme Environmental load combination. No load factors of the extreme environmental load (SSE) combination has to be considered.

All loads with appropriate load combinations shall be considered to act with the corresponding load factor. The most unfavorable effect on the structural element shall be considered for design. In the load combinations, under Severe Environmental and

Extreme Environmental condition, the earthquake and the wind loads are considered not to act concurrently. Moving loads such as those of monorail hoists, EOT crane together with the loads lifted are considered only for normal load combinations. In other combinations their static load effects without the loads being lifted are to be considered. Loading effects due to truck or transformer movement are to be considered under normal load combination. Construction load shall be combined with dead load only.

For CCW Tunnels relevant requirements specified in the AWWA standards and requirements specified in C-2-5 shall be met.

2.4 Submission of design report

The analysis shall be carried out using NISA, ANSYS, ABAQUS, SAP which has been validated. The bidder shall make copies of all the analysis & design documents available to the owner in required numbers as desired by the purchaser.

2.5 ANALYSIS AND DESIGN METHODOLOGY

Prior to carrying out actual analysis, the structural analysis software needs to be validated by solving some benchmark problems.

2.5.1 Modeling of Soil Structure Interaction

2.5.1.1 Evaluation of Geotechnical Properties

Soil Structure Interaction shall be taken into account by providing suitable springs at the foundation nodes.

The following approach for soil springs calculation for raft foundation with/without pile shall be followed, unless approved otherwise by the engineer:

a. The soil profile in the site consists of two parts. The upper layer is known as improved soil consisting of soil-cement mix to mitigate the liquefaction potential. The layer below the improved layer is natural soil. The depth of excavation and soil improvement is shown in the Drawing No. GHAVP-1&2/16000/2003&2004/DD.

b. Design soil profile up to a depth where net increase in vertical pressure becomes less than 10% of the initial overburden pressure from founding level of the structure shall be considered in the analysis.
c. Geotechnical parameters of the Improved Soil and natural soil profile (below the improved soil) shall be considered are per its properties given in Annexure -1 &1A.
d. Wherever geotechnical data are not available up to required depth, worked out as per para (b) above, the geotechnical properties of the last available layer of soil shall be considered up to the required depth for which data are not available.

2.5.1.2 Evaluation of Soil Springs using above Geotechnical Properties

In case of structure supported on raft foundation or combined piled raft foundation (CPRF), evaluation of springs for soil/soil & pile shall be carried out as follows:

a. Detailed Soil –Structure-Interaction (SSI) analysis with appropriate simulation of soil-pile-structure interaction shall be carried out using ABAQUS or similar software to compute the stiffness of soil spring (i.e., for raft foundation system) and soil & pile spring (for CPRF) for both static and dynamic condition.
b. Validation report of the calculation of springs using above software shall be submitted.

Suggested approach for evaluation of static and dynamic spring by detailed Soil-Structure Interaction using ABAQUS or similar software:

I. Geometric modeling of layered soil strata shall be done, as 3D finite element of size 3LX3L where L is the longest dimension of raft/structure.
II. Boundary condition of soil layer element in lateral direction shall be considered as fixed and vertical direction free. And boundary condition of bottom elements of soil is fixed in all direction.
III. Geometric modelling of structure (including pile for CPRF) shall be carried out.
IV. Modelling of interface of soil – structure and soil-pile-structure shall be done, which requires computation of following interaction parameter:
   (a) Friction factor ($0.75\tan\phi$)
   (b) Critical/limiting shear stress $\{0.75x\ (Cu+\sigma\tan\phi)\}$
   (c) Elastic slip

V. Perform static analysis with static modulus of elasticity, E_{static} values of soil profile under sustained load, which includes dead load, equipment load and live load. The modulus of subgrade reaction value (Kz_{static}) is estimated by dividing the induced contact pressure at typical i_{th} node of the raft with displacement of that node. The modulus of subgrade reaction thus obtained is multiplied by the contributory nodal area of that node to obtain the vertical stiffness of soil and pile spring at typical i_{th} node.
VI. Similarly dynamic analysis shall be performed using dynamic modulus of elasticity, $E_{dynamic}$ (using correction factor of $G/G_{max} = 0.4$, where G_{max} corresponds to low strain shear modulus) under sustained load plus Earthquake loading to obtain dynamic springs as $Kx_{dynamic}$, $Ky_{dynamic}$ and $Kz_{dynamic}$. The stiffness at typical i_{th} node in lateral directions is computed by dividing the induced contact shear stress in that

direction with the lateral displacement along that direction and further multiplied this value by the contributory nodal area of that node.

VII. To obtain static spring stiffness in lateral direction (x &y direction) at typical i_{th} node, following equations may be followed

$Kx_{static}=Kx_{dynamic}$ x $(Kz_{static}/Kz_{dynamic})$

$Ky_{static}=Ky_{dynamic}$ x $(Kz_{static}/Kz_{dynamic})$

2.4.1.3 Using spring values calculated by above approach further structural analysis shall be carried out using any standard Finite Element software like NISA, ANSYS, ABAQUS, and SAP etc.

2.5.2 F.E. Modelling & Design of Turbine Building, Electrical Bay, PCB, Access Bridge &Transformer Yard

The structures should be idealised as a 3D framed system. Raft, Pile(if applicable) Columns, beams and slabs should be modeled using suitable finite elements available in the structural analysis software to be used. Commercially available software for structural analysis like NISA, ANSYS, ABAQUS, SAP etc.

3D static analysis has to be done to obtain the member forces due to the static load conditions.

To obtain the member forces due to earthquake, response spectrum analysis with 3-D model of the structure has to be performed using the response spectra as per IS 1893. For collapse study under SSE , the response spectra given in Annexure -3 shall be used **.**

2.5.3 TG BLOCK

The TG block consists of top deck, columns, intermediate platforms and TG mat. Top deck supports the turbine, generator and the exciter. The columns of TG pedestal, independent columns supporting the platforms, some internal columns and pit walls are supported on the TG mat.

The design of TG block shall be based on working stress method. The permissible stresses in concrete and reinforcement shall be based on IS: 456 and IS: 2974 (part-3). In addition to functional requirement mentioned above codal requirements of IS: 2974 (Part-3) shall be satisfied. Some of the important requirements are listed below:

- The base mat shall be so dimensioned that the resultant force due to weight of the machine, the top deck, intermediate floors/platforms, columns supporting the TG deck, equipments and supporting structures resting on mat, basement walls resting on the mat etc., shall not have eccentricity with respect to the centre of gravity of the base area more than 3% of the base dimensions in the direction of the eccentricity.
- Adequate haunches shall be provided at intersections of the beams and the columns to avoid large concentration of stresses and to increase general rigidity of the frame.

- Fundamental natural frequency of the TG block in horizontal direction shall be separated by a minimum of 20% of the operating speed and fundamental natural frequency in vertical direction shall be separated by 50%.
- Minimum reinforcement for the deck beams shall be 0.25% of the sectional area at top and bottom and 0.1% of sectional area at sides.
- Allowable bearing pressure on soil/rock shall be 80% of allowable safe bearing pressure on soil
- For grouting of machine bed plates and pockets for anchor bolts, non-shrink grout shall be used.
- TG block should have adequate strength to withstand the worst combination of static, dynamic and seismic loads.
- Raft should be rigid enough to ensure fixed end conditions for the columns and prevent non-uniform settlement. If required , the Piles shall be provided under the raft.
- The natural frequency of the machine foundation system to be such as to avoid resonance at operating speed of the turbo-generator and the amplitude of displacements or any other specific criterion specified by the Turbine / Equipment Manufacturer.

2.5.4 Tunnel Trenches

The Tunnels are to be designed for the worst combination of loads considering Internal water pressure , wherever applicable (Considering Surge both positive & negative pressure & Shutoff Pressure), Earth Pressure (considering fully saturated soil conditions) , Surcharge, Seismic Loads, Loads from vehicular movement over tunnels and any other additional loads etc as applicable. The support for tunnel shall be properly modeled considering the springs or any other elements as the case may be. The suitability of design shall be checked for completely filled as well as in its empty condition etc also.

The tunnels are to be designed meeting requirements specified in IS 3370

2.5.5 SPECIFIC REQUIREMENTS

2.5.5.1 FIRE RATING & CORROSION

The Turbine building& other associated structures in the scope of this tender will have to cater the fire rating specified in Section C-1-3, unless approved otherwise. The following minimum dimensions and clear covers shall be provided.

Element	Parameter	Minimum Dimension (mm) for Resistance Period			
		1 hour	2 hour	3 hour	4 hour
Column	Side	200	300	400	450
	Cover	25	35	35	35
Load	Thickness	125	150	200	250

bearing wall	Cover	15	25	25	25
Slab	Thickness	100	125	150	175
	Cover	15	25	35	45
Beam	Width	125	200	250	275
	Cover	30	60	70	80

Note: Covers indicated relate to main reinforcing bars. Floor finishes shall be taken as part of clear cover for top reinforcement in beams and slabs . Fire rating requirements will not govern for secondary structural elements like lintels, transoms, mullions and canopies. Weld mesh shall be provided wherever cover is more than 40 mm.

2.5.5.2 EMBEDDED PARTS (EP)

These shall be designed for maximum forces arising out of Operating condition and Earthquake (codal) condition**.** It may be noted that the usage of Cinch anchors for anchoring any equipment is prohibited unless specifically permitted by the engineer. Therefore the bidder should provide adequate number of EPs for fixing the equipments and services. However, anchors less than 6 mm dia may be used to provide electrical fixtures etc.

3. CLEARING AND EARTHWORK

3.1 EARTHWORK EXCAVATION

3.1.1. GENERAL

SCOPE OF WORK :

The major excavation of site will be carried out by the Purchaser. The area after excavation up to a depth susceptible for liquefaction is improved using compacted soil- cement mix to a level as indicated in the drawing no. **GHAVP-1&2/16000/2003& 2004/DD.**

It is preferred to take up the foundation of various structures from the levels indicated in above mentioned drawing. However as per layout and structural arrangement opted by the bidder or system requirements , if the founding levels are lower than the levels specified in Drawing no GHAVP-1&2/16000/2003& 2004/DD, the ground shall be lowered by bidder using appropriate cutting tool like chisel etc which does not disturb and damage the improved soil below founding level. In case of damage the same shall be corrected by the contractor without any extra cost to Purchaser.

The above work of excavation shall be carried out as per relevant technical specifications. The contractor has also to make necessary arrangements for side protection to avoid any slippage of soil etc. at his own cost. No extra payment will be

made to remove any of slipped earth etc in the excavated area**.** The contractor is also requested to visit the site prior to quoting & satisfy himself with the actual site conditions. In case further excavation is required, the same shall be carried out as per following specifications:

A) This section covers all the excavation works to be performed under this contract which shall consist of clearing of site and excavation of all existing material of whatever nature, to the lines and grades shown on the construction drawing or as otherwise directed by the engineer. The work shall also include chiseling, loading, hauling and disposal of materials in designated spoil, stockpile areas or directly as construction materials.

B) The contractor shall also be responsible for excavation which is not specifically required for the construction of permanent structures, but incidental to the installation of temporary facilities such as site roads, approach ramps etc.

C) Slope protection and stabilization measures, which may be needed in conjunction with surface excavation work, shall be carried out as defined in other sections of these specifications by the contractor at his own cost.

D) The approval given by the Engineer during the course of execution, to the contractor's methods and equipment shall not relieve the contractor of his full responsibility for the proper and safe execution of excavations, or of liability for injuries to, or death of persons, or any other obligations under this contract. It shall also not relieve his responsibilities for the accuracy or adequacy of the plan for obtaining the desired results in the stipulated time schedule.

3.2 SUBMITTALS

A) The contractor will be required to submit along with the bid, a detailed method statement, drawings and work programme for the excavation. The method statement has to give the details on the plant and equipment proposed to be used by the contractor for excavation and haulage, blasting methods, drainage and safety precautions, disposal of material, procedures for installation of soil supporting and stabilization works, and for construction of temporary site facilities such as roads, temporary drainage lines etc.

B) After the award of work and at least 15 days prior to commencement of the actual excavation, the contractor shall submit to the Engineer an updated method statement and programme for the activities set out in (A) above giving refined and full details of the proposed excavation methods in improved ground and sequences including necessary plans for site drainage and safety precaution. Any and all variations from the corresponding data submitted with the tender will be explained and justified in the updated document to the satisfaction of the Engineer. The data shall include the following:

i) Method for excavation of improved ground
ii) Method of mucking & disposal of excavated material.

iii) Details of the equipment to be deployed with proper justification.

C) Within 7 days of receipt of the above updated excavation method statement and programme, the Engineer will advice the contractor in writing, of his acceptance of, or comments on the submitted documents. The Engineer reserves the right to reject the proposed plan, if, in his opinion, undesirable damage to improved ground or existing structures would result from the proposed excavation method. If acceptance is withheld, a new plan in whole or in part shall be submitted. Excavation shall only be carried out in areas for which the Engineer has accepted the plan.

D) At least 15 days prior to dumping and stock piling any excavation material, the contractor shall submit the layout of spoil or stock pile areas which will be within the areas designated on the tender drawings or as approved by the Engineer. All pertinent data of working methods and provisions for stability and temporary and permanent drainage of the areas shall be included. Details of volume proposed to be stored, material types, heights of storage and grades shall be provided.

E) The Contractor shall submit and agree with the Engineer a monitoring plan for the progress of the excavation as well as to observe potential or actual movement of the slopes of the excavated pit. This plan shall also give details of the procedure and equipment to be employed by the contractor to stabilize or to protect as quickly as possible any areas in which untoward movement or slope deformation is likely to occur or has occurred.

3.3 CLEARING THE SITE (IF APPLICABLE)

All the areas upon which the construction is to be carried out and over which excavation is to be done and areas which are required by the Contractor for his construction facilities are to be cleared of all rubbish, and any other objectionable matter. All spoils and unserviceable materials and rubbish shall be disposed of at locations away from the work site in a manner directed by the Engineer. Care shall be taken to see that unsuitable waste materials are disposed off in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction. Useful materials, saleable timber, firewood etc., shall be stacked properly at the work site in a manner directed by the Engineer and finally handed over to Purchaser.

3.4 LAYOUTS AND LEVELS

Under no circumstances shall the contractor remove or disturb any permanent benchmarks / reference pillars installed by Purchaser. The contractor shall carefully maintain and protect all benchmarks and reference pillars and shall layout all his works by accurate reference thereto. The layout and levels of all structures shall be made by the Contractor from the general grid of the plot and bench marks given by the Engineer. The Contractor shall make his own surveying arrangements for laying out and establishing the reduced levels based on two reference grid lines and one bench mark as furnished by the Engineer and shall be responsible for the accuracy of layout and levels.

The theodolite and leveling instruments to be used by the Contractor shall be of digital type (total station). He shall also render necessary assistance to the Engineer by way of surveying instruments, materials and men for checking the layout and levels.

The ground level shall generally be taken at spacing at a grid of 5m x 5m.Where local mounds or abrupt undulations are met with or when so directed by the Engineer, the grid spacing may be at closer interval not exceeding 2m. The ground levels shall be properly recorded and plotted on plans, which shall be signed by the Contractor and the Engineer before the earthwork actually commences.

3.5 EXTENT OF EXCAVATION, LINES AND GRADES

The contractor shall perform excavation in all types of soils, murrum, soft and hard improved cement-soil mix., etc. in foundation, over areas and in trenches to widths, lines, levels, grades and curves as shown in the drawing or to lesser widths, lines and levels as directed by the Engineer.

3.6 APPLICABLE CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

a) IS-3764 - Safety Code for Excavation Work.

b) IS:9758 - Guidelines for de-watering during construction.

c) IS:10379 - Code of practice for field control of moistures and compaction of soils

d) Indian Explosives Act 1940 (Latest Version)

e) IS-2720 - Part-II - Determination of water content.

Part-VII - Determination of water content. - Dry Density Relation Using Light Compaction.

Part-VIII - Determination of Moisture content - Dry Density Relation Using Heavy Compaction.

Part-XXVIII - Determination of Dry Density of Soils, In-place, by the Sand Replacement Method.

Part XXIX - Determination of Dry density of Soils, In place, by core cutter method.

f) IS-4081 - Safety Code for Blasting and Related Drilling Operation.

g) IS-1200 - Method of Measurement of Building Works.

3.7 EARTHWORK EXCAVATION -GENERAL

Excavation shall be done to lines and levels defined in the drawings or as directed by the Engineer. The earthwork shall also include, where required temporary sheet piling or sheeting, bracing and shoring, to maintain the excavated pits, without interruptions to service lines, cables, duct banks, etc., encountered within the area of excavation or within reasonable distance of excavation.

3.7.1 LIMITS OF EXCAVATION

All excavation shall be carried out very carefully using methods and techniques that will produce smooth and sound surfaces with minimum over-break beyond the lines and grades/ limit of excavation shown in the construction drawings and will preserve the structural integrity of the excavated area. The contractor shall take all precaution to preserve in the soundest possible and undisturbed condition all materials beyond the limits of excavation. Special care shall be exercised where vertical or near vertical faces are required. Any extra excavation beyond the specified limit shall be made good by the contractor at his own cost with the class of material proposed to be laid over it or any other material approved by the Engineer.

Soft pockets, if any, shall be removed even below the final level and extra excavation shall be filled up by material which is proposed to be laid over it or any other material approved by the Engineer.

3.7.2 CLASSIFICATION OF EARTH WORK

For purposes of work to be executed in accordance with this specification, the following classification shall apply.

A) All types of soils, murrum, loose boulders of size with volume up to 1 cum, intrusions and soft rock

The excavation work shall further be categorized in the following 3 categories:

A) Excavation in General Areas & grading work up to grade level.
B) Excavation for buildings /structures foundations below grade level.
C) Excavation for Tunnel & trenches etc., below grade level

3.7.3 EXCAVATION IN SOIL

This includes earth, murrum, top deposits of agricultural soil, reclaimed soil, clay, sand or any combination thereof, soft and hard murrum, shingle etc. which is loose enough to be removed with spades, shovel, pick axes, poclain & poclain mounted rippers.

When the bottom of the excavated pit as indicated in the construction drawing is disturbed or loosened by the excavation process, the contractor shall improve it at his

own cost with the class of material proposed to be laid over it or any other material approved by the Engineer.

3.7.4 EXCAVATION IN HARD CEMENT SOIL MIX:

This includes all improved soil other than materials mentioned above, , which shall be removed only by , chiseling and wedging etc. as approved by the engineer.

3.7.5 STRIPPING BLUFFS AND LOOSE SOIL

All loose soil, not directly in the excavation but close to the area to be excavated as to be liable, (in the opinion of the Engineer), to fall or otherwise endanger the workmen, equipment, or the work etc. shall be stripped off and removed away from the areas of excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion, which was originally sound and safe. Any materials not requiring removal as contemplated in the work, but which, in the opinion of the Engineer, is likely to later become loose or unstable shall also be promptly and satisfactorily removed as directed by the Engineer.

3.7.6 APPROACH RAMPS/ROADS

The contractor shall adopt method of mucking by clamshell, dragline or conveyors. However only under exceptional circumstances where ramps are unavoidable, the Contractor may provide the same with the prior approval of the Engineer. Berms, if required at intermediate levels may be provided beyond 6-m depth with the prior approval of the Engineer. Such ramps shall be excavated later and the excavation shall be finished to the lines and grades shown on the approved drawings and to the satisfaction of the Engineer. No extra payment shall be made for formation of such berms , ramps etc. The berms , ramps falling outside the line of excavation shall be made good after the completion of work as directed by the Engineer.

3.8 STABILITY OF EXCAVATION

The methods of excavation shall, in every case be subject to the approval of the Engineer. The Contractor shall ensure the stability and safety of the excavations, adjacent structures, services and the works. The Contractor shall ascertain himself the nature of materials to be excavated and difficulties likely to be encountered in executing the excavation. Coffer dams, sheeting and shoring, bracing and maintaining suitable slopes, draining etc. shall be provided and installed by the contractor. The contractor shall submit drawings to the Engineer showing the proposed arrangement with detailed design calculations and shall obtain written approval from the Engineer. Irrespective of the approval of the Engineer, the responsibility for adequacy of such measures shall rest fully with the contractor.

If any slip occurs, the Contractor shall remove all the slipped material from the excavated pit, at his own cost. Also, if any damage to the built up structure occurs because of the slip, the Contractor shall make good the same at his own cost & to the satisfaction of the Engineer.

3.8.1 TIMBER SHORING

Timber shoring shall be as specified in IS: 3764-Safety Code for Excavation Work. Wherever the shoring is required for deep excavations, the same shall be designed by the Contractor and got approved by the Engineer prior to its use in the work

Timber shoring shall be 'Close' or 'Open' type, depending on the nature of soil and the depth of pit or trench. The type of shoring shall be as approved by the Engineer.

3.8.2 OPEN TIMBERING

In the case of open timbering, the entire surfaces of the side of trench or pit are not required to be covered. The vertical boards of minimum 25 cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangements, sizes of the timber and the spacing shall be subject to the approval of the Engineer.

3.8.3 CLOSE TIMBERING

Wherever so directed by the Engineer the contractor shall provide close timbering

3.8.4 LEFT IN SHORING

If the Engineer directs any timbering to be left in for the safety of the structure or otherwise for reasons commensurate with the type of construction, necessitating such decision, the same shall be provided by the contractor.

3.8.5 REMOVAL OF SHORING

The removal of shoring timber shall be done very carefully to prevent the collapse of the pit or trench. It shall start at one end and proceed systematically to the other end. No part of the work should be damaged during the removal of the shoring. No claim shall be entertained for any shoring, which cannot be withdrawn and is lost and buried.

3.9 ACCEPTANCE OF EXCAVATED AREA

Excavated area shall be cleaned, trimmed to exact shape and size. All disturbed material and other debris shall be removed and the surface shall be thoroughly cleaned to the satisfaction of the Engineer. A joint survey of the excavated pit shall be carried out at various stages of excavation before acceptance of the excavated area. The joint survey report duly signed by NPCIL and the contractor. Before any further work with concrete or backfill is commenced, the Contractor shall inform the

Engineer and get the area approved by him.

3.10 DISPOSAL OF SURPLUS MATERIAL

All surplus materials shall be carried away from the site and disposed at dumping site/ stock piles, in separate heaps as per the utility of the material, as directed by the Engineer. The Engineer may ask the contractor to dump the excavated materials in low lying areas, regular heaps, bunds, blankets riprap with regular slopes and level so as to provide natural drainage. As a rule, all softer material shall be laid towards the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. All such works as mentioned above are deemed to have been taken into account while quoting .

All excavated material from the pits shall be the property of the Corporation and if the Contractor wants to use it, he shall have to obtain it from the Engineer at a rate fixed by the Purchaser, until unless specified otherwise.

In no case, the excavated soil shall be stacked within a distance of 1.5 m from the edge of the excavation or 1/3rd of the excavation depth, whichever is more.

3.11 PRECIOUS OBJECT, RELICS, OBJECTS OF ANTIQUITY ETC.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or on the site shall be the property of the Corporation and contractor shall duly preserve the same to the satisfaction of the Engineer and from time to time deliver the same to such person or persons as the Engineer may from time to time authorize or appoint to receive the same.

3.12 USE OF EXCAVATED MATERIAL:

The Contractor may note that useful material excavated from the structures shall be used for backfilling. All the material suitable for backfilling shall also be stacked suitably. The excavated material used for backfilling will be available free of charge, if required the contractor has to break the bigger sized available material to the suitable size as specified in the specification, for backfilling at his own cost .

4. BACKFILLING

4.0. GROUND IMPROVEMENT /BACKFILLING USING COMPACTED SOIL / SOIL-CEMENT MIX

4.1 OBJECTIVE

The objective of this document is to lay down the specifications for Ground improvement of GHAVP-1&2 site by replacement of in-situ soil from

existing/excavated level as per drawing by well compacted in-situ soil / in-situ soil cement mix.

The bidder shall study this specification along with the other documents and input data given by NPCIL and work out the detailed working methodology for the execution of the work.

4.2 SCOPE

As per the Liquefaction studies carried out at site, the soil is found to be susceptible for liquefaction in varying depth . Based on records of water table the ground upto EL 95.40M is only susceptible for Liquefaction. Based on Purchaser's experience from earlier projects and geotechnical studies , the Ground improvement upto the depth susceptible for Liquefaction, within the battery limits of this package is carried out by the Purchaser upto the top levels as indicated in Drawing No GHAVP-1&2/16000/2003 &2004/DD.

Any area which is to be raised (including after excavation) shall follow the requirements given in Clause 1.11. The specifications given below shall be followed for backfilling .

1. Improvement of soil characteristics by mixing cement in soil at Optimum Moisture Content (OMC) corresponding to modified Proctor density (Heavy compaction) test and application of suitable roller compaction to achieve the target maximum modified Proctor density at site.

2. Improvement of soil characteristics by suitable roller compaction of soil at OMC corresponding to modified Proctor density (Heavy compaction) to achieve the target maximum modified Proctor density at site, wherever specified or specifically approved by the Engineer.

This specification covers the following aspects:

(a) Study of trial report on Ground Improvements (Compacted soil/ soil- cement mix) and liquefaction analysis by USNRC guidelines.

(b) Collection of soil samples from site for carrying out laboratory tests.

(c) Conducting laboratory tests to arrive at optimum moisture content and modified proctor's density of soil and soil cement mix samples.

(d) Carrying out grain size analysis, moisture content (for soil) and unconfined compressive strength and stability for soil cement samples.

(e) Excavating and drying soil in drying beds, mixing/batching of soil/soil cement mix in suitable batching-mixing plant, laying and spreading of soil/ soil cement mix at OMC in layers and compacting each layer by suitable vibro rollers.

(f) Conducting field tests to find out moisture content, density & SPT values for compacted soil and soil - cement mix.

(g) Determining post improvement values of cohesion & angle of internal friction of soil.

(h) Carrying out liquefaction analysis as per USNRC guidelines using the above laboratory and field test values.

(i) Maintaining batching, mixing, compaction & testing records.

NOTE

Report on field mockup - report no. GHAVP-1&2/Civil-1/10120/Report/2017/02/R2 is provided for *broad information/ general understanding purpose*. The work shall be carried out in line with the recommendations of the trial mock up. Any modification suggested by the successful bidder for optimization purpose shall be demonstrated to yield desired results by conducting additional mock up by the bidder at his own cost.

4.3 REFERENCE CODES/ DOCUMENTS

- Trial mock up Report: Report no. GHAVP-1&2/Civil-1/10120/Report/2017/02/R1
- IS 2131: Method for Standard Penetration test of Soil.
- IS: 4332- Part-1: – Method of sampling and preparation of stabilized soils for testing.
- IS: 4332- Part-2: – Determination of moisture content of stabilized soil mixtures.
- IS: 4332- Part-3: – Test for determination of moisture content- dry density relation for stabilized soil mixtures.
- IS: 4332- Part-4: – Wetting and drying, and freezing and thawing tests for compacted soil-cement mixtures.
- IS: 4332- Part-5:– Determination of unconfined compressive strength of stabilized soils.
- IS: 4332- Part-7: – Determination of cement content of cement stabilized soils.
- IS: 2720- Part-4: – Methods of test for soils; Grain size analysis.
- IS: 2720- Part-5:– Method of test for soils; Determination of Liquid and Plastic limit.
- IS 2720- Part-7: Determination of Water Content-Dry Density relation using Light Compaction.
- IS 2720- Part-8: Determination of Water Content-Dry Density relation using Heavy Compaction.

- IS 2720- Part-28: Determination of dry density of Soils In-place, by the Sand Replacement Method.
- ASTM D5778-12: Standard Test method for electronic Friction Cone &Piezocone penetration testing of Soil.
- IS 12175: – Specification for rapid moisture meter for rapid determination of water content for soil.
- IS 3764: – Excavation work- Code of Safety.
- IS: 269: Specification for 'Ordinary Portland Cement'
- IS: 456: Specifications for 'Plain and Reinforced Concrete'
- IRC SP-89: Guidelines for Soil and Granular material stabilization using cement, lime and fly ash.
- Soil-Cement Inspector's Manual by Portland cement association.
- Specifications for road and bridge works, Indian roads congress, Ministry of shipping,
- road transport & highways.

4.4 MATERIALS

Following material shall be used for the work under this specification:

1. Soil excavated from Project area.
2. Ordinary Portland cement.
3. Water

4.5 INPUTS BY NPCIL

NPCIL will provide the following documents with regard to this work:

GHAVP-1&2/Civil-1/10120/Report/2017/02/R2: Report on Field Mock-up for Ground Improvement by Replacement of Liquefiable Strata by Compacted soil/Soil-Cement Mix.

4.6 DEWATERING: The dewatering for the area will be carried out by the Purchaser through some other agency. However, if any water accumulates within the building same shall be dewatered by the bidder at his own cost.

4.7 COLLECTION OF SOIL FROM PROJECT AREA

The excavated soil from the project area shall be used for preparation of soil/ soil-cement mix. Contractor shall prepare the drying beds for facilitating natural drying of the excavated soil. The excavated soil shall be spread in the drying beds for sufficient time before using the same for preparation of compacted soil/ soil-cement mix. Soil in

drying beds shall be protected against rains through provision of suitable sheds, bunds, cut-off trenches, diversion channels, etc. and also protected during subsequent stages, i.e. transportation to batching plant, transportation to site for placement and after placement & compaction. The size and number of such drying beds shall be planned so as to meet the overall construction schedule. All efforts shall be made to minimize dust pollution during handling/ transportation/ mixing of soil/ soil-cement in mixing/ batching plant etc.

4.8 PREPARATION OF COMPACTED SOIL/ SOIL-CEMENT MIX

The methods of ground improvement to be adopted for this work i.e.

1. Compacted soil-cement mix (with 5 % of cement) in consultation with the Engineer.
2. Compacted soil.

The dried soil shall be thoroughly pulverized and taken to batching-mixing plant for preparation of compacted soil/ soil-cement mix. Mixing of soil/ soil and cement with water, as the case may be, shall be done in a mechanical mixer/batching plant. The quantity of water to be added shall be such that optimum moisture content (OMC) is achieved at the time of compaction. The capacity of batching-mixing plant shall be commensurate with the construction schedule requirements.

Tolerance on water content shall be maintained within +0.5% & -2% of OMC. Layer displaying plastic behavior in the form of bumpiness during compaction shall not be accepted & removed.

4.9 MIXING, TRANSPORTATION, PLACEMENT & COMPACTION

Automated plant with weigh batching shall be used for mixing.

The mix shall be transported to site in tippers (covered, if necessary, depending on ambient atmospheric conditions) and placed in position by conveyor belt or other appropriate means. Transit time shall not be more than 30minutes for soil-cement mix. Suitable ramps shall be prepared for entry/exit to/from excavated pit. The mix shall be placed on dry sub-base and in no case pooling of water shall be allowed at any point of time. The compaction of soil/ soil-cement mix shall be done at OMC in layers of maximum compacted thickness of 200 mm each by adequate number of passes of suitable vibratory roller so as to achieve 95% of modified proctor's density for both soil and soil-cement mix. Moisture loss from soil cement shall be minimized by either laying of subsequent layer of soil cement or curing with damp burlap (in case of break in laying of subsequent layer). Interlayer gap for soil cement mix as adopted in mockup will be adhered to. For soil cement mock-up, compaction must be finished within the Initial Setting Time and next layer shall not be laid before the final setting time.

The work shall be carried out strictly as per the recommendations of the trial mock up. Any modification suggested by the successful bidder shall be demonstrated to yield desired results by conducting additional mock up by the bidder at his own cost, however the capacity, type of vibro-roller and number of passes in mutually perpendicular directions shall meet requirement of target dry density.

4.10 LABORATORY & FIELD TESTS ON SOIL SAMPLES

4.10.1 LABORATORY TEST

The following laboratory tests shall be conducted on the soil samples as per relevant IS.

1. Grain size analysis
2. Atterberg's Limits of Soil.
3. Bulk density and dry density of soil.
4. Natural moisture content.
5. Modified Proctor density to find out maximum dry density at OMC for soil/ soil cement mix.
6. Unconfined compressive strength, stability tests and cement content (through procedural means) on soil-cement samples.
7. Organic content of soil

4.10.2 FIELD TESTS

1. Measurement of ground water table.
2. Measurement of ground Levels.
3. Standard Penetration tests (SPT) on compacted soil and compacted soil-cement. After completion of SPTs the bore hole shall be grouted with cement sand in the proportion of 1:10.
4. Measurement of in-situ Moisture content.
5. In-situ density of the compacted backfill shall be determined by any of the following three methods:

- Nuclear Method
- Sand Cone method
- Rubber-Balloon method

The contractor shall develop laboratory facility at site to carry out day-to-day testing of soil and soil-cement mix. However, for any special/ non routine laboratory tests, testing may be carried out at NPCIL approved laboratory with prior permission of the Engineer.

4.11 INSPECTION AND TESTING PLAN

The following testing frequencies shall be adopted for the work:

The soil dried in the drying beds shall be tested for grain size analysis & moisture content before mixing. The testing frequency shall be 1 test per 1000 cum. & 200 cum. respectively.

All the cement supplied shall be accompanied by manufacturer's test certificate. The cement shall be tested for Normal consistency, Compressive strength (3 days and 7 days) & Initial and final setting time for every batch/week no. subject to minimum of 1 test per 250 MT.

Sample extracted from prepared mix, before compaction shall be tested at site for OMC requirement for every 200 cum.

The soil cement mix shall be tested at the age of 3 days & 7 days for unconfined compressive strength, at the rate of one sample (consisting of three specimens) from each layer for every 2500 sqm. For the purpose of this testing, the core/ specimen shall be extracted from the compacted soil cement layer with the help of sampler immediately after compaction i.e. in green condition and removing the core from the sampler with the help of plunger.

Both soil & soil-cement mixes shall be tested for in-situ density in each layer along with moisture content. The testing frequency shall be one test per 500 sqm of each layer.

After completion of compaction of all the layers of soil, SPT shall be conducted as per the given frequency: one test per 900 m2 area for the improved portion of soil. For soil-cement mix one SPT per 9000 m2 area shall be conducted. The SPT shall be done at 1.5 M interval throughout the depth of improvement for both soil and soil-cement mix.

In case of soil-cement mix owing to high resistance to penetration (as observed during mockup), the test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, efforts shall be made to extract the core for conducting Unconfined Compressive Strength.

After completion of SPTs the bore hole shall be grouted with cement sand in the proportion of 1:10.

The consolidated recommended ITP for various activities is summarized below:

Testing frequency for soil mix		
S.No.	Type of test	Frequency of test

1	Grain Size	1 Test per 1000 cum
2	SPT	1 Test per 900 sqm
3	Moisture Content (before mixing)	1 Test per 200 cum
4	Moisture Content (after mixing before compaction)	1 Test per 200 cum (*to be staggered with S.No.3 above)
5	In-situ dry density with moisture content	1 Test per 500 sqm per layer

Testing frequency for soil-cement mix		
S.No.	Type of test	Frequency of test
1	Grain Size and Modified Proctor's Density in case of both soil and soil cement	1 Test per 1000 cum
2	Cement content of soil-cement mix	1 Test per 500 cum(Through procedural checks on cement consumption)
3	Soil cement core compressive strength	1 Test per 2500 sqm per layer (3 & 7 days)
4	Cement- Normal consistency	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
5	Cement- Compressive strength (3 days & 7 days)	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
6	Cement- Initial & Final Setting time	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
7	Moisture Content (before mixing)	1 Test per 200 cum with minimum of 1 test on each day of ground improvement
7a.	Organic matter (before mixing)	1 Test per 50000 cum
8	Moisture Content (after mixing before compaction)	1 Test per 200 cum (to be staggered with S. No. 7 above)
9	In-situ dry density with moisture content	1 Test per 500 m2 per layer
10	SPT	1 Test per 9000 m2 *
11	Stability test of soil-cement mix	1 Test per 2 lakhs cum of GI considering the grain size distribution of soil covering different soil types.
12	Multichannel Analysis of Surface Wave Studies for confirmation of uniformity in improved ground.	Two profiles covering the entire area of improved ground for every 10000 m2 after laying all the layers.

* In case of high resistance to penetration (as observed during mockup), the test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, efforts will be made to extract the core for conducting Unconfined Compressive Strength.

4.12 RECORDS

Records shall be kept for procurement, production, compaction and post compaction and testing activities. The following records shall be maintained by contractor and submitted to NPCIL:

1. Test certificates of cement.
2. Testing records of soil & cement.
3. Batching/ mixing records.
4. Testing records on soil & soil-cement mix.
5. Field records on placement & compaction at site.
6. Testing records connected with post compaction testing

4.13 SUPERVISION & QUALITY ASSURANCE

During the entire process of works under this specification, independent qualified QA inspectors shall be deployed by the contractor. Contracting agency shall make all the arrangements for testing and inspection by NPCIL.

A detailed work procedure with resources deployment and cycle time calculations shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work.

4.14 ACCEPTANCE CRITERIA

The target minimum in-situ dry density of compacted soil/ soil-cement layers shall be 1.8 gm/cc as one of the acceptance criteria to be met during compaction. This is on the basis of densities achieved during the mockup.

For soil-cement method of ground improvement, 7 days UCS of samples casted at mixing plant shall be controlled. SPT will be conducted however, in case of high resistance to penetration, the SPT test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, the core shall be extracted for conducting Unconfined Compressive Strength as a quality control measure for variability

Contractor may optimize the type of equipment (roller type) and number of passes to achieve and demonstrate meeting the acceptance criteria as per ITP mentioned above by conducting mockup.

5. **DEWATERING :** The dewatering for the area will be carried out by the Purchaser through some other agency.

6. CONCRETE

6.1 SCOPE

a) This specification covers all the aspects of concrete production like procurement of ingredients, storing, proportioning, mixing, placing, vibrating and curing of plain, reinforced, pre-stressed and pre-cast concrete etc. This specification broadly covers: -

i) Requirements for source-qualification, procurement, batch qualification testing and storage of concrete ingredients.

ii) Requirements for proportioning of concrete mix, batching, mixing, Transportation, sampling, testing and acceptance of concrete of specified grades.

iii) Requirements for preparation and placement of concrete including chilling, conveying, depositing, compaction, curing, finishing, inspection, testing and preparation of construction joints and repairing, if needed.

b) Wherever information shown is in contradiction to the contents of this specification, all information pertaining to plain, reinforced, pre-stressed and pre-cast concrete shown and noted on the drawings shall be considered part of this specification and shall supersede this specification.

c) During concrete mix proportioning, it may be required, in consultation with the Engineer, to include pozzolanic material (fly ash, micro silica, GGBS etc.) either individually or in combination, to meet the specified requirement of strength and durability. Special provisions with regard to allowable limits of these pozzolanic materials, effect on properties of concrete, durability requirements of concrete have been highlighted. To achieve high level of mechanization in concrete production and placement, special requirements for batching plant, concrete pumping equipment, field practices etc. have also been highlighted.

6.2 QUALIFICATIONS AND APPROVAL OF SOURCES

All materials required for the manufacture of concrete and used for curing of concrete shall be procured only from approved sources. Such approvals shall be given by the Engineer only after due evaluation of tests and test certificates and also after further sampling and testing the materials as per relevant specifications by the contractor. It is the responsibility of the contractor to carry out investigations and evaluation of sources of material for pre-qualification. The contractor shall also ensure that at least two sources of each material are pre-qualified for ensuring uninterrupted supply of material. Bulk procurement of the ingredients of the concrete shall be made only after the contractor has completed the process of pre-qualification and the Engineer has

duly approved the sources/ products. The approval of the Engineer does not, however, absolve the contractor of his responsibility for the quality and consistent supply of the materials.

6.3 STANDARDS AND SPECIFICATIONS

The provisions of the latest revisions with amendments, if any, of the following Indian Standards and other relevant codes shall form part of this specification to the extent they are relevant. Where the provisions of these Standards/Codes are in conflict with the stipulations of this specification, the specification supersedes the respective Standard or Codes.

6.3.1 BUREAU OF INDIAN STANDARDS

IS – 383	Specification for coarse and fine Aggregates from natural sources for concrete.
IS – 456	Plain and reinforced concrete – code of practice
IS – 460	Specification for Test Sieves (Part I, II & III).
IS – 516	Methods of Tests for strength of concrete.
IS – 1199	Methods of sampling and Analysis of concrete.
IS – 1343	Pre-stressed Concrete - Code of practice
IS – 1727	Methods of test for pozzolanic materials.
IS – 1791	General requirements for batch type concrete mixers
IS – 2386	Methods of Test for Aggregates for concrete. (Part I to VIII)
IS – 2395 Part I & II	Painting of concrete, masonry and plaster surfaces - Code of practice.
IS – 2430	Methods of sampling of aggregates for concrete.
IS – 2505	Concrete vibrators – immersion type. - General requirements
IS – 2506	General requirements for concrete vibrators, screed board type.
IS – 2514	Specification for Concrete vibrating Tables.
IS – 2645	Integral Waterproofing Compounds for Cement Mortar and Concrete – Specification.
IS – 2722	Specification for portable swing weigh batchers for concrete. (Single & Double bucket type).
IS –3025	Methods of sampling and test (Physical and Chemical) for water and waste water (Part 1 to63)
IS – 3085	Method of test for permeability of cement mortar & concrete.
IS – 3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS-3812 (Part-I)	Pulverized Fuel Ash – Specification: For use as Pozzolana in Cement, Cement Mortar and Concrete.
IS – 4031	Methods of physical tests for hydraulic cement (Part 1

	to 15).
IS – 4032	Method of chemical analysis of hydraulic cement.
IS – 4082	Stacking and storage of construction materials and components at Site - Recommendations.

IS – 4634	Batch type concrete mixers - method of test performance of.
IS – 4845	Definitions and terminology relating to hydraulic cement.
IS – 4925	Concrete batching and mixing plant: specification
IS – 5816	Splitting Tensile Strength of Concrete – Method of Test.
IS – 5892	Concrete transit mixers - specification
IS – 6461	Glossary of terms relating to cement concrete (Part-1 to 12)
IS – 7320	Specification for Concrete slump test apparatus.
IS – 7325	Specification for Apparatus for determining constituents of fresh concrete.
IS – 7861	Code of practice for Extreme weather concreting (Part 1 & Part 2).
IS – 8112	Specification for 43-grade ordinary Portland cement.
IS – 8142	Method of test for determining setting time of concrete by penetration resistance.
IS - 9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS – 9103	Concrete Admixtures – Specification
IS – 10262	Concrete mix proportioning - Guidelines.
IS – 12089	Specification for granulated slag for manufacture of Portland slag cement.
IS – 12269	Ordinary Portland cement 53-grade - Specification.
IS – 12600	Portland cement low heat - Specification.
IS – 14687	Falsework for concrete structures – guidelines.
IS –14959 (Part-I)	Determination of Water Soluble and Acid Soluble Chlorides in Mortar and Concrete (Fresh mortar and concrete).
IS- 15388	Silica fume- Specification
SP-23	Handbook on Concrete Mixes.

6.3.2 ASTM STANDARDS

ASTM C-33	Standard Specification for Concrete Aggregates.
ASTM C-94	Standard Specification for Ready Mixed Concrete
ASTM C-295	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C-494	Standard Specification for chemical admixtures for concrete.
ASTM C–1202	Standard Test method for electrical indication of concrete's ability to resist chloride ion penetration.
ASTM C-1240	Standard Specification for silica fume used in cementitious mixtures.

ASTM C–1260	Standard test method for Potential Alkali Reactivity of Aggregates (Mortar - Bar Method)
ASTM D–75	Standard practice for Sampling Aggregates
ASTM D–1411	Standard Test methods for Water - Soluble chlorides present as admixtures in graded aggregate road mixes.

6.3.3 ACI / ASME CODES AND SPECIFICATIONS

ACI 211.1	Standard Practice for selecting proportions for normal, Heavy Weight and mass concrete.
ACI 304.1R.	Guide for the use of Preplaced Aggregate Concrete for Structural and Mass concrete Applications.
ACI 304.2R	Placing Concrete by Pumping Methods.
ACI 318	Building code requirements for structural concrete and commentary.
ACI 349	Code requirements for Nuclear safety - related concrete structures
ASME Sec-III Division-2	Code for Concrete Containments

6.3.4 OTHER STANDARDS

a) Railway Specifications – Tests for chloride and sulphate content of aggregates.

b) The European guidelines for Self-Compacting Concrete – Specification, Production and Use (EFNARC Publication).

c) DIN-1048 Specification for water permeability of concrete.

d) Concrete library of JSCE No. 36 – Recommendations for construction of concrete containing ash as a mineral admixture

e) JSCE Concrete engineering series 31- Recommendation for self-compacting concrete

f) BS6699- Specifications for Ground Granulated Blast Furnace Slag for use with Portland cement

6.4 STORAGE OF MATERIALS

a) The contractor shall make necessary arrangements, for safe storage and ensure prevention against deterioration of the materials. Cement, fly ash, GGBS, micro silica, super plasticizers, admixtures, retarders etc. shall, invariably, be stored in weather proof sheds of adequate capacity for storage of the material for at least 3 weeks' of work. However, the contractor shall ensure that sufficient quantities of all materials are available for uninterrupted progress of the work. Cement and other construction materials shall be stored as per recommendations of Indian Standards and as per manufacturer's recommendation. Storage silos shall be watertight. In the

storage area, proper access and lighting shall be provided for inspection, identification and drawl of material. The material shall be stored batch wise with proper identification tag, indicating the quantity received, batch number and the date of receipt and issue. The consignments shall be used in the order of receipt at site, unless otherwise directed. In case of large concrete pours, the material to be used shall be identified and procured well in advance, taking the quantity required for a particular concrete pour into consideration. The cement shall be used within three months from the date of manufacture. However, in exceptional circumstances, if approved by the Engineer, the above stipulation may be relaxed subject to the condition that the material shall be retested to ensure the conformity with the technical specifications. Normally, materials of different type or grade shall not be stored in the same godown. If materials of different type or different grade are stored in the same place, it shall be clearly demarcated and separated to avoid intermixing.

b) The contractor shall prepare an elaborate procedure for the periodic inspection and testing of the materials to detect any deterioration and also for segregation of the deteriorated material. The above procedure shall be approved by the Engineer and implemented by the contractor. It is the responsibility of the contractor to provide all samples and other facilities to the Engineer for carrying out inspection and testing of materials both at the source and at the site of work at his own cost. The rejected materials shall be removed from the site within 48 hours. If the contractor fails to remove the rejected material within 48 hours, the right to get the materials removed from the site rests with the Engineer and all the expenditure incurred by the Engineer for such removal shall be borne by the Contractor.

c) Coarse and fine aggregate (both normal and heavy) shall be stacked on concrete/masonry platforms separately in a manner to prevent their intermixing and to avoid contamination by foreign materials. Each size of aggregate shall be kept separately with wooden, steel, concrete or masonry bulkheads in such a way, to prevent intermixing. If necessary, rock ladders, reclamation tunnels etc. may be provided so that the grading of the material is not affected.

d) All storage arrangements, handling schemes shall be subject to the approval of the Engineer. If the storage arrangement is not to the satisfaction of the Engineer, he may direct the contractor to make such arrangements as he considers necessary and in the event of non-compliance, the Engineer reserves the right to make such arrangements as may be needed at the contractor's risk and cost.

e) A detailed record of receipt and issue of all materials with the associated test certificates shall be maintained by the contractor and shall at all times be available to the Engineer for his scrutiny.

6.5 CONCRETE INGREDIENTS

6.5.1 CEMENT

6.5.1.1 SOURCE QUALIFICATION

a) In no case, cement shall be purchased from agents/ distributors. A minimum of two cement plants shall be pre-qualified well before the start of the concreting works.

b) In general, Ordinary Portland cement (OPC) of 43 grade conforming to IS 8112 and 53 grade conforming to IS 12269 shall be used. In addition to the requirements specified in these standards, following additional requirements shall also be met with:

i) Chloride content shall not be more than 0.05% by mass of cement.
ii) C_3A content shall be between 5% and 8%.
iii) In case of alkali reactive aggregate, alkali content, as Na_2O equivalent shall not be more than 0.6% by mass of cement.

c) Any other special type of cements i.e. Portland Pozzolana Cement (IS 1489 – Part 1 and 2), Portland Slag Cement (IS 455), Sulphate Resisting Cement (IS 12330), Low Heat Portland Cement (IS 12600), Rapid Hardening Portland Cement (IS 8041) may be used in works only with the written permission of the Engineer and only if the design of structures demands the usage of the same.

6.5.1.2 PRE-DISPATCH TESTS

All the consignments of cement shall be accompanied by the manufacturer's test certificate for individual batches, ensuring that cement meets all the requirements of the specification.

6.5.1.3 TEST AT SITE (BATCH QUALIFICATION)

a) In addition to the manufacturer's test certificate, the Contractor shall arrange for testing of the cement either at site laboratory or at any other outside laboratory approved by the Engineer. Cement samples, for such tests, shall be drawn, in the presence of the Engineer or his authorized representative. A composite sample shall be collected representing 250 MT (or such smaller quantity as may be decided by the Engineer) of cement from each grade / brand with proper batch identification. At least 10 grab samples shall be taken representing the entire batch. When cement is supplied in bowser / bulker and directly fed to the silo, grab sample shall be taken from each bowser / bulker. Composite sample shall be prepared by thorough mixing of the grab samples to represent the entire batch.

b) The tests and their frequency shall be as given in Table 6.1.

TABLE 6.1

FREQUENCY OF TESTING OF CEMENT

Sl. .No	Description of Test	Frequency
1	Normal consistency	250 MT or lesser
2	Compressive strength 3 days, 7 days, 28 days	250 MT
3	Initial and final setting time	250 MT
4	Specific gravity	2000 MT

5	Soundness	
a	Le Chatelier's method	2000 MT
b	Auto clave method	2000 MT
6	Specific surface	2000 MT

c) All the chemical tests specified in the relevant standards shall be conducted at an independent laboratory for every 20000 MT of cement supplied or at every 6 months whichever is earlier for each brand/grade. All the chemical compounds shall be reported separately. Bogue's compounds shall also be calculated and furnished.

d) The Engineer shall be able to witness sampling, testing and inspection of cement at the site laboratory or at independent laboratory. Cement shall be released for use, only after ensuring that it meets the requirements of initial and final setting time as well as 3 days compressive strength results. If required, necessary co-relation shall be established between accelerated 1-day strength with 3, 7 and 28-day strengths. Based on this co-relation, cement may be inducted into the work with the prior approval of Engineer in exceptional cases only.

e) Cost of above testing shall be borne by the Contractor. Contractor shall ensure that the construction schedule is not affected because of testing of material at outside laboratory.

f) Test results either from the site laboratory or from an approved outside laboratory shall be taken as final for acceptance or rejection criteria.

6.5.2 FLY ASH

a) Fly Ash conforming to IS 3812 (Part 1) shall only be used. Bottom ash, Ash from Air pre-heater and pond ash shall not be used for mortar as well as for concrete production. Fly ash shall be collected in dry condition from the source with proper moisture proof packing arrangement. Fly ash can also be supplied in bulk containers. For source qualification, three samples from a particular source shall be collected and tested for physical and chemical properties. If all the three samples pass the requirements given in IS 3812 (Part-1) then the source shall be considered as acceptable. However, loss on ignition shall not be more than 2% and particles retained on 45-micron sieve shall not exceed 20%. This requirement is in variance with IS 3812 (Part-1). Bidder will have to meet the requirements given in the specification. In case the quality of fly ash collected from the source does not meet the requirements the contractor will have to use the processed flyash or install a classifier at his own cost.

b) All the physical and chemical tests specified in IS 3812 (Part-1) shall be conducted at every 2,000 MT of fly ash or at every 1-month intervals whichever is earlier. However for fineness only percentage retention on 45-micron sieve shall be the criteria for acceptance or rejection. The discretion to change this frequency rests with the Engineer depending upon the consistent performance of the previous batches. The fly ash, if stored for more than 3 months, it shall be re-qualified before its use.

c) The contractor shall get the test certificate for each batch of supply from the fly ash supplier. The contractor at his own cost shall undertake the following tests either at field laboratory or at outside approved laboratory for each batch of 100 T or part thereof:

i) Percentage retained on 45 micron sieve
ii) Loss on ignition
iii) Moisture content

6.5.3 MICRO SILICA

a) Though micro silica is available in three forms i.e. un-densified, densified and slurry form, only densified form of silica fume shall be used and shall conform to the requirements of IS: 15388.

b) Test requirements of micro silica for source qualification as well as batch qualification shall be as per Table 6.2. For batch qualification tests specified under serial No. 2, 3,5 and 6 of following table (Table 6.2) shall be conducted for every 100 Tons and all other tests shall be carried out at every 2000 Tons.

TABLE 6.2

TEST REQUIREMENTS OF MICRO SILICA

Sl. No.	Description of test	Test method	Requirements
1	SiO_2,(%), min	IS 1727	85.0
2	Maximum Moisture content (%)	See Note 1	3.0
3	Loss on ignition (%), max	IS 1727	4.0
4	Alkalies as Na_2O (%), max	See Note 2 and 3	1.5
5	Oversize percent retained on 45 micron IS sieve (%), Max	IS 1727	10.0
6	Compressive strength at 7 days as percent of control samples	IS 1727 See Note 3	85.0
7	Specific surface (m^2/g), min	IS 15388 Annexure A	15.0
8	Specific gravity*	IS 1727	-

NOTE:

1. For determination of moisture content, dry a weighed sample as received in an oven at 105^0C to 110^0C. Express the percentage loss in mass and record as moisture content.

2. For determination of alkalis, method of test used for determination of alkali in cement may be adopted.

3. In the test method for determination of compressive strength of silica fume cement

mortar in accordance with IS: 1727, the value of factor N may be taken as 1.

4. Specific surface test is optional.

5. Tests specified above shall be carried out by the contractor at his own cost.

(*) For batch qualification the specific gravity value shall not deviate by ±0.2 from the values obtained during mix qualification

6.5.4 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

a) The GGBS shall conform to BS 6699. The GGBS may be used with OPC (Ordinary Portland Cement) 43 grade conforming to IS: 8112 or 53 grade conforming to IS: 12269.

b) Test requirements of GGBS for source qualification as well as batch qualification shall be as per Table 6.3. Cost of testing shall be borne by the Contractor.

TABLE 6.3

TEST REQUIREMENTS OF GGBS AS PER BS 6699

Sl. No	Description of test	Test method	Requirements
1	Fineness (M^2/Kg)	EN-196-6	275 (minimum)
2	Soundness (Le Chatelier Expansion) in mm	EN-196-3	10.0 (maximum)
3	Loss on ignition (%), max	EN-196-2	3.0 %
4	Insoluble Residue (%)	EN-196-2	1.5 (max)
5	Initial Setting Time (IST)	EN-196-3	Not less than IST of OPC
6	Magnesia content (%)	EN-196-2	14.00 (max)
7	Sulphide Sulphur (%)	EN-196-2	2.00 (max)
8	Sulphite Content (%)	EN-196-2	2.50 (max)
9	Magnese Content (%)	EN-196-2	2.00 (max)
10	Chloride Content (%)	EN-196-21	0.10 (max)
11	Moisture Content (%)	BS 6699-APPN-E	1.00 (max)
12	Glass Content (%)	BS 6699-APPN-D	85 (min)
13	Compressive strength in (N/mm^2) After 7 days After 28 days	EN-196-1	 12.0 (min) 32.5 (min)
14 a b c	Chemical Moduli $CaO + MgO + SiO_2$ $CaO + MgO / SiO_2$ CaO / SiO_2	EN-196-2	66.66(Min) > 1.0 < 1.4

In case of use of Portland Slag Cement the cement shall meet all the requirements

given in IS 455.

c) All the physical and chemical tests shall be conducted at every 500 MT of GGBS or at every 6 months intervals whichever is earlier. The discretion to change this frequency rests with the Engineer depending upon the consistent performance of the previous batches. The contractor shall also get the test certificate for each batch of supply from the GGBS supplier.

6.5.5 AGGREGATE

a) The samples of coarse and fine aggregate shall be tested by the contractor at his own cost as per Table-6.4 while qualifying the source and thereafter at regular intervals as mentioned therein. The regular supply of coarse and fine aggregates shall commence only after approval of the source. The layout of the crushing, washing and batching plant shall be subject to the approval of the Engineer. The crushing plant shall include vertical shaft impactor in the system, so as to obtain cubical aggregate as well as crushed fine material for use as manufactured sand. ***Contractor shall note that crushing of aggregate at GHAVP site is prohibited.*** Direct purchasing of crushed aggregate from outside suppliers may be allowed subject to the condition that the material so procured meets this specification. The contractor, however, is advised to procure the boulder and crush the same at a place convenient to him. Alternatively, he may establish crushing machinery at the quarry and transport the crushed aggregates/ crushed sand. All efforts should be made by the contractor to contain the dust level to the minimum so as to meet environmental standards by incorporating suitable filters and/ or any such arrangements.

TABLE 6.4

AGGREGATE TESTING SCHEDULE AND REQUIREMENTS

Sl. No.	Activity/Test	Frequency	Applicable Code	Requirement
1(*)	Petrographic strained quartz analysis by weight	One sample for new source or change in source of aggregates	IS: 383 / ASTM C-295	<20%
2(*)	Alkali reactivity			
a)	Mortar bar method	One sample fornew source or change in source of aggregates.	ASTM C-1260	Expansion shall be less than 0.10% at 16days
b)	Chemical method	One sample for new source or change in source of aggregate and Subsequently once in 6 months during progress of work.	IS: 2386 / IS: 383	Shall fall in innocuous zone
3	Chloride content	-do-	IS 14959(P-I) / Railway Spec	0.04% by wt. max.
4	Sulphate	-do-	IS 3025(P-24)	0.40% by wt. max.

Sl. No.	Activity/Test	Frequency	Applicable Code	Requirement
	content		/Railway Spec.	
5	Iron content for heavy density aggregates	One sample for every 5000 MT for new source or change in source	NPC Spec.	Shall not be less than 60% 4.65 (for HA)
6	Specific gravity (SSD condition)	-do-	IS: 2386	2.6 (for C.A.) 2.55(for F.A.)
7	Deleterious material	-do-	IS: 2386 / IS: 383	Refer Table No.6 and 8
8	Size and Gradation	One sample for every 1000 Cum of concrete (minimum one sample per week)	IS: 2386 / IS: 383	Refer Table No. 5 and 7
9	Absorption/. Moisture content	One sample daily	IS: 2386	3% max.
109	Silt content (for natural sand only)	Once in a week	IS: 383	8% max. By volume
10	Organic impurity (for natural sand only)	Once in six months	IS: 2386 / IS: 383	No impurity
11	Flakiness and elongation index (for C.A. only)	Once in a month	IS: 2386	Individual-15% max.
12	Crushing value (for C.A. only)	Once in six months	IS: 2386	45%** max.
13.	Abrasion value (for C.A. only)	Once in six months	IS: 2386	
14.	Impact valve (for C.A. only)	Once in six months	IS: 2386	

(*) Based on the test results of Petrographic examination and /or alkali aggregate reaction test, if aggregate is found alkali reactive, remedial measures like restricting the alkali content of cement, admixture and/or addition of pozzolanic material shall be resorted to with the approval of the Engineer. As a normal rule, such aggregate shall not be used into work and efforts shall be made to obtain non-reactive aggregate.

(**) These limits shall be 30% (maximum) for aggregate to be used in road construction.

6.5.5.1 WASHING OF AGGREGATE

The impurity level in both coarse aggregate and fine aggregate shall be controlled. If impurities are beyond acceptable limits, the contractor shall at his own cost make necessary arrangements to wash the river sand/ aggregate before inducting the same into concrete. Silt content of sand shall be checked for each truckload and shall be brought within acceptable limits by washing. Both coarse aggregate and fine aggregate shall be washed thoroughly to remove all vegetation, perishable substances, and objectionable amounts of foreign matter, quarry dust, clay lumps, silt and such other deleterious materials. A suitable washing mechanism shall be provided as per scheme approved by the Engineer. The contractor shall prepare a detailed procedure for washing indicating the washing arrangement and get approval of the same from the Engineer. The washing arrangement shall be such as to remove the wastewater along with the unwanted materials and drain the same away from the site. It shall also not be directly let into the river/ nallah or such other existing water bodies.

6.5.5.2 FINE AGGREGATE

Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof. Fine aggregate having a specific gravity of less than 2.55 (saturated surface dry condition) shall not be used. Fine aggregate shall be graded within the limits specified in Table 6.5. The sand shall be of siliceous material, sharp, hard, strong and durable and shall be free from adherent coating, clay, dust, alkali, organic material, deleterious matter, lumps, etc. Sampling of fine aggregate shall be in accordance with IS: 2430. Fine aggregate shall be so graded that concrete of required workability, density and strength could be produced using the specified water binder ratio. The method of determination of gradation shall be as per IS: 2386.

TABLE 6.5

GRADING LIMITS FOR FINE AGGREGATES

IS Sieve designation	Percentage passing by weight		
	Zone-I	Zone-II	Zone-III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-75	55-90	95-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

NOTE :

1. For crushed sand, the permissible limit on 150 micron IS sieve shall not exceed 20%. This shall not affect 5% allowance permitted on clause 1.3 of IS – 383 applying to other sieve size.

2. Fine aggregate complying with the requirement of both grading Zone-I and II of Table–1.5 are only suitable for concrete production. However, in exceptional cases, with the specific permission of Engineer the Zone –III sand may also be used.

3. In addition to above, the fine aggregate shall be so graded that the concrete of the required workability, density and strength can be produced. The method of determining gradation by sieve analysis shall be in accordance with IS: 2386.

6.5.5.2.1 FOREIGN MATERIALS LIMITATIONS IN FINE AGGREGATE

The fine aggregate shall be free from injurious amounts of dust, clay lumps, pyrites, coal, lignite, soft, elongated or flaky particles, shale, alkali, organic matter, loam, mica and other deleterious substances. The percentage of deleterious substances in the fine aggregates, as delivered to the mixer, shall not exceed the values given in Table 6.6, when tested in accordance with IS: 2386.

TABLE 6.6

LIMIT OF DELETERIOUS MATERIALS IN FINE AGGREGATE

Description of test	% By weight	
	River sand	Crushed Sand
a) Material passing 75 micron	3.0 (max)	15.0 (max)
b) Shale	1.0 (max)	Nil
c) Coal and Lignite	1.0 (max)	Nil
d) Clay lumps	1.0 (max)	1.0 (max)
e) Total of other deleterious substances such as alkali, Mica coated grains, soft and flaky particles and loam	2.0 (max)	2.0 (max)
f) Total of all above substances	5.0 (max) *	2.0 (max) *

* Excluding (a)

6.5.5.2.2 ORGANIC IMPURITIES

Aggregate, when tested in accordance with IS: 2386 (Part-2), “The method of test for aggregate for concrete – Estimation of deleterious materials and organic impurities”, producing a colour darker than the standard shall be rejected. However, such sand, when tested for mortar-making properties and the mortar develops a compressive strength at 7 and 28 days of not less than 95% of that developed by a similar mortar made from another portion of same sample which has been washed in 3% solution of sodium hydroxide followed by thorough rinsing in water, then the Engineer may permit use of such sand on works.

For sand that is used after washing, the washed water from the sand shall be free from water-soluble chloride and sulphate content. The presence of chloride and sulphate

content can be checked with silver nitrate and barium chloride respectively. Prior approval of the Engineer shall be taken for bringing sand from new sand quarry or change in quarry.

6.5.5.2.3 USE OF CRUSHED SAND

If the contractor desires to replace sand partially or completely, with crushed sand, he may do so only if the quality of final product meets all the requirements of these specifications. It shall be noted that crushed sand shall be manufactured by specially crushing it from the aggregate by deploying proper machinery for the same. Crusher dust obtained while producing aggregate shall not be directly used for replacing sand unless it meets the technical specifications/ grading limits specified in Table Nos.6.4, 6.5 and 6.6.

6.5.5.2.4 FREQUENCY OF TESTING AND OTHER CHARACTERISTICS

The fine aggregate shall be tested for physical, chemical & mechanical properties and impurities content as per schedule given in Table Nos. 6.4, 6.5 and 6.6.

6.5.5.2.5 COARSE AGGREGATE

Coarse aggregate for normal concrete shall consist of hard, strong, durable particles of crushed stone and shall be free from thin elongated soft pieces, vegetation or other deleterious matter. It shall have no adherent coating. Coarse aggregate shall have an average specific gravity (saturated surface dry condition) 2.6 or more and no individual value shall be less than 2.55.

6.5.5.3.1 GRADING

The size of normal aggregate shall be selected from the standard sizes given in Table 6.7. The method of determining grading by sieve analysis shall be according to IS: 383. The stones required for making aggregates shall be transported to the crushing plant, preferably to be installed near the site of work and shall be crushed by the Contractor in primary and secondary crushers to yield the aggregates to the required sizes and specification as described under various items of schedule of quantities in Section-VIII of the document. In areas, where there is congestion of reinforcement and embedment, the Engineer may direct the contractor to use smaller size of aggregate without any additional cost for screening off the higher sizes.

TABLE 6.7

GRADING REQUIREMENTS OF COARSE AGGREGATES

Sl. No.	Nominal size	Amounts finer than each sieve (square openings) weight							
		50 mm	40 mm	20 mm	12.5 mm	10 mm	4.75 mm	2.36 mm	1.18 mm

1	40 to 4.75 mm	100	95 -0	30-70	-	10-35	0-5	-	-
2	20 to 4.75 mm	-	100	95-100	-	25-55	0-10	-	-
3	12.5 to 4.75 mm	-	-	100	90-100	40-85	0-10	-	-
4	10 to 2.36 mm	-	-	-	100	85-100	0-20	0-5	-
5	20 to 10 mm	-	100	85-100	-	0-20	0-5	-	-
6	40 to 20 mm	100	85-100	0-20	-	0-5	-	-	-

6.5.5.3.2 FOREIGN MATERIALS LIMITATION

The amount of deleterious substances in coarse aggregate shall not exceed the limits given in Table 6.8.

TABLE 6.8

LIMIT OF DELETERIOUS MATERIALS IN COARSE AGGREGATE

Sl. No.	Deleterious substances	Maximum percent by weight of total sample
1	Coal and Lignite	1.00
2	Shale	NIL
3	Clay Lumps	1.00
4	Soft fragments	NIL
5	Material finer than 75 micron	3.00
6	Sum of percentage of all Deleterious materials	5.00

6.5.6 WATER

a) Water used for both mixing of concrete and curing shall be clean and free from injurious amounts of oil, acids, alkalis, salt, sugar, organic materials or other substances that may be deleterious to the concrete or steel. Potable water is generally considered satisfactory for mixing and curing of concrete. The pH value of water shall generally be not less than 6. The sources of water shall have approval of the Engineer. The quality of water shall meet the provisions of IS: 3025 particularly Parts 22 and 23. The sample of water taken for testing shall represent the water proposed to be used for concreting, due attention being paid to seasonal variation. The quality of water shall be tested at every 6 months. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete or curing. The sample shall be stored in a clean container previously rinsed out with similar water. ***The exploitation of Ground Water for construction work is prohibited at GHAVP site .***

b) Permissible limits of solids, when tested in accordance with IS: 3025 are given in Table 6.9.

TABLE 6.9

PERMISSIBLE LIMIT FOR SOLIDS

Sl. No.	Description of test	Tested as per	Permissible limits (max.)
1	Organic	IS3025 (Part 18)	200 mg/l
2	Inorganic	IS3025 (Part 18)	3000 mg/l
3	Sulphates (as SO_3)	IS3025 (Part 24)	400 mg/l
4	Chlorides (as Cl)	IS3025 (Part 32)	2000 mg/l for concrete not containing embedded steel and 500 mg/l for reinforced concrete work
5	Suspended matter	IS3025 (Part 17)	2000 mg/l

c) In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests of concrete.

d) Average 28-day compressive strength of at least three 15 cm size concrete cubes, prepared with water proposed to be used, shall not be less than 90 percent of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with IS: 516.

e) The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes. The initial setting time shall also not differ by more than +30 minutes from the initial setting time of control test block prepared with the same cement and distilled water. The test blocks shall be prepared and tested in accordance with IS: 4031 (Part 5).

6.5.6.1 USE OF ICE AND CHILLED WATER

a) The Contractor shall study the placement temperature requirement, the ambient conditions and work out the refrigeration plant capacity to meet the construction schedule. It shall be noted that the temperature of the concrete indicated in the drawings/ specifications is at the placing point. The contractor shall submit his scheme of temperature control of concrete with detailed calculations before the actual commencement of work. The temperature control may be achieved either by mixing chilled water or by addition of ice flakes depending upon the ambient conditions and transportation time.

b) Mixing water shall be kept cool by storing it under cover. Storage tank shall always be kept clean. Water shall be transported to the mixing plant in such a way that there

is no rise in temperature. If chilled water or crushed ice is used as a part of mixing water to achieve the specified temperature of water, the Contractor shall install and maintain in good working condition a refrigeration plant to produce chilled water at temperature not exceeding 8^{o}C. The Contractor shall also build and maintain well-insulated adequate capacity storage tanks for cold water with insulated piping. To supplement this refrigeration facility, the Contractor may establish ice plant of suitable capacity. The full quantity of crushed ice shall be stored in cold storage 24 hours in advance of start of concreting. The temperature in the cold storage shall not be higher than (-2°C).

c) Ice, if used as replacement for a portion or all of the mixing water, shall be produced from water, which meets the requirements of this specification. Ice shall be in flaky condition and such ice flakes shall have thickness less than 3 mm. The ice plant should be capable of producing flaked ice. The Contractor shall make his own arrangement for storing adequate quantity of ice. Commercial ice shall not be used. In case of large pours, where the existing refrigeration capacity is not adequate, the contractor may use commercial ice, subject to the approval of the Engineer, after ensuring that the quality standards of this specification are met with.

6.5.7 CHEMICAL ADMIXTURES

a) The Contractor shall procure all chemical admixtures required in the specification. The Contractor shall ensure consistent behavior of proposed admixtures in concrete mixes and at all ambient temperatures likely to be experienced at project site throughout the year, and especially at the recommended placement temperatures. Contractor shall arrange for pre-qualification of such admixtures to fulfill the requirements specified in ASTM C-494 at his own cost. Qualification of chemical admixtures shall be carried out as per the guidelines given in ASTM C 494, using concrete with a cement content of 307 kg/m^3. Setting time of concrete with admixtures shall be decided by casting specimens and keeping the same in a temperature controlled room at a temperature of 23 (+/-) 2^{0}C. Base material of admixture shall be either sulphonated naphthalene formaldehyde based or poly carboxylic ether based only. High range water reducing and retarding admixture conforming to type G of ASTM C-494 shall be used.

b) Generically high range water reducing and retarding admixture shall be of either Sulphonated Naphthalene Formaldehyde condensate (SNF), Sulphonated Melamine Formaldehyde condensate (SMF) or Poly Carboxylate and conform to type G of ASTM C-494 depending on the fines content and limitation of chlorides, sulphates and other alkali contents.

c) The admixture to be used for Viscosity Modifying Agent (VMA) shall generically be either of Modified Cellulose or Poly-ethylene Glycol.

d) Admixture samples, when tested, shall meet the requirements given in Table 6.10.

TABLE 6.10

ADMIXTURE QUALIFICATION TEST

Sl. No	Description of Test	Acceptance values for Type G
1	Water Reduction as % of Control Mix	18 % minimum (*)
2	Air entrainment	± 1 % of control mix
3	Initial Setting Time Deviation from control At least Not more than	 1:00 hour later 3:30 hours later
4	Final Setting Time Deviation from control At least Not more than	 -- 3:30 hours later
5	Compressive strength As % of Control Mix 1 day 3 day 7 day 28 day	 125 % min 125 % min 115 % min 110 % min
6	Flexural Strength as % of Control Mix 3 day 7 day 28 day	 110 % min 100 % min 100 % min
7	Specific gravity at 25^0C	Within ±0.02 of the value stated by manufacturer
8	Solid content	With ± 3% of the value stated by the manufacturer
9	Ph	7-8
10	Chloride content	0.2 % max
11	Infrared Spectrograph	Identification of base material of the admixture

(*) This value is at variance with the ASTM C 494.

6.5.7.1 SAMPLING

a) The manufacturer's tests certificates shall accompany all individual batches of admixtures. Batches of admixture, not accompanied with correlating test certificates, shall not be inducted into the work till the tests are completed and the material found

meeting the standards. The batches/lots of admixture, accepted for testing, shall be identified with the unique sample number. Location of the product containers shall be distinctly identified and cordoned off to prevent mix-up with other products and brands and unacceptable materials.

b) Admixture shall be thoroughly agitated by using mechanical agitator, prior to sampling and a composite sample shall be collected representing 25.0 MT of admixture with proper batch identification. Grab sample shall be taken from each batch. Even if number of batches are less than 4, minimum 4 such grab samples shall be taken representing 25 MT of admixture and composite sample shall be prepared by thoroughly mixing the grab samples. Volume of each grab sample and composite sample shall be as decided by the Engineer.

c) It may also be noted that the admixture shall be thoroughly stirred before actual use. Mechanical stirring is mandatory and manual stirring shall not be permitted.

6.5.7.2 BATCH QUALIFICATION

Each batch of 25 MT (or lesser) of admixture shall be tested and qualified before use. All the tests, as given in Table-6.10, except 1-day compressive strength and flexural strength, shall be conducted. Admixture shall be released only after meeting the specified requirements. Infrared spectrograph of each batch shall be compared with the signature infrared spectrograph of that brand taken at the time of brand qualification to ensure consistent quality. In the event of tests failing to meet the specified requirements during batch qualification, the particular batch shall be rejected and removed from site.

Once accepted by the Engineer, one representative sample of 5 litres (approx.) shall be preserved from each batch upto 1 month from its expiry date. Such representative samples shall be identified, tagged and sealed indicating the sample identification number, brand name, batch number, date of manufacture, date of collection and expiry date.

6.5.7.3 STORAGE

The admixture shall be accompanied by manufacturer's certificate indicating the expiry date. The product shall not be used after this date. Admixture shall be used as per manufacturer's instruction and with the control specified by the Engineer.

Utilization and storage conditions shall conform to in the corresponding technical documentation given by the manufacturer.

Contractor shall make adequate arrangement for procurement of admixture at least 45 days prior to use, as testing time for batch qualification takes minimum 30 days. Adequate quantity of tested material shall be stored to meet the construction schedule.

6.5.7.4 OTHER TYPE OF ADMIXTURES

The Engineer may, at his discretion, instruct the contractor to use any other type of admixture in concrete i.e. admixture conforming to ASTM C-494 Type A to F, water proofing admixture conforming to IS 2645 etc. These admixtures, if used, shall be qualified, on the same lines before use.

6.5.7.5 VISCOSITY MODIFYING AGENT (VMA)

a) Viscosity modifying agent shall be used in self-compacting concrete (SCC) to increase the segregation resistance of concrete. VMA shall be added in SCC as per the recommendations of the manufacture and it shall be ensured through trials that it does not have any adverse effect on any of the properties of green and hardened concrete.

b) The VMA shall generically be of water-soluble polymers, Modified Cellulose or Poly-ethylene Glycol, which are adsorbed on to the surface of the cement granules causing changes in the viscosity and the rheological properties of the mix. It shall be chloride free and compatible with all cements envisaged by IS standards.

c) Sulphonated Naphthalene based superplasticizer SNF is avoided, as it is not compatible with VMA. Other type of VMA can also be used if it meets the desired parameters of SCC, and compatible with the superpasticizer. It may be noted that there is no specific testing for qualification of VMA, other than its meeting desired properties of SCC for each batch of material (VMA).

d) Super plasticizers containing VMA may also be used for the production of self-compacting concrete subject to meeting all the desired properties of SCC.

6.6 CONCRETE MIXING PLANT

A numbers of modern concrete batching and mixing plant capable of producing concrete of specified quality and at the required output rate shall be established by the Contractor at site. For mixing fly ash at site, Pan type mixer is preferred. A balanced complement of mixing, transporting, handling and placing equipment shall be deployed. Prior to use, the concrete mixing plants shall be completely installed and operated for a sufficient length of time to enable the Engineer to make the necessary physical tests (to assess the performance). Batching plants shall be fully automatic with computerized control along with the facility of automatic moisture correction.

Contractor shall provide, along with the tender proposal, full details of the batching plants to be deployed at site. After the award of the work, the layout of the plants, the full technical data and other details shall be submitted to the Engineer well before the actual setting of the plant.

6.6.1 TYPE OF PLANT

a) The type of plant to be deployed shall be automatic. The term ‘automatic’ is used to define a plant in which:

i) Batch weights are set on a mix selector manually,

ii) Mixes are batched in weigh hopper by operation of electric switch in one operation automatically,

iii) Ingredients are charged in the mixer, concrete is mixed and unloaded in a hopper in one operation by selecting mix number and operating a push button or through operation by computer.

b) Batching plant shall be capable of producing concrete according to the proportion set and controlled by the computer within the desired accuracy and tolerances specified for each of the ingredients, with different combinations of mixing sequences to produce concrete of different grades with the help of a single command. Plant software shall be capable of giving the batch weight records for each batch along with mixing cycle time in a format approved by the Engineer.

c) Each batching and mixing plant shall preferably comprise offour or five overhead storage bins for coarse and fine aggregate and cylindrical silos for cement, fly ash, GGBS and / or micro silica of adequate capacity, arrangement of adding water and admixture, to meet uninterrupted supply of concrete for placement in different pours. If cement is brought to the site in browsers / bulkers and directly loaded to the silos, then it is preferable to have minimum 3 silos for each batching plant for storage of cement. Alternatively, the silos can be kept connected to all the batching plants by providing interchangeable facility. Separate silos of adequate capacities are to be provided for fly ash, GGBS and micro silica, as the case may be, with suitable arrangement for direct loading and charging into the mixer. For loading fly ash, GGBS and micro silica, pneumatic conveyer shall be used, as screw type conveyers get choked frequently.

d) Storage bin of sufficient capacity for ice flakes shall be installed and fixed in such a way that water from melting ice shall not flow in the mixer through batcher but shall be collected in a conical vessel and drained outside.

e) The least count of weighing dials for 1 cu.m batch size plant shall be as per Table 6.11

TABLE 6.11

CAPACITY AND LEAST COUNT OF WEIGHING MECHANISM

Si.No.	Item	Capacity of dial (Kg.)	Least Count (Kg.)
1.	Cement	600	1
2.	Fly ash	600	1
3.	GGBS	600	1
4.	Microsilica	100	0.2
5.	Aggregate	2500	5
6.	Water	250	1

7.	Ice	250	1
8.	Admixture	25	0.1

f) If the batch size is different from 1 cu.m, then the capacity and least count of dials shall be modified accordingly. However, considering the demand rate of concrete, batching plant mixer of 2 cu.m. Capacity is preferred for all major concrete works.

g) Control room of the batching plant housing the instrumentation shall be free from vibrations and dust and shall be arranged as per the specification of the manufacturer. Indicators shall be fixed in such a way that operator is able to see batching of aggregate, mixing of concrete etc. directly and also all the dial indicators are clearly visible from one point.

h) All operations from charging the mixer to unloading of mix shall be interlocked so that unless mixer is empty, no new batch of ingredients is charged into the mixer.

6.6.2 WEIGHING AND BATCHING

6.6.2.1 WEIGHING UNITS

Every delivery point of aggregate, cement, fly ash, GGBS and/or micro silica into the mixer charging hopper shall have a weighing unit and each weighing unit shall include a visible, spring-less direct reading dial which shall indicate the scale load at all stages of the weighing operation from zero to full capacity. As far as practicable, the scale dials and the weighing equipment shall be in full view of the operator, so that he may conveniently observe the operation of the batcher gates and the discharge of the materials. Provision shall be made for adjustment and change in weights of materials being charged into the hopper.

Bins with adequate compartments shall be provided in the batching plant for fine aggregate and for each required size of coarse aggregate. Each bin compartment shall be designed and operated so as to discharge efficiently and freely into the weighing hopper with minimum segregation. Means of control shall be provided such that, when quantity desired in the weighing hopper is approached, the gate shall shut off with precision. Weighing hoppers shall be so constructed that it will eliminate accumulations of tare materials and material is discharged fully.

6.6.2.2 MEASURING WATER AND ICE

Water and Ice shall be measured by weight. The mechanism for measuring and delivering water to the mixers shall not permit leakage when the valves are closed. The filling and discharge valves for the water tank shall be so interlocked that the discharge valves cannot be opened before the filling valve is fully closed.

6.6.2.3 MOISTURE CORRECTION

The batching plant shall be provided with at least one moisture probe attached to the fine aggregate bin. This probe shall sense the moisture in the fine aggregate at the

time of batching and send the appropriate signal to the computer of batching plant so that adjustment in water quantity and fine aggregate quantity is made.

6.6.2.4 DISPENSER FOR ADMIXTURE

The concrete plant shall include dispensing device to accurately measure and deposit the full quantity of admixture into each mix at one time. The dispenser shall be interlocked with the batching and discharging controls of the water so that the batching and discharge of the admixtures will be automatic. The device shall be capable of ready adjustment to permit varying the quantity of the admixtures to be batched. The equipment shall be kept in a clean and fully operable condition.

6.6.2.5 TOLERANCE IN BATCHING WEIGHMENT ERRORS

The accuracy of weighing devices shall be as per Table 6.12:

TABLE 6.12

ACCURACY OF WEIGHING MECHANISM

Material	Percent of accuracy
Cement / Fly ash/GGBS	± 1 (by weight)
Water/Ice	± 1 (by weight)
Aggregate	± 2 (by weight)
Admixture	± 1 (by weight)
Micro silica	± 1 (by weight)

At least once in a month, the contractor shall check that the quantities of materials leaving the scales comply with the specified quantity within the tolerances. If discrepancies are noticed, he shall immediately make necessary required corrections and shall undertake re-calibration.

6.6.3 MIXING TIME

a) The mixing time required should be based upon the ability of mixer to produce uniform concrete throughout the entire manufacturing process and for this; the manufacturer's specifications shall be followed. However, final mixing time should be based on the result of mixer performance test (uniformity test) made at frequent intervals throughout the duration of job. The mixing time shall be measured from the time all ingredients are in the mixer. Batch time with audible indicators used in combination with interlocks, to prevent under or over mixing of the batch and premature discharge, should be provided. The mixer shall be design for starting and stopping under full load.

b) In case of concrete with micro-silica, to ensure that agglomerates of densified micro silica break fully, mixing time required would generally be 1.5 times the time

required for normal concrete and the same shall be established by conducting trials. Micro silica concrete needs additional mixing time. It is preferable to charge micro silica into the mixer along with coarse and fine aggregate, premix it for 10 seconds followed by charging of remaining ingredient i.e. cement, fly ash, water, ice and admixture into the mixer and final mixing of around 30 to 60 seconds. The time and sequence of loading shall be established by conducting trials.

c) Mixer is considered to pass the uniformity test if two samples taken after discharge of approximately 15% and 85% of the load meet the requirement given in Table 6.13**.**

TABLE 6.13

MIXER PERFORMANCE REQUIREMENTS

Sl. No.	Test	Requirement, expressed as maximum permissible difference in result of tests of samples taken from two locations in the concrete batch
1	Air entrainment	1.0 %
2 a) b)	Slump Average slump is less than 100mm Average slump is more than 100mm	 25 mm 40 mm
3	Average compressive strength at 7 days for each sample, based on the average strength of all compressive test specimens	7.5 %

d) Once the batching plant passes the performance test, for further compliance only slump test will be conducted at the frequency specified in Table 6.13.

6.6.4 RECORDS AND CHARTS

a) The Contractor shall maintain accurate records of the following at the batching plant for each batch:

i) The weight of cement, fly ash, GGBS, micro silica, water and admixture.
ii) The weight of coarse aggregate for each size recorded separately.
iii) The weight of fine aggregate for each size separately.
iv) The concrete Temperature immediately after mixing.
v) Mixing time of each batch, after all the materials are loaded into the mixer.
vi) Time of delivered of the concrete is from the mixer.
vii) Ambient temperature

b) The record shall be maintained by automatic recording and printout. Computer printouts shall also indicate the preset quantity of each ingredient, actual quantity discharged and error in it. The limits specified in the Table 6.12 shall be met (as an average) at the end of loading cycle of each transit mixer.

6.6.5 MAINTENANCE

The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free from hardened concrete. Mixer blades shall be replaced when worn down more than 10 percent of their depth. Should any mixer at any time produce unsatisfactory results or mortar leakage is observed, its use shall be promptly discontinued, till it is repaired.

6.6.6 PROVISION FOR INSPECTION

The complete plant assembly shall include provisions to facilitate the inspection of all operations at all times.

6.6.7 SAMPLING FACILITIES

Suitable facilities shall be provided for readily obtaining representative samples of concrete ingredients from any of the batchers and suitable devices for obtaining representative samples of concrete for determination of properties of fresh and hardened concrete to be made by the Contractor. All necessary platforms, tools and equipment for obtaining samples shall be made available at the start of work and shall be maintained throughout contract period.

6.6.8 CONCRETE SPECIMEN

Concrete specimen shall be prepared from the mixes used in the work and tested to determine the adequacy and accuracy of control for the materials entering into the concrete mix. The Contractor shall perform preparation, storage and testing of the specimen in presence of the Engineer to his entire satisfaction.

6.6.9 TEST WEIGHTS AND CALIBRATION

The Contractor shall provide standard test weights and any other auxiliary equipment, required for checking the operating performance of each scale or other measuring device. All the weighing scales shall be calibrated every month or whenever doubts arise or before any major pour, as directed by Engineer. Batching plant shall be allowed to use for production of concrete only if it meets the specified requirements.

6.7 PRE-REQUISITIES OF CONCRETE

6.7.1 CLASSES OF CONCRETE

Unless otherwise specifically stated as Nominal Mix, all concrete, contemplated under this specification, shall be taken to mean as "**Controlled Concrete**".

6.7.2 CONTROLLED CONCRETE

Controlled concrete is a concrete where the mix proportions are determined by mix design, preliminary mix proportioning and laboratory tests. These shall be carried out at specified intervals and also whenever the Engineer has reasons to believe that there

has been a change in the quality, properties, or grading etc of any of the constituents of concrete, which, in his opinion, would impair the strength and /or durability.

Each class of concrete shall be identified by designation consisting of a prefix and two numbers like N/25/40. Prefix 'N', 'H' and 'SH' signifies Normal concrete, Heavy concrete made with hematite aggregates and Super Heavy concrete with a combination of hematite aggregates and chilled iron shots or steel punching respectively. Next two numbers e.g. 25 and 40 would denote the Uniaxial characteristic compressive strength at 28 days in MPa (25 MPa and maximum size of coarse aggregate in mm (40 mm) respectively.

6.7.3 NORMAL CONCRETE

Class designation of concrete shall be as specified on the drawing. Maximum size of aggregate shall be 20 mm unless specified otherwise. However, when concreting has to be carried out in congested areas, maximum size of aggregate may be suitably reduced, with the approval of the Engineer.

Unless otherwise specified on drawings or called for in the schedule of Quantities, the class designation of normal concrete to be used shall, generally, be selected from Table 6.14.

TABLE 6.14

GRADES OF NORMAL CONCRETE

Class	Characteristic Compressive Strength of 15 cm cubes at 28 days in MPa	Maximum size of aggregate in mm
N/10/20	10	20
N/20/20	20	20
N/30/20	30	20
N/35/20	35	20
N/40/20	40	20
N/45/20	45	20
N/50/20	50	20
N/60/20	60	20
Normal Grout	30*	Fine Aggregate

Normal concrete shall have a net unit weight of not less than 2400 Kg/cu.m.
* The compressive strength for grout shall be on cubes having area of face 50 cm^2.

6.7.4 MIX PROPORTIONING CRITERIA

The mix proportioning, in case of OPC concrete shall be based on 28-day characteristic strength. For concrete containing fly ash, GGBS or any other mineral admixture, the concrete acceptance criteria shall be based on 56- day strength. Any other specific requirement, if any, will be as indicated on the construction drawings.

6.7.5 DURABILITY OF CONCRETE

To meet the requirement of durability, the water content as well as water to binder ratio shall be as low as practicable. In addition, there shall be adequate compaction and immediate curing as well as curing for longer period is necessary.

6.7.6 EXPOSURE CONDITIONS

Various conditions for which the concrete will be exposed during its service life are given in the Table 6.15.

TABLE – 6.15

ENVIRONMENTAL EXPOSURE CONDITIONS

Sl. No	Environment	Exposure Condition
1	Mild	Concrete surface protected against weather or aggressive conditions except those situated in coastal area.
2	Moderate	Concrete surface sheltered from severe rain or freezing whilst wet Concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non-aggressive soil / ground water. Concrete surfaces sheltered from saturated salt air in coastal area.
3	Severe	Concrete surface exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in seawater. Concrete exposed to coastal environment.
4	Very Severe	Concrete surface exposed to seawater spray, corrosive fumes or severe freezing conditions whist wet. Concrete in contact with or buried under aggressive subsoil / ground water.
5	Extreme	Surface of members in tidal zone Members in direct contact with liquid/solid aggressive chemicals

Unless otherwise specified in the drawing, **'Severe' and 'Moderate'** exposure conditions shall be considered for Coastal and inland sites of NPP respectively and mix proportioning of all types of concrete shall be carried out accordingly.

6.7.7 MINIMUM CEMENT CONTENT, MAXIMUM W/C

Unless specifically mentioned in the drawings, the values for minimum cement content and the maximum free water-cement ratio given in the Table 6.16 for different exposure conditions and for 20 mm maximum size aggregate may be used in the mix design.

TABLE 6.16

MINIMUM CEMENT CONTENT, MAXIMUM WATER-CEMENT RATIO AND MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH NORMAL WEIGHT AGGREGATE OF 20MM NOMINAL MAXIMUM SIZE

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum Cement Content kg/m^3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m^3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete
Mild	220	0.60	-	300	0.55	M 20
Moderate	240	0.60	M 15	300	0.50	M 25
Severe	250	0.50	M 20	320	0.45	M 30
Very Severe	260	0.45	M 20	340	0.45	M 35
Extreme	280	0.40	M 25	360	0.40	M 40

Notes:

a) Cement content prescribed in this table is irrespective of grade of cement and is inclusive of mineral admixture like fly ash, micro silica, GGBS etc

b) Maximum quantity of fly ash that shall be taken into account in the concrete composition for minimum cement content computation specified above shall be 35 % of Minimum cementitious material specified in above table, which is in line with IS 1489 requirements. However, 35% is not a maximum limit on fly ash content of concrete mix proportion.

c) Maximum quantity of GGBS that shall be taken into account in the concrete composition with respect to minimum cement content requirement specified above shall be 65 % of Minimum cementitious material specified in above table, which is in line with IS 455 requirements. However, 65% is not a maximum limit on GGBS content of concrete mix proportion.

d) Minimum cement content shall be increased by 40 kg/m^3 for 10 mm maximum size of aggregate and shall be reduced by 30 kg/m^3 for 40 mm maximum aggregate size.

6.7.8 EXPOSURE TO SULPHATE ATTACK

Requirements for concrete exposed to sulphate attack shall be as per relevant provisions of IS 456. All the recommendations for the type of cement, maximum free water/cement ratio and minimum cement content, which are required at different sulphate concentrations in near-neutral ground water having pH 6 to 9, given in the Table 6.17, shall be followed.

For the very high sulphate concentrations in Class 5 conditions, some form of lining such as polyethylene or polychloroprene sheet; or surface coating based on asphalt, chlorinated rubber, epoxy, or polyurethane materials should also be used to prevent access by the sulphate solution.

The decision of Engineer shall be followed in this regard. Such liner shall be measured and paid separately.

TABLE 6.17

REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK

Class	Concentration of sulphates expressed as SO_3			Type of Cement	Dense fully compacted concrete made with 20mm nominal Max. Size of Aggregate complying with IS 383	
	In soil		In ground water (g/l)		Minimum cement content kg/ m^3	Maximum W/C ratio
	Total SO_3 (%)	SO_3 in 2:1 water soil extract(g/l)				
1	Traces <0.2	< 1	< 0.3	OPC, PPC or Portland Slag cement	280	0.55
2	0.2 to 0.5	1 to 1.9	0.3 to 1.2	OPC, PPC or Portland Slag cement	330	0.50
				Super sulphated cement or Sulphate resisting Portland Cement	310	0.50
3	0.5to 1	1.9 to 3.1	1.2 to 2.5	Super sulphated cement or Sulphate resisting Portland Cement	330	0.50
				PPC or Portland Slag cement	350	0.45
4	1 to 2	3.1 to 5	2.5 to 5	Super sulphated cement or Sulphate resisting Portland Cement	370	0.45

5	More than 2	> 5	> 5	Sulphate resisting Portland Cement or Super sulphated cement with protective coatings	400	0.40

Notes:

a) Cement content given in this table is irrespective of the grade of cement.

b) Use of Super sulphated cement is generally restricted where the prevailing temperature is above 40ºC.

c) Supersulphated cement gives an acceptable life provided that the concrete is dense and prepared with a W/C ratio of 0.4 or less in mineral acids, down to pH 3.5.

d) The cement content given in above table is the minimum recommended. For SO_3 contents near the upper limit of any class, cement content above these minimums are advised.

e) For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, consideration should be given to a further reduction of W/C ratio.

f) Portland Slag Cement conforming to IS: 455 with slag content more than 50% exhibits better sulphate resisting properties.

g) Where chloride is encountered along with sulphate in soil or ground water, ordinary Portland cement with C_3A content from 5 to 8% shall be desirable to be used in concrete, instead of sulphate resisting cement. Alternatively, Portland slag cement conforming to IS: 455 having more than 50% slag or a blend of ordinary Portland cement and slag may be used provided sufficient information is available on performance of such blended cements in these conditions.

6.8 PROPERTIES OF CONCRETE

6.8.1 CONCRETE MIX PROPORTIONING

Concrete shall be proportioned to obtain workable mixes for intended purpose and to meet the strength and finish requirements.

Preliminary mix proportioning shall be established by conducting trials by the contractor, well in advance, so as to meet the time schedule. Mix proportion adopted shall meet the specified properties of green as well as hardened concrete.

While conducting trials, contractor shall use the ingredients that are qualified for actual work. All efforts shall be made to carry out the trials in laboratory and after the mix is finalized, final trials shall be done at batching plant for final qualification of the mix proportion.

6.8.2 TARGET MEAN STRENGTH

The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times standard deviation. The standard deviation for each grade of concrete shall be calculated separately. When sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in Table 6.18 may be assumed for mix proportioning in the first instance. As soon as the test results on sufficient number of samples are available, actual standard deviation shall be calculated and used in mix proportioning. However, when adequate past record for a similar grade exists the same may be used for deciding target mean strength.

TABLE 6.18

ASSUMED STANDARD DEVIATION

Grade of Concrete	Assumed Standard Deviation MPa
M 10 M 15	3.5
M 20 M 25	4.0
M 30 M 35 M 40 M 45 M 50 M 60	5.0

Note:

a) The above values correspond to the site control having proper storage of cement; weight batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. In case there is deviation in the control measures at site, the value of standard deviation given in the Table-6.18 shall be increased by 1 MPa.

6.8.3 MIX PROPORTIONING METHOD

Concrete mix proportioning may be done by methods given in IS 10262, SP-23, ACI 211.1, or on the basis of past experience or by any other suitable method so that the final product meets the specified requirements for green as well as hardened concrete. Efforts shall be made to keep cement content as well as unit water content as minimum as possible, with the use of suitable quality of chemical admixture.

6.8.4 POZZOLANIC MATERIAL

Fly ash, micro silica or ground granulated blast furnace slag (GGBS), individually or in combination, may be used in concrete along with OPC of 43 or 53 grade with the approval of Engineer. The upper limit for use of these pozzolanic materials is as given below:

a) Fly ash - 50% (max.) of total cementitious material for RCC and Prestressed concrete and 70%(max) for PCC
b) Micro silica - 7.5% (max.) of total cementitious material
c) GGBS - 65% (max.) of total cementitious material for RCC and Prestressed concrete and 80%(max) for PCC

However, minimum cement content requirement specified in 6.7.7 above shall be fulfilled. It has to be ensured that desired concrete characteristics are met with. In case of self-compacting concrete, fly ash quantity in excess of 50% can be used to meet the requirement of higher fines content.

6.8.5 WORKABILITY AND SLUMP

The workability measured in terms of slump shall be determined by slump tests as per IS 1199. As majority of concrete is desired to be placed using pumps, the workability of concrete shall be such that mix is pumpable. As a general guideline, slump of 125 mm at placement point is suitable for pumping of concrete. The requirement of slump for various pours, based on the placement methods and reinforcement congestion shall be decided at site with the concurrence of the Engineer.

6.8.6 UNIT WEIGHT

Normal concrete should have a net dry theoretical unit weight of 2400 kg/m^3, when tested as per IS 1199. The unit weight of concrete of any grade shall not be lower than 2375 kg/m^3.

6.8.7 AIR CONTENT

Air content of the concrete shall be tested as per IS 1199. While deciding on mix proportioning, air content for different aggregate sizes shall be as per Table 6.19

TABLE 6.19

AIR CONTENT OF CONCRETE FOR DIFFERENT MAXIMUM AGGREGATE SIZE

Maximum Aggregate Size	Max Air Content
40 mm	1%
20 mm	2%
10 mm	3%

The actual air content of concrete mix shall not exceed by more than 1% of the values given in Table 6.19.

6.8.8 SETTING TIME

Setting time of concrete shall be determined as per IS 8142. As the setting time depends on the temperature of concrete at the time of production as well as ambient conditions, it is required to check the setting time of concrete under same temperature and ambient conditions, as envisaged in the work.

Final setting time of concrete may be kept around 10 hours during summer and around 12 hours during winter. This parameter is required to be established for different ambient conditions for deciding time at which green cutting at construction joints is to be carried out.

6.8.9 BLEEDING

Bleeding of concrete shall not exceed 5% of the water content of the concrete, when tested as per IS 9103.

6.8.10 CHLORIDE CONTENT IN CONCRETE

The total acid soluble chloride in fresh concrete determined as per IS 14959 Part-1 shall not exceed 0.6 kg/m^3 and 0.4 kg/m^3 for reinforced and pre stressed concrete respectively.

6.8.11 CUBE COMPRESSIVE STRENGTH

Uniaxial Compressive cube strength shall be determined on 150 mm size cubes, as per IS 516.

6.8.12 CYLINDER COMPRESSIVE STRENGTH

Uniaxial Compressive cylinder strength shall also be determined on 150 mm diameter 300 mm long size cylinder, as per IS 516.

Uniaxial characteristic compressive cylinder strength shall not be less than 80% of characteristic compressive cube strength.

6.8.13 Deleted

6.8.14 FLEXURAL STRENGTH

Flexural strength of concrete shall be determined as per IS 516. Flexural strength shall not be less than $0.7\sqrt{f_{ck}}$ MPa where f_{ck} is the characteristic compressive cube strength of concrete in MPa.

6.8.15 MODULUS OF ELASTICITY

The modulus of elasticity of concrete shall be determined as per IS 516. The modulus of elasticity shall not be less than $5000\sqrt{f_{ck}}$ MPa, where f_{ck} is the characteristic compressive cube strength of concrete in MPa.

If the actual measured value differs by more than ± 20% from the value obtained from the above expression then it shall be reported to the Engineer.

6.8.16 PERMEABILITY

Permeability shall be determined by conducting Rapid Chloride Penetration Test (RCPT) as per ASTM C-1202. RCPT value shall not exceed 2000 Coulombs at 56 days.

6.8.17 TRIAL MIX AT LABORATORY

Based on the guidelines given above concrete mix design and proportioning shall be carried out so that it meets the requirements of strength, workability and durability.

Preliminary trials shall be carried out to optimize the quantity of cement, pozzolanic materials and other ingredients of concrete. To qualify a mix proportion, at least 4 trials shall be carried out in the laboratory using the preliminary mix design. Following tests shall be carried out on these mixes.

(a) Slump at 0 min, 30 min and 60 min.

(b) Unit weight

(c) Air content

(d) Initial and final setting time

(e) Compressive cube strength at 7, 28 and 56 *days

(f) Split tensile strength**

(g) RCPT at 56 days

* Only for concrete containing fly ash, GGBS or other pozzolana
** Only for containment structure or specified elsewhere

The concrete shall meet the specified values for all the above properties. The mean of 28 days cube compressive strength of all the four sets shall be more than or equal to fck + 4.0 MPa and individual test value shall be greater than or equal to fck, where fck is the characteristic cube strength of the concrete in MPa.

6.8.18 ACCEPTANCE TEST AT BATCHING PLANT

To ensure that laboratory proportioned concrete mix meets all the requirements when produced using the actual batching plant and other equipment, at least 4 trials shall be conducted at batching plant. It has to be ensured that all the requirements specified in above clause are met with. At least one test shall be conducted to check the yield of the concrete. In case of significant difference from the theoretical yield and the observed yield, it shall be investigated and rectification measures shall be taken.

Contractor shall submit a detailed report on the concrete mix proportioning to the Engineer for his approval. This report shall include the test results on concrete ingredients, laboratory trial results and batching plant trial results.

6.9 TESTS ON CONCRETE

Samples from fresh concrete shall be taken as per IS 1199 at the placement point or pumping point. Frequency of testing shall be as given in Table 6.20

TABLE 6.20

FREQUENCY FOR DETERMINATION OF PROPERTIES OF FRESH AND HARDENED CONCRETE

Sl. No.	Description of test	Frequency of testing
1	Slump	First 3 transit mixers and then from every 5th transit mixer
2	Temperature	First 3 transit mixers and then from every 5th transit mixer
3	Unit weight	At the time of casting of cubes one sample per day for each grade
4	Air content	One sample per week for each grade
5	Initial and final setting time	One sample per week for each grade
6	Bleeding	Whenever required
7	Cube compressive strength 7, 28 and 56* days	One sample per 50 cum up to 100 m^3 of concrete, there after one sample for each 100 m^3 or part thereof. At least one sample on each day of concreting for each grade.
8	RCPT	One sample per week for each grade
9	Chlorides and sulphate content test	One sample for each grade of concrete per six monthly

- Only for fly ash concrete/GGBS concrete.
- One sample for strength test means sufficient number of cubes to determine average of at least 3 cubes at specified time

6.9.1 ACCEPTANCE CRITERIA

Concrete of each grade shall be analyzed separately. The concrete shall be deemed to comply with the compressive strength requirements when both the following criteria are met with:

a) The mean strength determined from any group of four consecutive test results compiles with the value given in column (2) of Table 6.21

b) Any individual test result complies with the value given in column (3) of Table 6.21

TABLE 6.21

COMPRESSIVE STRENGTH COMPLIANCE REQUIREMENT

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in MPa	Individual Test Result in MPa
(1)	(2)	(3)
M 15	$\geq (f_{ck} + 0.825$ X established standard deviation (rounded off to nearest 0.5 MPa) or $(f_{ck} + 3)$ MPa Whichever is greater	$\geq f_{ck} - 3$ MPa
M 20 or Above	$\geq (f_{ck} + 0.825$ X established standard deviation (rounded off to nearest 0.5 MPa) or $(f_{ck} + 4)$ MPa Whichever is greater	$\geq f_{ck} - 4$ MPa

NOTE:

a. In the absence of established value of standard deviation, the value given in Table 6.18 may be assumed, and attempt should be made to obtain result of 30 samples as early as possible to establish the value of standard deviation.

b. Concrete is liable for rejection, if criteria mentioned in Table 6.21 is not met with.

c. If the concrete, after opening the shutter, is found to be porous or honeycombed, or concrete placing is interrupted without providing a proper construction joint or the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met with, it is liable to be rejected.

d. However, the same may be accepted if remedial measures are feasible and if the same are carried out to the satisfaction of the Engineer-in-charge.

6.9.2 USE OF 7 DAYS TEST

For any mix, a correlation between 7 day and 28 day strengths may be established in the laboratory. Soon after a job starts, a similar correlation shall be established during actual progress of the work. After the correlation has been established, the results of

the 7 day test may be used as the precursor for the expected compressive strength at 28-days. If 7-day test indicates low compressive strength, corrective measures shall be taken without waiting for 28-day strength results. Similarly for concrete with fly ash, GGBS and micro silica, co-relation shall be established between 7, 28 and 56-day compressive strength.

6.9.3 FAILURE TO MEET STRENGTH REQUIREMENT

In the event of concrete, tested in accordance with the relevant standards, fails to meet the acceptance criteria specified in Table 6.21 above with the approval of Engineer, any or all of the following measures shall be taken by the contractor, with no extra cost to the owner.

1. Taking cores from the structural element, where the test has failed, (IS: 456).
2. Extended curing of the concrete represented by the specimen.
3. Load tests on part of structures as per IS: 456.
4. Non -destructive test on structure.
5. Replacement of affected part / parts of the structure.

6.9.4 NON DESTRUCTIVE TESTS

In case of doubts about the quality of concrete in the construction, non -destructive tests shall be conducted as directed by the Engineer. The tests shall be carried out by a specialized agency as per the provisions of IS 456. Based on the NDT evaluation, decision on acceptance of structure or otherwise shall be taken by the Engineer.

6.9.5 CORE TEST

Three cores shall be extracted from the structure for determination of compressive strength represented by that structural element. The diameters of core shall be at least 3 times the maximum size of aggregate used in the concrete and height to diameter ratio shall be 2.0. Core shall be tested as per IS 516. Concrete in the member, represented by a core, shall be considered acceptable, if the average equivalent cube strength of the core (computed as 125% of the core cylinder strength) is equal to at least 85 percent of the specified characteristic strength and no individual average equivalent cube strength of core has strength less than 75% of the specified characteristic strength.

6.10 CONCRETE PRODUCTION, TRANSPORTATION & PLACEMENT

6.10.1 TEMPERATURE CONTROL

a) The concrete placement temperature shall be specified in the construction drawing. Normally, four different placement temperatures i. e. not exceeding 19^0C, 23^0C, 29^0C & 38^0C may be specified in the drawings. Generally, concrete temperature at the production point shall be maintained lower than the specified placement temperature so as to meet the criteria of specified placement temperature. Required temperature shall be achieved by reducing the temperature of water, replacement of part of mixing water with ice flakes and also by controlling the temperature of coarse and fine aggregate.

b) The stockpiles of the aggregate shall be protected from direct sunlight to avoid heating of aggregate. Wherever water is sprayed, suitable correction shall be applied so that the mix proportioning is not altered. Water shall be sprayed on the aggregate stockpile at every 300 mm or 450 mm height as the stockpiles are built up. The stockpiles, thereafter, shall be kept cool by water sprays. Fine aggregate may be stored under shed / in covered area, if the contractor so chooses.

c) If necessary, the coarse aggregate shall be taken into the bins and chilled water at temperature not more than 8^0C shall be sprayed on it through perforated pipe and allowed to be drained through screen fixed at the bottom. Draining screen shall remove excess water from the aggregate. The capacity and arrangement of the bins shall be such as to supply moisture free cooled aggregate to the top of the batching plant so that continuous supply of temperature controlled concrete is maintained.

6.10.2 TRANSPORTATION

a) The concrete shall be transported from the batching plant to the placement point as rapidly as possible by using insulated transit mixers for preventing segregation and loss of any of the ingredients. During hot weather, transit mixer shall be insulated to reduce loss of water by evaporation and heating of concrete from the ambient heat.

b) Once the concrete is mixed in the batching plant, no further water shall be added.

c) Concrete shall be placed and compacted in its final position within the forms within 90 (Ninety) minutes after the addition of water to the mixer or initial setting time of the concrete whichever is less.

d) The Concrete that has been left standing and has become stiff, such that it cannot be placed in satisfactory condition, shall be removed from the place of work immediately.

e) All equipment, used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, transit mixers and other equipment shall be thoroughly cleaned periodically during placement and after completion of concreting.

6.10.3 RE-DOSING OF ADMIXTURES

a) In case, when transit mixer reaches placement point, the loss of slump is observed, re-dosing of admixture may be carried out, to get required consistency for getting pumpable mix. However, basis for re-dosing shall be established by conducting trials in advance to establish re-dosing requirement for getting required slump. The total quantum of admixture established at the trial stages shall, however, not be exceeded during re-dosing.

b) Suitable arrangements for re-dosing of admixture with dispensing unit shall be made to ensure accurate re-dosing and proper mixing.

c) Record shall be maintained for each such re-dosing and shall be incorporated in batch weight record of batching plant. Samples for determination of compressive strength and other parameters shall be taken only after re-dosing.

6.10.4 PLACING OF CONCRETE

a) The concrete shall be preferably placed to its final position in the structure using pumps and placer booms in such a manner that both quality and uniformity of concrete, in terms of W/B or W/C ratio, slump, air content and homogeneity is preserved.

b) Before any concrete is placed, the entire placing programme detailing equipment, layout, and proposed method shall be submitted to the Engineer for approval. No concrete shall be placed until the Engineer's approval is obtained. Such plan shall include all the standby arrangements and shall be submitted at least 48 hours prior to actual concreting.

c) Sufficient plant capacity and transportation equipment shall be available to ensure continuous delivery of concrete at the desired rate of pour. The rate of delivery of concrete shall be such as to ensure proper handling, placing, vibrating and finishing of the concrete and to ensure that the cold joint is avoided. No concrete shall be transported in open, while it rains. If there is any sign of washing of cement and sand, the concrete shall be removed immediately. If the concrete is to be placed at night, sufficient illumination shall be ensured. Safe working condition shall also be ensured.

d) The method of delivering and handling of concrete shall be such as to facilitate placing with minimum of re-handling and without damage to the structure or the concrete.

e) All items to be embedded in concrete shall be correctly positioned and securely held in position, well in advance of placing of concrete. However, shutter alignment shall be checked and cleared only after fixing and correctly aligning the embedded parts.

f) Concrete shall be deposited at or near its final position in the form. The concrete shall not be pushed laterally with the help of vibrator. Struts, stays and braces serving temporarily to hold the forms in correct shape and alignment during the placing of concrete, shall be removed only when the concrete placing has reached an elevation

rendering their service unnecessary. These temporary members shall be entirely removed from forms and not buried in the concrete.

g) While preparing for placing of concrete, all sawdust, wood chips and other construction debris, shall be removed from the forms. Prior to placing of concrete on a rock surface, it shall be thoroughly cleaned and soaked with water for about 24 hours and surface shall be remain moist condition.

h) Concrete shall be placed in such a way that segregation is avoided and also the displacement of the reinforcement and embedment is avoided. Open troughs and chutes shall be of metal or metal lined. Where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths to adjust the direction of movement. The addition of water, at any point in the system of transportation, to facilitate the movement of concrete shall not be permitted. All chutes, troughs and pipes, shall be kept clean and free from coatings of hardened concrete by thoroughly flushing them with water after each placement. Water used for flushing shall be discharged clear of the structure. Concrete shall neither be permitted to fall freely from a height of more than 1.50 m nor to strike the forms at an angle. Where drop chutes are used, a sufficient numbers must be provided so that the concrete discharged from the chutes are not required to flow laterally more than 10 m However, SCC can flow horizontally upto approx. 12 m to 15 m without segregation. Where a drop chute is swung from the vertical, the bottom two sections must be maintained in a vertical position to avoid segregation. Flushing water quality shall be same as that of the water, which is being used, for making concrete. Based on the work demand, if lift height is to be increased beyond 1.5 m proper arrangements for vibration shall be ensured. In locations, where direct placement is not possible and in narrow forms, suitable drop chutes or “elephant trunks” shall be provided to confine the concrete during placement.

i) Concrete shall not be placed into the forms, until the cleaning of concrete surfaces of previous pours and the placement of reinforcing steel and embedded parts have been inspected and cleared by the Engineer.

j) Storm water or water from curing of concrete, which may get accumulated on the surface of the bedding layer, shall be removed by suitable means before start of placement. No concrete shall be placed on a water-covered surface. However, the surface must be sufficiently soaked and shall be in saturated surface dry condition.

k) Concrete shall be placed in successive layers ranging in thickness not exceeding 500 mm or as directed by the Engineer. The bucket loads or other units of deposit shall be spread progressively along the face of the layer with such overlap as will facilitate spreading the layer of uniform depth and texture with a minimum hand shoveling. Any tendency to segregation shall be corrected by shoveling stones into mortar rather than mortar on to stones. If such condition arises, the cause or causes shall be investigated and corrective action shall be planned. If required, mix proportion can be revised or method of placement can be modified.

l) When less than a complete layer is placed in one operation, it shall be terminated at a vertical bulkhead. Each layer of concrete shall be placed and compacted before initial setting of concrete of the previous layer takes place, to prevent injury to green concrete and to avoid separation between the consecutive layers.

m) During hot weather and rains, the concrete shall be covered with tarpaulins. Transportation, placement and consolidation of concrete shall be done in shortest possible time. Adequate precautions shall be taken to cover the transit mixer and chilled water may be sprayed over the transit mixer and the pipelines to maintain the temperature during the hot weather.

n) When concrete is to be placed in hot weather conditions, special provision shall be made for handling, placing and protecting the concrete, to ensure that concrete of full strength and free from damage, is obtained. For meeting the desired objective, means such as concreting during cooler hours of the day, use of chilled water, cooling of pipes etc., shall be resorted to. Commencement of concrete pour shall be avoided during heavy rains, storms and high winds.

6.10.5 COMPACTION

a) Vibrator should be inserted and withdrawn vertically at close intervals, using a systematic pattern of vibration to ensure that all concrete is adequately consolidated. As long as a vibrator needle sinks into the concrete by its own weight, it is not too late for the concrete to benefit from re-vibration, which improves compressive and bond strengths. Vibrators should not be used to move concrete laterally

b) On vertical surface, where air void holes are expected, voids can be reduced by the use of form vibrator or light tamping with wooden mallets.

c) Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into corners and angles of the forms.

d) Internal vibrators shall be inserted in a vertical position only, at intervals of about 450 mm depending upon the mix, the equipment used, the type of structure and experience gained on job. The vibrator needle shall be inserted by minimum 100mm in the previously laid layer. The zone of influence of needle vibrator is approximately 100 times cross sectional area of the needle being used. The vibrators shall be withdrawn slowly, approximately at the rate of 75 mm/sec. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to move concrete laterally inside the forms. Vibrator needle shall be kept clear of forms least by 100 mm. Over-vibration as well as under vibration shall not be done.

e) The internal-immersion type vibrators shall be high frequency vibrators with speed of not less than 7000 rpm when immersed in the concrete. Vibrators shall be used in sufficient numbers and power of each unit to properly consolidate all concrete in each layer immediately after it has been placed in the forms. It shall be ensured that sufficient numbers of vibrators are available at site along with adequate standby units.

f) While placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be taken to ensure adequate vibration, blending and melding of the concrete between the succeeding layers. The vibrator shall penetrate full in the layer being placed and also penetrate the layer below by about 50 mm while the under-layer is still plastic, to ensure good bond and homogeneity between two layers and prevent formation of cold joints.

6.10.5.1 USE OF FORM VIBRATORS

In case of the columns having congestion of reinforcement, supplemental form vibration may be used in addition to needle vibrators. Care should be taken to avoid excessive vibration, which would cause a weak paste on surface. However, this shall be preplanned activity and shutter as well as staging shall be designed for the additional loads form the vibrators.

6.10.5.2 USE OF SURFACE VIBRATORS

Surface vibrators may be used for horizontal elements like slabs. The vibrator operator shall be qualified before deploying on a job. Re-qualification shall be carried at suitable interval.

6.10.6 CONSTRUCTION JOINTS AND KEYS

When the work is to be interrupted, horizontal and vertical construction joints and bonding keys shall be located and shall conform to the details given on the drawings. In case of water retaining structure, containment structure and other structures, water stops as specified on the drawing shall be provided.

In case of columns, beams and slabs etc, the location of the joints shall be as indicated in the drawing or as directed by the Engineer. Concrete in a beam shall be placed throughout, without a horizontal joint. Before fresh concrete is placed, cement skin or any loose or porous material of partially hardened concrete shall be thoroughly removed and cut back until the solid face is exposed and surface made rough by hacking, or any other method. Rough surface shall be thoroughly wetted for about two hours and shall be in surface dry condition before new layer of concrete is placed over it.

6.10.7 TREATMENT ON SUSPENSION OF WORK

Whenever work is suspended on any section for more than two hours, the horizontal edges of the concrete next to the forms on surfaces that will be exposed shall be brought to a horizontal plane perpendicular to the plane of the forms and treated, so that the finished work will show smooth straight lines.

6.10.8 EXPANSION JOINTS AND SEPARATION JOINTS

These joints in concrete structures shall be provided, as specified in the drawing. The thickness of polythene sheet, if used, shall not be less than 500 microns. For Expansion joints relevant specification shall be followed.

6.10.9 WASH WATER

Wash water shall be removed in a manner to prevent running down and staining of concrete surfaces, exposed on completion of the job. Should unsightly wash-water streaks develop on the exposed surface, the same shall be removed to get a uniform colour and texture.

6.10.10 PLACEMENT INTERVAL

Placement interval between two subsequent or adjacent pours shall be as specified in the drawing.

6.10.11 CONSTRUCTION JOINT TREATMENT

Green cutting shall be made to treat the entire construction joint. Suitable surface retarder shall be used to retard the setting of concrete to a depth of 5 to 7 mm from the exposed surface that is going to receive subsequent concrete.

Green cutting shall be done by using air water jet at a suitable pressure to remove laitance from concrete surface at construction joint, exposing aggregate matrix, and shall be done only after the concrete is in final set condition. The water from the air water jet, used for green cutting of the concrete surface, shall be properly drained so as not to harm the quality of the concrete already placed. It shall also be ensured that this water does not get stagnated on the surface of concrete, depositing washed cement particles. As a pre-qualification, field mock-ups shall be conducted to check the adequacy of the material and method to be deployed on the job, before adopting in the field. In case of change in material source / type or methodology of green cutting, pre-qualification shall be redone. In areas where green cutting is not feasible, spraying of retarders followed by wire brushing immediately after final setting shall be adopted.

Approved brand of surface retarding (set retarding) agent shall be used for preparation of construction joint by green cutting of concrete. It shall be solvent free poly-hydroxyl compound and shall have a distinctive colour, which could be easily identifiable on its application over concrete. It shall be suitable for removing the cement-sand matrix between 5 to 7 mm depth after final setting time, when air water jet with a pressure of around 7 Kg/cm^2 from distance of approx. 500 mm is used. It may be noted that there is no specific testing for qualification of surface retarders other than its meeting desired performance specified above.

6.10.12 PLACEMENT OF CONCRETE AROUND LARGE OPENINGS

While placing concrete around large openings in walls, adequate care shall be taken to ensure proper flow and compaction of concrete on the underside of such openings. Adequate number of windows shall be provided in the formwork for air to escape and also for insertion of vibrators. Once the concrete reaches the level of such window, the same shall be properly closed before proceeding with further concreting.

6.10.13 PLACING CONCRETE BY PUMPING

a) As far as possible, concrete shall be placed using pumping. A steady supply of pump-able concrete is necessary for satisfactory pumping. Concrete pumps to be deployed on the work shall be able to deliver concrete at a desired rate up-to the placement point uninterruptedly.
b) Requisite numbers of concrete pumps, capable of pumping concrete at required rate, together with a complement of pipelines, accessories, spare parts, power controlled placer booms, experienced pump operators and maintenance staff shall be deployed.
c) The pumping plant shall be installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of concrete, to enable conducting pump-ability tests and necessary adjustments for the mix proportioning, prior to use in actual work.

6.10.14 PUMPABILITY TRIALS

No mix shall be used in actual work until pump-ability trial is conducted. The actual field condition shall be simulated. The batching and conveying by transit mixers shall be in the same way as that will be in actual work. The pipe and hose layouts shall simulate the actual condition, as far as practicable. The system shall be able to meet uninterrupted desired supply of cohesive mix at the placement point. The samples shall be collected at batching plant, at pumping point and at placement point after pumping for slump and determination of compressive strength.

6.10.15 FIELD PRACTICES

a) Proper planning of concrete supply, pump location, line layout, placing sequence and the entire pumping operation shall be done by the Contractor, before commencement of concreting.

b) The pumps shall be as near to the placing area as practicable and proper access roads shall be available for movement of transit mixers and other equipment around the location.

c) Direct communications shall be maintained between the pump operator, concrete placing crew and the batching plant. As a final check, the pump shall be started and operated without concrete to assess that all moving parts are in operating conditions.

d) The mortar shall be pumped into the line to provide initial lubrication for the pump and pipeline. The mortar used for lubrication shall be collected in the bucket and disposed off. This mortar shall not be placed in the forms. As soon as concrete is received, the pump shall be run slowly until the lines are completely filled and the

concrete is slowly moved. Once the pumping starts, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking.

e) Continuous pumping should be ensured. If delay occurs due to supply of concrete, form repairs, or any other reason, the pump shall be slowed down to maintain some movement of the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be kept moving in the line by giving one stroke of the pump at longer interval. In confined areas, attempt shall be made by the Contractor to run a return line back to the pump, so that the concrete can be re-circulated during such delays.

f) Minor blockages shall be cleared by operating a few strokes of the pump in reverse direction and then by returning to normal forward pumping. If this fails, a succession of reverse and forward strokes shall be carried out to remove the blockage. Should this fail, the blockage may be due to air lock and the entrapped air has to be removed.

g) Blockages in the pipe are usually assessed by the sound when the pipe is struck. To remove the obstruction, the concrete pipe shall be taken out at the assessed location and cleaned. The pumping process shall then be started again.

h) This method of checking the blockage and setting it right shall be done as early as possible, as excessive delay will cause setting of concrete in the pipeline downstream of the blockage. When the blockage is being found out and remedial measures taken, the pump shall periodically be given one or two strokes forward to keep the concrete in motion. If blockage occurs in the placer boom, a pipe joint near the base of the placer boom shall be opened and the boom made vertical to drain the concrete by gravity.

i) The termination of pumping operation shall be carefully planned to utilize the concrete dormant in the pipeline and the hopper, when the pump is stopped. However, concrete at placement point shall be kept green, avoiding cold joint, by operating standby pump or by any other standby arrangement.

j) When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a go-devil be inserted and forced through the line to clear it out. Water under pressure shall be used to push the go-devil. The go-devil shall be stopped about one meter from the end of the line, so that the water in the line does not spill over into the placement area. After flushing, water in the pipe shall be removed by drain cock provided for this purpose, in the lowest part of the line. After all concrete has been removed from the line, pipes and equipment shall be immediately cleaned.

6.10.16 QUALITY CONTROL

Contractor shall ensure good workmanship and also the plant shall be maintained to meet peak demand. Degree of control on all the concrete operation, right from

selection of the ingredients to the final testing of specimen, shall be in line with the approved Quality Assurance Plan.

The Contractor shall engage experienced supervision at all levels. Complete crew, engaged in each of the concreting activity, shall be duly qualified for a particular activity and shall demonstrate their skills and capabilities to produce the final product meeting specified parameters.

6.10.17 CURING OF CONCRETE

a) Exposed surface of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least 7 days (10 days for hot weather condition) from the date of placing concrete in case of OPC Concrete and at least 10 days (14 days for hot weather condition) where mineral admixture or blended cement is used. The Quality of curing water shall be the same as that used for mixing concrete. Any type of the covering that would stain or damage the concrete during or after the curing period shall not be permitted. Covering shall be kept continuously wet during the curing period.

b) The structural elements with concrete having low water binder ratio and also when cement is partially replaced by pozzolanic material, the curing shall be done in two stages viz., initial curing and final curing.

c) **Initial Curing:** The initial curing shall start immediately after finishing. The concrete surface exposed to environment shall be kept covered by plastic sheet or other type of impermeable covers. The wet curing shall start immediately after the final set. This shall be carried out with the help of placing wet burlaps over the concrete surfaces.

d) **Final curing:** The final curing shall be done with water. It shall commence immediately after initial curing and continue upto a minimum period specified above. Hessian cloth can be wrapped on to columns and on vertical surfaces and the same shall be kept wet all the time by a suitable arrangement.

e) Contractor shall make suitable arrangement for continuous water supply, along with necessary equipment for getting a nozzle pressure of not less than 7 kg/cm^2, even at the highest elevation, for convenient and effective jetting on concrete surfaces for green cutting, for cooling aggregate, for curing and for other requirements. All necessary appliances such as hose, sprinklers, spraying devices etc. may be made available.

f) For curing of concrete in pavements, sidewalks, floors, flat roof or other level surfaces, the ponding method of curing is preferred. Special attention shall be given to edges and corners of the slab to ensure proper protection. The ponded area shall be kept continuously filled with water throughout the curing period.

g) **Membrane Curing:** Curing compound may be used in lieu of moist curing with due qualification of material and process, if permitted by the Engineer. Such compounds

shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

6.10.18 PROTECTING FRESH CONCRETE

Newly placed concrete shall be protected from rain, sun and wind. Concrete placed below the ground level shall be protected from falling earth during and after placing. Concrete placed in ground, containing deleterious substances, shall be kept free from contact with such ground or with water percolating from such ground during placing of concrete and for a period of at least 3 days. The ground water around newly poured concrete shall be maintained to a level lower than the fresh concrete layer by pumping or other means of drainage. Adequate steps shall be taken to prevent flooding. Fresh concrete shall be protected by, leaving the forms in place, prevention of disturbing shocks and vibrations and avoiding premature stressing until the concrete attains sufficient strength to sustain such loads or shocks.

6.11 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

A procedure shall be prepared by the contractor for carrying out inspection, repair and replacement of unsatisfactory concrete. Repair of unsatisfactory concrete shall be carried out by means of removing the unsatisfactory portion and replacing it with new concrete. Suitable keys, dovetail slots etc. may be provided to get proper bond between new concrete and old concrete. Prepared surface shall be kept wet for 24 hours immediately before the patching material is placed. However, surface shall be dry. Repair of concrete shall be carried out using skilled workmen. Repairs shall be undertaken as soon as practicable, after removal of forms, so as to meet the requirements of finish in that particular location. The portion of the concrete to be repaired may be reinforced with steel mesh, if directed by the Engineer. The contractor shall carry out all such repair with no extra cost to the owner.

The complete methodology for the repair shall have approval of the Engineer before undertaking such repair job. Proper curing shall be ensured for the repaired portion.

6.11.1 USE OF EPOXY

For bonding fresh concrete with old concrete epoxy shall be used if specifically directed by the Engineer. The type of epoxy and its application shall be as directed by the Engineer. Epoxy shall be applied in strict accordance with the instructions of the manufacturer. Approved material shall be arranged by the Contractor to undertake this activity.

The epoxy shall meet the requirements of ASTM C-881 and shall be used as per manufacturer’s recommendations.

6.11.2 REPAIR WITH EPOXY MORTAR

The defects in concrete (within the acceptable limits, as decided by the Engineer) may be repaired using Epoxy mortar as per the instructions of the Engineer. No extra payment shall be made for such repairs.

6.11.3 MATCHING OF PATCH SURFACES

Filling material used in repair of surfaces, which will be exposed after completion of the project, shall be used with cement from the same source as that used in concrete and blended with a sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. Patched surface shall be given a final treatment to make the texture of the patch to match with the surrounding area.

6.11.4 CURING OF PATCH WORK

Immediately after any patchwork is completed, the area shall be covered with non-staining, water-saturated material and the same shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the area shall be kept continuously wet by a fine spray or sprinkling of water. The layers of patch may be reinforced with steel wire mesh, if directed so by the Engineer at no extra cost to the owner.

6.11.5 APPROVAL BY ENGINEER

All materials, procedures and activities for repair work as well as finishing work shall be subject to the approval of the Engineer.

6.12 FINISHING & OTHER GENERAL WORKS

6.12.1 FINISHING

a) Unless otherwise specified, concrete finishes shall conform to the following classifications and shall be provided as specified in the drawing.

b) Finish F1, F2 and F3 shall describe formed surfaces.

c) Finish U1, U2 and U3 shall describe unformed surfaces.

d) Offsets or fins caused by displaced or misplaced form panels, lining or form section or by defective form lumber shall be referred to as ‘abrupt irregularities’. All other irregularities shall be referred to as ‘Gradual irregularities’. Gradual irregularities shall be measured as deviation from a plane surface with a template 1.5 m long for formed surfaces and 3.0 m long for unformed surfaces.

6.12.2 FORMED SURFACE

a) Finish F1 shall apply to all formed surfaces for which finish F2, F3 or any other special finish is not specified.

b) Finish F1 shall include filling all form tie holes and localized air holes.

c) Finish F2 shall apply to all formed surfaces as shown on the drawings. Finish F2 shall include filling all form tie and localized air holes, repair of gradual irregularities exceeding 6 mm, removal of ridges and fins and abrupt irregularities by grinding.

d) Finish F3 shall apply to all formed surfaces exposed to view or where shown on the drawings. It shall include all measures specified for finish F2. In addition, filling air holes with mortar and treatment of the entire surface with sack rubbing shall include in F3 finish. It shall also include clean up of loose and adhering debris. The surfaces shall be prepared within two days after removal of the forms. The surfaces shall be wetted and allowed to dry slightly before mortar is applied by sack rubbing. The mortar used shall consist of one part cement to one and half part by volume of fine sand passing IS No. 16 sieve. Only sufficient mixing water, to give the mortar a workable consistency, shall be used. The mortar shall then be rubbed over the surface with a fine burlap or linen cloth so as to fill all the surface voids. The mortar in the voids shall be allowed to stiffen and solidify after which the whole surface shall be wiped clean with burlap so that the entire surface presents a uniform appearance without air holes and irregularities. The finished surface shall be cured for a period of 3 days.

6.12.3 UNFORMED SURFACES

a) Finish U1 shall apply to all unformed surfaces for which finish U2, U3 or any other special finish is not specified. Finish U1 shall include screeding the surface of the concrete to the required slope and grade, as specified on drawings.

b) Surfaces, to be covered with concrete topping, terrazzo etc., shall be smooth, screeded and leveled to produce an even surface and irregularities not exceeding 6 mm.

c) Finish U2 shall apply to all unformed surfaces, as shown on the drawings. Finish U2 shall include screeding and applying a wood float finish to the surface of the concrete to the required slopes and grade, repair of abrupt irregularities unless a roughened texture is specified and repair of gradual irregularities exceeding 6 mm.

d) Finish U3 shall apply to unformed surfaces for which a high degree of surface smoothness is required, where shown on the drawings. Finish U3 shall include screeding, floating and applying a steel trowel finish to the surface of the concrete to the required slope and grade, repair of gradual irregularities exceeding 6 mm, finishing joints and edges of concrete with edging tools.

6.12.4 FOUNDATION BEDDING, BONDING AND JOINTING

a) All surfaces or concrete beds shall be prepared by suitable shaping, thorough cleaning, washing and keeping the surface in SSD condition

b) All soil surfaces, upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or yielding soil shall be removed and replaced with lean concrete or with selected soil and compacted to the same density as the surrounding area. The surface of absorptive soil, against which concrete is to be placed, shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete.

c) The concrete surfaces, upon which additional concrete is to be placed, shall be prepared by green cutting technique. Surface retarder shall be spread on the surface of newly laid concrete, just after finishing work is completed. After the concrete attains final set, high-pressure air water jet shall be used to remove cement matrix, exposing aggregate matrix. The water shall be drained properly along with cement particles. In case where green cutting is not adopted, with approval of the Engineer, scarifying and cleaning while the concrete is between its initial and final set shall be done. Great care shall be taken in performing this work to avoid removal of too much mortar and weakening of the surface by loosening of aggregate.

d) Concrete surfaces, upon which new concrete is to be placed, shall be cleaned and wetted, immediately before placement of the concrete. The bonding shall be with mortar having the same cement-sand ratio as that of the concrete being placed. Cost of the same will be deemed to have been included in the rate for concrete. However, no bonding mortar is required when green cutting technique is adopted for surface preparation.

Similar treatment shall be given at vertical construction joint.

6.12.5 WORKMANSHIP OF CONCRETE

Workmanship shall be conforming to relevant Indian Standards and good engineering practices. The mix proportioning shall have prior approval of the Engineer. Concrete shall be produced at fully automatic batching plants. In case, where the tilting drum mixer is used, adequate and accurate weight batching arrangement shall be provided. Tilting drum mixer shall be fully discharged before taking new batch. Partly set concrete shall be immediately removed. On completion of work the mixer as well as all other equipment shall be thoroughly cleaned.

6.13 SELF-COMPACTING CONCRETE (SCC)

Self-Compacting Concrete shall conform to European specification for Self-Compacting Concrete – Specification, Production and Use. All the ingredients of SCC are same as that of normal concrete, except Viscosity Modifying Agent (VMA) as an additional ingredient Quality of all the ingredients shall be the same as that for normal concrete. VMA shall be added to increase shear resistance of the concrete. All

the test equipment as well as desired parameters for fresh concrete shall be as detailed in European specification. After the mix proportion is finalized, adequate mock-ups shall be done, to ensure consistent quality of self-compaction. SCC may be used for casting all the structural elements of the plant buildings. It shall be kept in mind that formwork design shall be carefully done for SCC, as the SCC remains in liquid form for a longer period. As far as possible, pumping shall be resorted to. All other requirements for testing shall be the same as that of normal concrete, specified elsewhere in these specifications.

Properties of the fresh concrete are to be checked as per the provisions in the European specification. The desired parameters are given in Table 6.22. Testing methods and testing equipments like flow table, V-funnel, L-box, U-box, fill box and segregation resistance test shall be as per European specification. The tests to be carried out to establish various properties are given in Table 1.24. Once it is established that the mix proportion is meeting the desired parameters and after establishing the consistency of the results, the flow table test and V- funnel test are to be conducted at production point and placement point as a quality control measures. For hardened concrete, the tests specified in Table 6.20 are to be carried out. These Two (2) tests shall be conducted for first 3 transit mixers and subsequently one for every set of 5 transit mixers.

TABLE 6. 22
PARAMETERS FOR SCC

Sl. No.	Test	Unit	Minimum	Maximum
01	Slump flow	mm	650	800
02	T50 cm slump flow	Sec	2	5
03	“V” funnel	Sec	5	15
04	‘L’ box	h_2 / h_1	0.8	1.0
05	‘U’ box	$(h_2 - h_1)$ mm	0	30
06	Fill box	%	90	100
07	Segregation Resistance test	%	-	20

TABLE 6.23
PROPERTIES TO BE ESTABLISHED BY TESTS

Slump flow test	Stability of mix (Cohesiveness)
T-50 cm time slump flow test	- do -
V-funnel test	Flow ability
L-Box test	Passing ability
U-Box test	- do -
Fill box test	Filling ability
Segregation Resistance test	Segregation

6.14 MATERIAL TESTING LABORATORY

The contractor shall establish a state of the art material-testing laboratory at site for testing of all the concrete ingredients, fresh concrete and hardened concrete. Fully automatic cube testing machines of adequate capacity and numbers shall be installed in the laboratory. Facilities for water permeability test as per DIN 1048 and Rapid Chloride Permeability Test (RCPT) as per ASTM-C-1202 shall also be available in the laboratory. Laboratory pan type mixer shall be available with the Contractor.

7. FORM WORK

7.1 SCOPE

The work covered under this section shall include the providing, erection and removal of formwork for all normal, and pre-cast concrete in walls, columns, foundations, slabs and beams, including its supporting members.

7.2 GENERAL

7.2.1 The formwork shall consist of but not limited to shores, bracings, sides of beams, columns, walls, rafts and bottom of slabs including ties, anchors, inserts, hangers, false work, wedges, etc. complete which shall be properly planned for the work. For the floors, supports can be taken from the floor down below with prior permission of the Engineer. Wherever required, provision shall be made to support the floor shuttering by means of trusses, which shall be spanned from the nearby walls/columns. Wherever specified, the left-in shuttering of adequate capacity shall be used.

7.2.2 The Contractor shall prepare, before commencement of actual shuttering work, design and drawing for formwork and centering and get them approved by the Engineer well in advance before fabrication and erection of formwork. Formwork shall be designed to fulfill the following requirements.

a) Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

b) Made of suitable materials.

c) Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.

d) Capable of withstanding without deflection the worst combination of self-weight, reinforcement and concrete weight, all loads including lateral pressure on vertical surfaces and dynamic effects arising from construction and compacting activities, wind and weather forces.

e) Capable of easy striking without shock, disturbance or damage to the concrete.

f) Soffit forms capable of imparting a camber if required.

g) Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete, design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

7.2.3 Forms shall conform to the shapes, lines, grades and dimensions including camber of the concrete as called for on the drawings. Ample struts, walers, braces, etc. shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of forms. Unless otherwise specified all forms in contact with concrete having F-3 finish shall be plywood panel formworks. Forms will be firmly bolted to previous pour of concrete. No through bolts embedded in concrete will be permitted in any underground structures. Threaded mild steel sleeves designed for holding in concrete and standard coil nuts/cone anchors shall be embedded in preceding concrete pours to anchor tie rods on lower end, while on the other end tie rods shall be provided beyond the lift under construction. Tie arrangement with baffle plate within the concrete may also be used as substitute for through tie with prior approval of the Engineer. The Contractor should finish all the coil nuts by dry packing. The recesses, if any, formed by removable timber wedges shall be filled with caulking compound or Epoxy mortar if depth is less at the Contractor's own cost. Formwork for removable hatchways and plugs shall be installed in place wherever possible. Back form for sloping concrete surfaces shall be provided as decided by the Engineer at no extra cost.

7.3 DESIGN AND FIXING OF FORMWORK

The formwork shall be designed and fixed to meet the tolerance in various areas as specified elsewhere in this specification. All floors and beam centering shall be crowned not less than 8 mm in all directions for every 5-meter span. Forms in contact with concrete shall be free from adhering grouts, projecting nails, splits or other defects. Formwork shall be so designed and erected with the forms for slab so that the sides of beams, columns and walls may be removed first, leaving the formwork to the soffits of beams and their supports in position. Where formwork for column is erected for its full height, one side shall be left open and built up in sections as placing of concrete proceeds, if so directed by the Engineer.

7.4 DESIGN LOADS

7.4.1 Unless prior approval in writing has been received from the Engineer all vertical wall forms shall be constructed for the minimum pressure as per CIRIA/ European Guidelines recommendations. The Contractor shall ensure that the constructions of the forms are adequate for all concrete placing condition and all the applicable CIRIA/European Guidelines recommendations are followed. However, in case of self-compacting concrete, the entire height of the pour shall be considered to be in fluid state and the lateral pressure shall be w x h, where "w" is the unit weight of green concrete and "h" is the height of pour.

7.4.2 All horizontal forms shall be constructed for pressures from the dead load of concrete including embedment and a minimum live load of 200 Kg/sq.m.

7.4.3 Forms constructed for retaining heavy concrete shall be built for pressures which have been increased by the ratio of the unit weight of heavy concrete to normal concrete.

7.4.4 Further, the formwork shall be designed to withstand all pressures arising out of placement of concrete using pumps, incidental loads if any and live load on the working platforms.

7.4.5 The form work shall be designed and fixed to meet the tolerances in various areas specified by the Turbine Manufacturer or as specified in the relevant drawings

7.5 TEMPORARY OPENINGS

Temporary openings, which can be conveniently closed, shall be provided at the base of the columns and wall forms and other places necessary to facilitate cleaning, inspection and vibration of concrete. Immediately before concrete is placed the forms shall be made sufficiently rigid and tight, thoroughly cleaned properly treated and free from foreign material. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected.

7.6 MATERIALS

7.6.1 Materials for the formwork shall be of plywood, formed steel plates, timber form covered with steel sheets, oil tempered hard board. Sliding forms and slip form shall be used for tall structures where specified and after approval by the Engineer. The supporting system shall be either adjustable props made of mild steel pipes for heights up to 6 meter or composite columns fabricated using M.S. Structural steel members.

7.6.2 Shuttering arrangement for concreting shall be of 12 mm/16 mm thick plywood backed with steel/DOKA framework and supports of horizontal and vertical walers connected to turn buckles. In case steel shuttering plates are used for formwork, the joints between the panels shall be sealed with suitable foam to make the formwork leak tight. Flat bar at top of soldier to be provided for maintaining thickness. Supports shall be rigid and strong enough to withstand effect of vibration without any deflection, bulging, distortion or loosening of its supports and shall be so as to prevent loss of slurry from the concrete. Plywood used shall be waterproof plywood conforming to IS: 4990. Test certificates from the manufacturers will be obtained and verified. Form strips or any other suitable sealing tapes will be used to prevent loss of slurry through the joints of formwork.

7.6.3 Suitable working platform will be provided for execution/ inspection of reinforcement, embedded parts and concreting.

7.7 CENTERING REQUIREMENTS

Centering using steel tubular props, H frames, built-up sections, with provisions to adjust heights of props shall be used and they shall be to true levels and rigid. They shall be adequately braced horizontally and vertically. For faster construction, quick strike decking system/ Acro/Doka systems shall also be used for shuttering supported on floors below, vertical props shall be so supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the shuttering. Bamboos or wooden poles shall not be used as props or cross bearers. Centering supported on structural steelwork shall also be designed for the conditions mentioned above.

7.8 TIE RODS

As far as possible MS tie rods left in type shall be used for supporting all forms. Retrievable type can also be used with prior approval of the Engineer. Tie rods shall have provisions for removal of a section of each rod at surface of the concrete to a depth of approximately 50 mm. All holes left by the removal of conical nuts or other removable fixtures embedded in the face of the concrete shall be filled and finished with sand-cement mortar in a manner specified in the finishing specification. Threaded inserts embedded on each face of the wall be cut for attaching the forms to previously placed concrete and when permitted shall be out off flush with the face of concrete or countersunk, filled and finished as required by the Engineer in the manner specified in the finishing specification. Measures shall be taken to prevent rust stains on concrete.. Through left-in Tie rods shall be permitted only upon approval of the Engineer.

7.9 FORM OIL

7.9.1 *Use of form oil shall not be permitted on the* surfaces, which require painting. If the Contractor desires to use form oil on the inside of the formwork of the other concrete structures, a non-staining mineral oil or other approved oil may be used provided it is applied before placing reinforcing steel and embedded parts. Such form oil shall be insoluble in water and not injurious to concrete and shall not become flaky or be removed by rain or wash water. Form oils that retard the setting of concrete shall not be used.

7.9.2 All excess oil on the form surface and any oil on metal or other parts to be embedded in the concrete shall be carefully removed. Before treatment with oil, forms shall be thoroughly cleaned of dried splatter of concrete from placement of previous lift.

7.9.3 The Contractor shall clean the concrete surfaces from any leftover form oil at his own cost if form oils are used.

7.10 SUSPENDED FORMWORK

7.10.1 In certain areas, as identified by the Engineer, metal decking/ and supported on structural steel framework shall be used as self-supporting shuttering as an alternative to the conventional shuttering in places where the area below has to kept free of scaffolding and centering works. The fixing of metal sheets to structural steel members shall be done by bolting / welding or any other alternative as advised by the Engineer .

7.10.2 Plate inserts may be embedded in the sidewalls during concreting, from which bracket supports can be obtained. Structural steel built-up sections or trusses shall be used for supporting the formwork. The Contractor shall submit the design and detailed drawings for the above scheme for the approval of the Engineer. The scope of work shall include design, fabrication, erection and dismantling of the supporting structure.

7.11 CHAMFERS AND FILLETS

Unless shown on drawings or elsewhere to the contrary, all corners and angles shall be formed with 45 Degree mouldings to form chamfers or fillets on the finished concrete. The standard dimension of chamfers and fillets, unless otherwise detailed or specified shall be 25 mm by 25 mm. For heavier work, chamfers or fillets may be 40 mm to 50 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the mouldings shall be planed or surfaced to the same texture as the forms to which it is attached. Unit rates quoted shall include providing the chamfers as specified or shown in the drawings.

Vertical construction joints on faces, which will be exposed at the completion of the project, shall be chamfered as above except where not permitted by the Engineer.

7.12 JOINTS

Joints in forms shall be truly horizontal or vertical unless otherwise specified and shall be sufficiently tight to prevent any leakage of cement slurry to avoid formation of fine or blemish. Faulty joints shall be sealed as directed by the Engineer. Suitable devices shall be used to hold adjacent edges together in accurate alignment. The Contractor shall use sealing tapes to avoid leakage of slurry through the formwork joints. On removal of forms the Contractor shall finish marks left by sealing tapes so as to merge with other concrete surface. The Contractor shall take care to maintain symmetry in formwork in slabs, walls, columns etc. so as to give a pleasant appearance to finished concrete surface. All forms shall be so made that they can be removed without hammering or prying against the concrete.

7.13 REUSE OF FORMS

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired or re-oiled before resetting. Formwork shall not be used/ reused, if declared unfit or unserviceable by the Engineer.

7.14 CLEANOUT PROVISIONS

Forms with limited working space within, shall be provided with temporary clean-out doors or openings for cleaning, washing, blowing and removal of water, wood chips, trash etc.

7.15 WORKING PLATFORM

The Contractor shall provide safe working platform for workmen, when working above ground level. Safe method of approach shall be provided to reach locations above ground level. Handrails shall be provided for all working platforms. Hanging platforms shall have safety net provisions. All ladders shall have handrails and shall not be kept vertical. All platforms, ladders, handrails etc. shall be firmly secured to ground or on supports. No loosely supported ladders or platforms shall be used in the work. All ladders and platforms shall have a kick plate 150 mm high either MS or wooden board for safety of personnel. Ladders and platforms shall be periodically cleaned of loose debris etc.

7.16 REMOVALOF FORMS

7.16.1 In the determination of time for removal of forms, consideration shall be given to the location and character of the structure, the weather and other conditions including the setting and curing of the concrete and materials used in the mix.

7.16.2 Forms and their supports shall not be removed without approval of the Engineer. Improper methods of removal of formwork likely to cause overstressing or damage to the concrete shall not be used. Supports shall be removed in such a manner so as to permit the concrete to uniformly and gradually take the stress due to its own weight.

7.16.3 The supports can be reinstated in anticipation of abnormal conditions. Re-propping of beams shall not be done except with the approval of the Engineer.

7.16.4 The minimum period for removal of forms shall be as mentioned below. However, The seven-day test results shall be as per IS: 456 (latest revision). If the strength requirements are not met with, the formwork shall be removed as per the instructions of the Engineer.

TABLE 7.1

MINIMUM PERIOD FOR REMOVAL OF FORMWORK

Sl. No.	Class of Structures	Earliest Concrete age at stripping for placing Temperature above 20 deg. C	
		Where ordinary Portland cement is used	Where mineral admixture is used
1.	Walls, Columns & Vertical sides of Beams	24 to 48 hrs. as decided by the Engineer	48 to 96 hours
2.	Slabs (props left under)	3 days	7 days
3.	Beam soffits (props left under)	7 days	14 days
4.	Removal of props to slabs		
	For thickness above 300mm		
	a) Spanning upto 4.5M	14 days	21 days
	b) Spanning over 4.5M	21 days	28 days
	For thickness upto 300mm		
	a) Spanning upto 4.5M	7 days	14 days
	b) Spanning over 4.5M	14 days	21 days
5.	Removal of props to beams and arches		
	a) Spanning upto 6M	14 days	21 days
	b) Spanning over 6M	21 days	28 days
6.	Cantilever construction	Not until adequate fix-ity is developed subject to a min. of 10 days	Not until adequate fix-ity is developed subject to a min. of 21days

7.16.5 For rapid hardening Cement Concrete 3/7 th of the period specified for ordinary Portland Cement will be sufficient subject to the minimum period of 24 hours.

7.16.6 Striking shall be done with utmost care to avoid any damage to concrete surfaces or any projections on it and without shock and vibrations, by gently easing the wedges/jacks. If after removing the formwork, it is found that timber has been embedded in the concrete, it shall be removed and made good as approved.

7.16.7 Tie rods, clamp form bolts etc., which must be entirely removed from the walls or similar structure, shall be loosened not sooner than 24 hours after the concrete was deposited. Works damaged due to premature or careless removal/withdrawal/ loosening/striking of forms shall be reconstructed at Contractor's cost.

7.17 STOPPER FORMWORK

Stopper formwork (Bulkhead) shall be provided at all vertical construction joints. Such formwork shall be leak-tight and shall not allow leakage of cement slurry. Wherever specified in the drawings, gas barrier/water stopper shall be provided in the stopper shutter. In addition to the erected stopper, emergency stopper formwork shall be kept ready before starting large concrete pours, with provision for gas barrier/water stopper if required. All stopper formwork shall be measured and paid in the item of

formwork only.

7.18 SLOPING FORMWORK

The bottom formwork shall be made out of plywood with wooden backing members. For slope above 15 Degree with the horizontal it is recommended to have plywood formwork for the top surface and supported on steel or wooden truss. These shall be divided into panels, which shall be fabricated in the shop to the required profile. The bottom of truss will be closed by plywood formwork at the time of concreting. Subsequently further closer formwork for the top surface will be extended after concreting and compaction of the lower portion The entire formwork shall be supported on structural steel/scaffolding supported on a firm base.

7.19 FORMWORK FOR SELF COMPACTING CONCRETE

The formwork shall be made out of plywood with wooden backing members. These shall be divided into panels, which shall be fabricated in the shop to the required profile. Special care should be taken so that there is no gap in the formwork joints so as to ensure not leakage of slurry due to increased workability and slump achieved by using appropriate admixtures. The lateral green concrete pressure on the formwork shall be governed as per Para titled “DESIGN LOADS” of this specification.

7.20 POCKETS FOR FOUNDATION BOLTS

Pockets for foundation bolts shall be made out of plywood or timber. These shall be made slightly tapered for ease of removal. The bottom of such formwork shall be necessarily closed so as not to allow entry of concrete from bottom. The timber pocket may have to be broken to withdraw after concreting. Templates shall be provided wherever required or as directed by the Engineer.

7.21 CURVED FORMWORK

This shall cover all such formwork, which is curved in plan. The formwork shall be fabricated to the required curvature at shop before use. Mismatch if any at site, shall be rectified by cutting or replacing the panel/members.

7.22 FORMWORK FOR PRE-CAST CONCRETE WORKS

All pre-cast units shall be cast in a suitable yard, bed or platform with firm foundation and free from wind. The platform shall have a smooth plaster finish. The yard shall be fenced and shall have a curing tank of adequate size and capacity. The Contractor shall be responsible for the accuracy of the level and shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or printed on each unit. Each unit shall be concreted in one operation. Reinforced concrete members shall be marked to indicate the upper surface.

The form shall be of steel sheets with only rigid steel frames. All components of

formwork shall be so held that during casting there is no deformation of the form resulting in the concrete units not confirming to dimensions indicated in the drawings. The shuttering shall be made with a tolerance of (±) 3 mm in all directions.

The side shutters shall not be struck in less than 24 hours for ordinary Portland cement after concreting and no pre-cast unit shall be lifted during striking the form.

7.23 METAL DECK SHEETING WORKS AS LEFT IN SHUTTERING

7.23.1 GENERAL REQUIREMENT

This part of the specification covers the technical requirements for deck sheeting to be used as left in shuttering for floors & roofs. Supply and installation of the deck sheeting shall be done by same agency. During handling / stacking, if any damage is done to sheet like distortion of edges, scratches on sheet etc., then such damaged sheet shall stand rejected and shall be immediately replaced by the contractor.

7.23.2 MATERIAL

7.23.2.1 Troughed permanently metal decking sheet for Floor / roof decking shall be made by steel feed material of minimum 1.0 mm (bare metal thickness i.e. metal thickness excluding thickness for coating and galvanizing) galvanised to grade 275 as per as per IS 277, of minimum yield strength of 250 Mpa of drawing grade as per IS 513 of approved profile, sectional properties.

7.23.2.2 For metal decking the sectional modulus and moment of inertia of troughed profile per meter width shall be so as to limit the deflection of sheets to span/250 over a span of 1.5 m under total super imposed loading (DL +LL) of minimum 1000 kg per Sq.M.

7.23.2.3 The maximum spacing of the fasteners shall be 390 mm c/c along the length of purlins/runners. However exact spacing shall be as per the design done by the bidder for the fasteners considering the wind load, self-load and other associated loads. Minimum diameter of the fastener shall be 5.5 mm and at least 3 nos. of fasteners shall be used per sheet.

7.23.2.4 Percentage elongation of the mild steel sheet having minimum yield strength of 250 MPa, shall be 23% as per IS:2062.

7.23.3 INSTALLATION AND FIXING

a. The sheeting shall be fixed as per the approved drawings. Sheets shall be supplied in required sizes (based on supporting member spacing) according to the cutting schedule. Generally cutting of sheets to length shall not be permitted at site. Specific approval under exceptional circumstances shall be obtained before cutting of any sheet at site. Power tools shall be used for cutting. Cutting and trimming of small openings which were not finalised at the time of working drawings can be allowed at site. Wherever possible, site cut edges shall be concealed at laps or with flashings.

Suitable steel members for stiffening shall be provided at the cut edges. No gas cutting shall be done on the sheet. If any sheet is found with gas cut mark, same shall stand rejected and shall be immediately replaced.

b. Distorted, blemished or water stained sheets shall not be used.

c. Before installing decking sheet, it shall be ensured that the purlins / supporting members are in true planes, correctly placed and securely fixed.

d. Side and end laps of the sheets shall be made weather proof by securing them with the fasteners not less than 4.0mm dia with 2.0 mm thick neoprene washer. Maximum spacing of the fasteners shall not to exceed 500 mm.

e. Precautions shall be taken during the erection of the sheets to ensure that partially erected decking sheets are protected during inclement weather and damage at all times.

f. Side and end of decking sheet shall be located and positioned in such a manner as to provide the maximum weather protection taking into account the direction of the prevailing wind.

g. Length of the sheet shall be such as to cover minimum 3 span purlin/ supporting members spacing.

h. The roof decking sheets shall be fixed to the purlins/ supporting members with the help of self drilling and tapping type fasteners and neoprene washers.

i. Sheets shall be laid over the supporting members/ purlins with a minimum bearing of 50 mm and end projection of 75 mm at lap joints.

j. End and side laps between the sheets shall be sufficiently large to ensure the weather tightness. In no case, the end laps shall be less than 150 mm and side laps less than one trough length with proper weather tight arrangement.

k. As required the suitable shear connectors shall be provided on deck sheeting for proper shear transfer between sheet & floor/ roof concrete.

7.24 CONSTRUCTION JOINTS & GROOVE FOR CAULKING

These shall provided as shown in the approved drawings or as desired by the Engineer. A trapezoidal groove tapering from the face of the wall to inside will have to be provided on containment walls and roof at all construction joints. For construction joints in thin sections a steel cover plate exposed from one side of the surface will be provided replacing the water stop within the thickness and concrete will be cast against the plate. Suitable grooves will be provided at the junction of the plate and the concrete. Also embedded parts passing through the wall will be provided with grooves around its periphery on the containment walls. All such

grooves shall be caulked by the flexible polysulphide compound or epoxy mortar as directed by the Engineer.

7.25 TOLERANCES

The following tolerances are permitted unless otherwise mentioned in the relevant drawings. The tolerances shall be taken as the departure from the true position at any point after completion of the structure.

Sectional dimensions	:	(±) 5 mm for cast-in-situ concrete.
Plumb	:	5 mm in 5 m but not cumulative. Tolerance in various sections should be compensatory and not cumulative
Levels	:	2 mm before any deflection has taken place for both cast-in-situ and pre-cast works.

Tolerances for climbing type of form work. Variation in walls: Not more than (+) 3 mm.

Total deviation at any point of climbing form / other formwork measured in horizontal plane with respect to the projection of a corresponding reference point at the base of the structure. (Total deviation consists of translational and rotational components.) : 3 mm per 6m height unless specifically required otherwise.

Latest computerised survey instruments shall be used for checking the verticality and alignment of the form works.

7.26 SUBMISSION OF CONTRACTOR'S SCHEME

Bidder shall submit along with his tender the scheme for shuttering, centering, scaffolding for important elements. These should be supported by preliminary drawing and design calculations. Final drawing shall be submitted before start of work.

The scheme submitted by the Contractor should be for all the different type of centering and shuttering schemes proposed and should be so elaborate keeping in mind the entire cross-section of the respective structures in general. The scheme should be such that the construction of one part of any building should not hinder the work on the other parts and keeping in mind the construction schedule.

For centering and shuttering of walls, columns, beams & slabs all the working drawings, details of erection methods calculation of stress and of deflections shall be supplied to the Engineer for approval at least six (6) months in advance of erection.

7.27 ALTERATIONS AND MAINTENANCE

Any modification that the Engineer may require shall be made by the Contractor. Notwithstanding the approval of or alteration suggested by the Engineer in the submitted design for any of the temporary work etc., the Contractor shall remain wholly and entirely responsible until the final acceptance of works, for the efficiency, security, safety and maintenance and for all obligations and risks in regard to such work specified or implied in the contract. The Contractor shall reinstate the same at their own cost, should any mishap or accident occur causing damage or injury thereto, subject however to such provisions of the conditions of contract as may be applicable in the case of such damage or injury.

8. WATERPROOFING OF UNDERGROUND CONCRETE STRUCTURES

8.1 SCOPE

This specification covers waterproofing of underground concrete structures viz. basement, sump, pit, tunnel and trenches against ground water.

The specification described here covers material description, physical and mechanical properties, testing, applicable codes and standards, acceptance criteria, surface preparation, placing in position, lapping and QA requirement etc of water proofing treatment of basement slab and walls.

8.2 GENERAL REQUIREMENTS

As a general guidance, the provisions contained in the contract shall be followed unless otherwise mentioned. Considering safety requirement, Nuclear Power Plant structures should meet special requirement regarding leak tightness.

The contractor shall do the proper concreting so that concrete is water tight in itself without waterproofing treatment. Quality control of concrete construction shall include inspection of preparations for concreting, mixing, transportation, placement, compaction, curing and protection.

The work of waterproofing of underground concrete structure shall be entrusted by the contractor to expert agency approved by NPCIL. The specifications of waterproofing mentioned here are generic in nature. The Contractor shall submit the detailed specification of waterproofing for NPCIL's approval.

8.3 MATERIAL

The plasticized PVC membrane shall be minimum 2.0 mm thick, single ply, twin colored preformed flexible membrane. The single ply plasticized PVC membrane shall be thermoplastic membrane manufactured by co-extrusion process. The membrane shall be of twin colour to provide visual indication of damage, due to any movement or any other reason. The sheet shall be minimum 2 meter wide and appropriate length to minimize the number of joints. The compartmentalization shall be done using specified size of water stop to confine any accidental damage within 100 square meters. All lap joints shall be tested for water tightness upto 2 Kg/sq cm

pressure prior to concreting. The membrane shall be suitable for defect free installation on all type of surfaces viz. horizontal, vertical and overhead and it shall be loosely laid (unbounded) to act independent of structural movement. Adjacent sheets shall be laid with an overlap of at least 80 mm.

The PVC membrane used for waterproofing membranes shall exhibit the following properties.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Thickness	UNI EN 1849 -2	mm	Minimum 2.00 mm
Specific weight	UNI EN 1849 -2	kg/m2	2.600
Ultimate Tensile strength	UNI EN ISO 527-3 Transverse Machine direction	 N/mm2 N/mm2	 Minimum 14.9 N/mm2) Minimum 15.2N/mm2)
Ultimate Tensile Strength (Ageing by complete immersion in ground water for 16 months at 50 ^{0}C)	UNI EN ISO 527-3 Transverse Machine direction	 N/mm2 N/mm2	Minimum 14.9 N/mm2) Minimum 15.2N/mm2)
Elongation	UNI EN ISO 527-3 Transverse Machine direction	 % %	 min 280 (-30%) min 280(-30%)
Mean Tensile Strength Variation	DIN 53455	%	3.5
Impact strength	DIN 16726 - 5.12	mm	> 600
Puncture resistance	DIN 16726 - 5.12	mm	> 1000 mm
Hydrostatic pressure resistance (6 hours at 5 bar)	UNI EN 1928 meth.B		Waterproof
Tear resistance	ISO 34 /ASTM D624	MPa	> 45
Resistance to static punching (CBR)	UNI EN ISO 12236	N	> 1700 N
Root resistance	DIN 4062		No penetration
Fire Behaviour	EN ISO 11925-2		Class E

For Sub-soil applications the chemical resistance of the PVC membranes shall be as fully resistant to the chemicals along with the respective compositions as listed below

as per ASTM D 6943 (i.e. complete immersion of sample in respective solutions for 15 days).

CHEMICAL NAME	NATURE OF CHEMICAL	% CONCENTRATION
Sulphuric Acid	Inorganic Acids	≤ 25
Sulphurous Acid	Inorganic Acids	≤ 6
Nitric Acid	Inorganic Acids	≤ 5
Benzoic Acid	Organic Acid	≤10
Acetic Acid	Organic Acid	≤10
Oxallic Acid	Organic Acid	≤ 25
Phthalic Acid	Organic Acid	≤ 25
Tartaric Acid	Organic Acid	≤25
Citric Acid	Organic Acid	≤ 25
Ammonium Hydroxide	Inorganic Bases	≤ 5
Potassium Hydroxide	Inorganic Bases	≤ 5
Sodium Hydroxide	Inorganic Bases	≤ 10
Chlorides	Salt Solutions	≤ 25
Sulphates	Salt Solutions	≤ 25
Nitrates	Salt Solutions	≤ 25
Soap Solution	Salt Solutions	≤ 25
Drinking Water	Salt Solutions	Any Concentration

8.4 THICKNESS & SPECIFIC WEIGHT OF SHEET

The thickness of the single ply plasticized PVC membrane shall be 2.00 (minimum as per UNI EN 1849). The specific weight of 2.0 mm thick single ply plasticized PVC membrane test piece shall be determined in mass per unit area.

8.5 TENSILE STRENGTH & ELONGATION TEST

The tensile strength and elongation requirement shall be as per UNI EN ISO 527-3. In this test, dumbbell shaped single ply plasticized PVC test pieces are cut using the standard dumbbell die are stretched in a tensile testing machine at a constant rate of traverse of the driven grip. Readings of transverse loads and elongation are taken as required during the uninterrupted stretching of the test piece and when it breaks. For the tensile strength of the joints they are subjected to varying tensile stresses for the overlap joints as per ASTM D638.

8.6 PUNCTURE RESISTANCE

The puncture resistance requirement shall be as per DIN 16726 - 5.12. This is measured using the truncated cone test, in which truncated cones are used as puncture points. The heights of the truncated cones are varied to determine the critical cone height, which is the height at which the puncture occurs for a given pressure. The

minimal permissible height for a 2.0 mm thick single ply plasticized PVC membrane used for waterproofing in case of basements is >800 mm.

8.7 HYDROSTATC PRESSURE RESISTANCE

The hydrostatc pressure resistance requirement shall be as per UNI EN 1928 meth.B. In this test the lateral hydrostatic pressure is exerted on below-grade foundations and slabs on grade by an elevated water table. Tests to quantify resistance to the passage of water should be specific as to the maximum pressure the membrane must be capable of withstanding. In case of single ply plasticized PVC membranes the minimum amount of pressure that the membrane can withstand is tested for a water table of 60mts as per the code. Subjected to these conditions there should be no penetration of water as per the specifying needs.

8.8 ROOT PENETRATION RESISTANCE

Root resistance is tested for single ply plasticized PVC waterproofing membrane through the composition of the membrane which provides an impenetrable barrier to root growth. Root resistant 2.0 mm thick single ply plasticized PVC membrane is quicker to install than separate waterproofing and root barrier layers.

8.9 TEAR RESISTANCE

This test method measures the force per unit thickness required to rupture, initiate, or propagate a tear through a sheet of 2.0 mm thick single ply plasticized PVC membrane. This testing is done so that the specified waterproofing membrane does not fail in service due to the generation and propagation of a special type of rupture called a tear. Tear strength is calculated as T= F/d, where T is the tear resistance, F is the load acting on the membrane and d is the thickness of the membrane. Tear strength of 2.0mm thick single ply plasticized PVC membrane should at least be 45MPa.

8.10 STATIC PUNCHING RESISTANCE

CBR Puncture is an index of puncture resistance that measures the force required to push a flat ended plunger through a 2.0 mm thick single ply plasticized PVC membrane. Instead of an 8 mm diameter probe with a beveled edge; this test utilizes a 50mm diameter, flat-ended probe (plunger) that is pushed slowly through the PVC membrane. The relatively large size of the plunger provides a multidirectional force on the PVC membrane and simulates big stones pressed onto the PVC membrane laying a relatively soft sub-base. The minimum value for a static punching resistance should be at the very least of 1700 N for subsoil applications.

8.11 FIRE RESISTANCE

This test determines the ignitability the specimen is subjected to direct impingement of a small flame at the edge or at the surface. The test specimen of size 250 mm × 90 mm is attached vertically on a U shaped specimen holder. A propane gas flame with a

height of 20 mm is brought into contact with the specimen at an angle of 45 °. For subsoil applications of 2.0 mm thick single ply plasticized PVC they should belong to Class E as per the ISO 11925-2 (Reaction to fire tests-ignitability of products subjected to direct impingement of flame-Part 2:single flame source test).

8.12 TESTING

For acceptance of material listed in above table, Manufacturer Test Certificate (MTC) from manufacturer confirming to above specified properties shall be submitted to NPCIL. However, membrane supplied from each batch shall be got tested for Thickness, Ultimate Tensile Strength, Elongation & Puncture Resistance. Testing of the membrane shall be carried out by the contractor as per approved QAP in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL as per above mentioned relevant standards at no extra cost to NPCIL.

8.13 PACKAGING SHIPMENT AND STORAGE

Materials delivered at site shall be clearly marked with legible and intact labels with manufacturer's name, brand name, product identification and batch number. The products (adhesives etc.) shall be in original, unopened containers.

Materials shall be stored in areas where temperatures conform to manufacturer's recommendations and instructions. All materials shall be stored in covered clear away from reinforcements, coarse aggregates and heavy engineering activities at site. All the materials like membranes, sealants etc. shall be kept away from sources of ignition.

All empty containers of various chemicals employed, left over chemicals shall be disposed off; in a safe manner on a dumping site approved by the site authorities.

All personnel of the applicator should wear all safety gears like gloves, helmet, goggles etc during installation.

8.14 INSTALLATION AGENCY

The works shall be carried out only by trained and certified applicator of the specialized agency carrying water proofing treatment/ membrane supplier.

8.15 INSTALLATION OF MEMBRANE

The plasticized PVC membrane shall be fixed on PCC surfaces strictly as per the detailed application guidelines of the manufacturer. Broadly the installation steps shall include

- Removal of Sharp protrusions
- Installation of Geo textile made of needle-punched 100% pure polypropylene yarns, with a minimum weight of 300 gsm.

- In case of Vertical walls, installation of roundels with mechanical fixtures.
- Laying of plasticized PVC membrane with specified lap joints
- Welding of Joints and testing for water tightness up to 2 Kg/Sqcm
- Water tightening of Pile heads/ rock anchors etc as applicable
- Compartmentalization of the PVC membrane using PVC surface water stops
- Laying of Second layer of Geo textile.
- Laying of Protective screed on horizontal surfaces
- Laying of minimum 25mm thick Protective boards / 115 thick Brick wall protection (the protective board shall be used in case of back filling done with soil / crushed sand , having no boulder/aggregate bigger than 80mm size) for the vertical walls.

A detailed scheme shall be submitted by the contractor including the layout of PVC water stop arrangement and injection ports etc (if proposed) for NPCIL approval prior to its application.

The main contractor shall ensure that all areas of the finished basement waterproofing system shall be protected from site related work traffic and other trades until completion of all works.

Adequate temporary protection shall be provided over the installed membrane during the works program, particularly at temporary walkways, access points to the basement, concreting material stockpiles etc. in order to prevent damage.

8.16 PREPARATION OF THE SUBSTRATE

The substrate shall be PCC concrete of sufficient thickness (minimum 50 mm) to ensure a firm substrate that will not crack or deform under normal trafficable conditions during waterproofing installation, and structural concreting operations. It should be smooth, free from debris and other irregularities, which may puncture and damage the waterproof liner.

The surface will be made clean, dry, smooth and free of contaminants such as grease, animal fats, coal tar and oil based products. Accumulation/ ponding of water shall be removed from the work surface prior to installing the system.

All horizontal or vertical surfaces should be covered with a uniform adjustment layer using Non-Woven Geotextile. It has the purpose of ensuring the uniformity of the substructure in order to avoid irremovable debris or other roughness in the underlying layer which may cause damage, perforate or punch, the waterproof layer.

8.17 WATERPROOFING SYSTEM FOR BASEMENT RAFT SLAB

The 2.0mm thick single ply twin colored plasticized PVC loosely laid membrane waterproof system should be installed over the hardened well leveled surface of the PCC overlaid with first layer of Geotextile. The Geotextile shall be resistant to micro-organisms, needle-punched 100% pure polypropylene yarns, with a minimum weight of 300 gsm. The PVC membrane system shall be compartmentalized using PVC

surface water-stop maximum size of compartmentalization shall be limited to 100 sq m). The PVC water stop used for compartmentalization shall be minimum 320mm wide, min thickness of 2.5mm and shall have minimum 4 ribs of 15 mm depth. These PVC water stops shall be welded with PVC membrane by hot air welding. The membrane shall be further covered with second layer of Geotextile ensuring no gaps in the Geotextile. The geotextile should be checked prior to laying of protection screed.

After checking all the joints & any visible damage, second layer of geotextile shall be laid over the member followed by laying of minimum 50mm thick layer of protection PCC (Minimum Grade M20) screed. The damage if any found, shall be recorded and the necessary patch repairs shall be conducted before laying of second layer of geotextile and protection layer.

8.18 WATERPROOFING SYTEM FOR VERTICAL/RETAINING WALL

The first layer of Geotextile Membrane shall be laid over the hardened well leveled surface. Over the Geotextile membrane 2.0mm thick single ply, twin colored, and plasticized PVC membrane waterproofing system shall be installed using rondels having maximum C/C spacing 1.0m .The rondels are provided to anchor & hold the Membrane at its position. The membrane is to be protected after installation with a 300gsm geotextile followed by protective layer of 25 mm thick expanded polystyrene boards (in case of back filling done with soil / crushed sand, having no boulder/aggregate bigger than 80mm size) or 115 mm thick brick wall. The PVC membrane system shall be compartmentalized using PVC surface water-stop at required locations, based on the site requirements (maximum size of compartmentalization shall be limited to 100 sq m).

8.19 CHECK FOR MEMBRANE TO MEMBRANE JOINT

Two adjacent membranes shall be welded using hot air welding. It shall be a double seam weld to maximum clear length of the membrane installed; double seam weld shall allow pressure testing of every length of joint. The double seam joint shall be tested to a pneumatic pressure of maximum 2 bars kept for minimum duration of 8 minutes. The loss of pressure after holding for 8 minutes shall not exceed 20%.

Wherever the double seam welding machine cannot be used, the single seam welding shall be done after obtaining prior permission from engineer, in such case the weld width shall be preferable 40mm, but shall not be less than 20mm in any case. The single seam weld shall be tested using a seam probe hook to check for any opening in the weld. In addition to above if any destructive testing is found necessary shall also be performed.

8.20 PILE HEAD TREATMENT

The single ply plasticized PVC membrane is dressed up to the outer surface of the pile head or anchor or up stand. The membrane is then encapsulated in with a high strength flowable epoxy mortar having a minimum thickness of 10mm below the

membrane and mini 20mm on top of it and extended to the edge of outer surface of the interface. The key properties of the high strength flow able epoxy mortar shall be as mentioned in the following table.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Solids Content	DIN 53213	%	100
Tensile Strength	BS 6319, Part 7	MPa	11
Compressive Strength	BS 6319, Part 2	MPa	100
Flexural Strength	BS 6319, Part 3	MPa	25

8.21 QUALITY ASSURANCE & SUPERVISION

A detailed work procedure and inspection and test plan (ITP) in line with this specification and manufacturer's specification with resources deployment shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work. Contractor shall carry out testing of materials as per direction of Engineer and shall submit testing reports and manufacturer's test certificates to the Engineer. A strict check on membrane properties and installation shall be exercised by Contractor's QA Engineer and necessary records in this regard shall be submitted to NPCIL. Contractor shall provide necessary assistance to NPCIL in supervision of water proofing work.

During the entire process of work under this specification, the Contractor shall arrange at his own cost the supervision of the work on water proofing by the manufacturer's/ specialized agency's representative to ensure that the work is being executed as per manufacturer's specifications and instructions.

8.22 GUARANTEE

The Contractor shall make periodical inspection and repair the waterproofing for any apparent defects to ensure complete waterproofing during the guarantee period. The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for an amount of 10% of the cost of water proofing works carried out. The bank Guarantee shall be valid for a period of ten (10) years from the date of acceptance of the water proofing work by NPCIL.

9. DELETED

10. REINFORCEMENT

10.0 SCOPE

The work covered under this section shall include supplying, cleaning, cutting, bending, placing, binding and securing of reinforcement in position for all structures.

For use of Fusion Bonded Epoxy Coated bars the relevant specification shall be followed.

10.1 STANDARDS AND SPECIFICATIONS

The provisions of the latest revisions with amendments, if any, of the following Indian Standards and other relevant codes shall form part of this specification to the extent they are relevant. Where the provisions of these Standards/Codes are in conflict with the stipulations of this specification, the specification supersedes the respective Standard or Codes.

10.1.1 BUREAU OF INDIAN STANDARDS

IS – 1786	High strength deformed steel bars and wire for concrete reinforcement-Specification.
IS – 456	Plain and reinforced concrete – code of practice
IS – 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS – 9417	Welding cold worked steel bars for reinforced concrete construction – recommendation for welding.
IS – 2751	Code of practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
IS – 822	Code of procedure for inspection of welds.

10.1.2 OTHER STANDARDS

1. ASME Section III DIVISION
2. Qualification of splicing system

10.2 MATERIAL

Material covered under this specification is a high yield strength deformed bar (HYSD) and TMT bars of grade Fe 500 conforming to IS: 1786, as specified in the drawing. For Fe 500 grade steel, the total elongation shall be more than 14.5 % and the ultimate tensile strength of the bar shall be 15 % more than the specified 0.2 % proof stress/ yield stress. This requirement is over and above the requirements specified in IS 1786. The Contractor shall submit the manufacturers test certificate for the material. Random tests i.e. minimum 1 sample per 150MT or at least one sample from each heat, for each diameter of bar shall be performed as required by the Engineer in his presence. All costs, incidentals to such tests shall be borne by the Contractor and shall be deemed to have been included in his quoted rates. Steel not conforming to the specifications shall be rejected. All reinforcement shall be clean, free from grease, oil, paint, dirt, loose mill scales, loose rust, dust, bituminous material or any other substance that will destroy/ reduce bond. All bars shall be thoroughly cleaned before fabrication and placement. Pitted and defective bars shall not be used.

The steel shall be supplied by main manufacturers like SAIL, TATA Steel & RINL etc., who manufacture the rebars using billet produced from ore itself and not by rerolling of steel.

10.3 STORAGE

10.3.1 The reinforcement steel shall not be kept in direct contact with ground but stacked on top of an arrangement of concrete pedestal or timber sleepers. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deteriorations.

10.3.2 It shall be stored under cover, as desired by the Engineer without any extra cost. If necessary, the reinforcement steel, other than Fusion Bonded Epoxy Coated bars, shall be coated with cement wash before stacking, to prevent scale and rust. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage. Any reinforcement, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for the work.

10.4 FABRICATION

10.4.1 The reinforcement bars shall be straightened, cut to size using cutting machine & shall be cold bent using bar bending machine, without the use of heat, to the shapes mentioned in the Drawings, as per relevant Indian Standards. Bars having cracks or splits on the bends shall be rejected. The bar bending schedules shall be prepared by the contractor in general (except for critical structure as decided by the Engineer) according to the reinforcement drawings and shall get it approved by the Engineer. In any case, the details given in the drawings shall be final. The high strength deformed steel bars/ TMT Bars shall not be re-bent or straightened without the approval of the Engineer. Crossing bars shall not be tack welded. Bars shall be properly tagged for easy identifications.

10.4.2 Where reinforcement bars are bent aside at construction joints and afterwards bend back into their original position, care should be taken to ensure that at no time the radius of the bend is less than 6 times the dia for HYSD TMT bars.

10.5 FIXING / PLACING

10.5.1 Rough handling, shock loading (prior to embedment) and the dropping of reinforcement from a height shall be avoided. Reinforcement shall be accurately placed and fixed by any approved means to maintain the correct position of bars as shown on the drawings for this purpose. The contractor shall use cover blocks, spacers and chairs as per IS: 2502 to prevent displacement during placing & compaction of concrete. Concrete cover blocks as directed by the Engineer shall be used for providing specified cover to the rebars. Bars intended to be in contact at crossing joints shall be securely bound together at all such points with 1.6 mm dia soft annealed Iron wire (Binding wire). The vertical and horizontal distance required between successive layers of bars in beams, walls or similar members shall be

maintained by the provisions of spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bar. The dia. of such spacer bar shall not be less than the dia. of the main bar. No reinforcement shall be bent when in position in the work, without the approval of the Engineer. In-situ bending of embedded bars using oxy-acetylene flame shall not be done. However, if it can be proved that cold bending is not possible the same may allowed at the discretion of the Engineer by taking due precautions. Erected and secured reinforcement shall be inspected and approved by Engineer prior to placement of concrete.

10.5.2 When reinforcement of the specified diameter is not available, Contractor may be allowed to replace with diameter higher than originally specified in the drawing on written approval of the Engineer at no extra cost to NPCIL. However, this option shall be used under exigency situations only and not as a general practice.

10.5.3 Exposed ends of dowel bars for underground structures shall be protected if necessary, by encasing the same in lean concrete, at no extra cost. Bars for the portion of structures above ground shall be given adequate coat of cement wash and if additional protection is needed as per the Engineer, shall be wrapped with plastic tape at no extra cost.

10.5.4 Wherever necessary/ as directed by the Engineer, before placing the reinforcement in the congested areas full-scale mock-ups shall be carried out and approval from Engineer shall be obtained. Such Mock-ups will be paid as per relevant items of BOQ.

10.5.5 For supporting the horizontal bars at height, supports drawings shall be prepared by the Contractor & shall be approved by the Engineer. Reinforcement chairs, spacers & support embedded in concrete as mentioned in the drawing or specified by the Engineer will be measured & paid separately.

10.6 TOLERANCE ON PLACING OF REINFORCEMENT

Unless otherwise specified in the drawings, reinforcement shall be placed in accordance with IS: 456.

10.7 LAP SPLICING OF REINFORCEMENT BARS

Lapping of reinforcement bars shall be done at locations shown in the drawings or as directed by the Engineer. The lap length shall not be less than that specified in the drawings and unless otherwise specified, the lap length shall be as per IS: 456. At locations where lap splice gives rise to congestion of reinforcement, such splice shall be replaced with welding/ mechanical splicing. For mechanical splicing of bar the relevant specification of mechanical splices (Threaded Coupler) shall be followed.

10.8 WELDING

10.8.1 Generally bars joints are to be made using mechanical splicing using threaded

couplers or lapping. In exceptional cases only joints shall be made by welding or any equivalent splicing system like CADWELD etc. The splicing system shall be qualified as per ASME Section III DIVISION 2.

10.8.2 Field welding of reinforcement will not be permitted, without the written permission of the Engineer. Such approval will require identification of the type of steel used. Where welding is permitted, detailed welding procedure shall be submitted to the Engineer for approval. Welding of reinforcement to structural steel if required shall be done as per standard practice. Welding of reinforcement if required will be paid for as per relevant item of schedule. Welding of High Strength Cold Twisted deformed bars/TMT bars conforming to IS 1786 shall be made in accordance with the relevant Indian Standards (IS 9417).

10.8.3 The material shall be examined and compared with the manufacturer's test certificates, ISI certification marks and inspection stamps. Special attention shall be paid to the chemical composition of the material and its general weldability to meet the required standards for strength. The material shall be examined for surface defects, rust and corrosion products, presence of contaminants and any other factors, which may hamper the production of a satisfactory weld.

10.8.4 The qualifying tests for welders engaged in arc welding shall be in accordance with IS: 2751.

10.8.5 The Procedure to be adopted for the welding shall be arc welding with double V butt joints. Oxy-acetylene welding is not permissible.

In addition to the requirements specified in IS 9417, the requirements given below shall also be followed:

10.8.6 All welding operations shall be controlled to prevent a supply of more heat to the steel at a time than can be dissipated by the steel owing to its high thermal conductivity without adversely affecting the strength of the welded bars. The non-twisted portion of the deformed bar at weld junctions (25 to 50 mm) must always be cut off. Scraping of rust at joint- surfaces prior to welding is essential.

10.8.7 For edge preparation, the bar ends to be welded should be shaped by power shears and grinders. If oxyacetylene torches are used for shaping the edges (chisel edge) last 2-3 mm of the cut faces shall be removed by grinding. The amount to be ground off may be determined by tests, but should not be less than 2 mm. To avoid crookedness in bars after welding, their axes should be properly aligned prior to the welding operation. During the welding procedure, the bar may be supported to about 1 m. on each side of the joint over steel channels 2 m. to 3 m. long. Removal of slag after each alternate welding run is to be effected by brushing. The electrode shall never be lighted from the hot bar, to avoid notch effect.

10.8.8 Fusion faces and surfaces adjacent to the joint for a distance of at least 50 mm on either side shall be absolutely free from grease, loose scales, moisture or any other substance which may interfere with welding or adversely affect the quality of the

weld.

10.8.9 Each layer of the multiple layer weld may be moderately peened with light blows from a blunt tool. Care must be taken to prevent scaling or flaking of weld.

10.8.10 Welded junctions of all reinforcing bars may be carried out at same section provided there are no bends, curved parts in reinforcement bars, or zones where variable loads predominate. It is recommended that all welds be located at least 50 dia away from bends.

10.8.11 Assessment after welding shall first be done to ascertain the correctness of the whole weldment by visual and dimensional inspection.

10.8.12 Mechanical testing in the form of tensile tests and 180-degree bend tests shall be carried out on prototype or sample welds. The choice of the samples will depend entirely on the Engineer, and will be made at random. Specimens for tension tests are to be chosen 1 out of every 100 joints prepared. The bend tests are to be conducted on 2 prototype specimens in 2 perpendicular directions, for every 200 joints. The specimen shall be bent by 180 degree for qualification.

10.8.13 The welded joint should be capable of resisting 90% of the actual bar strength and should not fail to develop at least 100% of the specified ultimate strength of the variety of steel under use. The failure shall not occur at the joint location.

Weldments incapable of developing full strength shall not be used as reinforcement.

Apart from tensile testing of weldments, liquid penetrate flaw detection test as recommended in IS: 822 shall also be made on 10% of total joints on root & final pass.

10.9 FUSION BONDED EPOXY COATING BARS

10.9.1 SCOPE

These specifications cover coating of reinforcement bars with fusion bonded epoxy coating (FBEC) to be provided as corrosion protection measure, in construction of Nuclear Power plant. This coating shall be used, wherever specified so in the drawings.

10.9.2 REINFORCING BARS

The reinforcing bars to be provided with Fusion Bonded Epoxy Coating shall conform to I.S. 1786. In spite of producing test certificates by contractor for the proper quality of reinforcing bars, the quality of steel should also be tested by the FBE coating agency for bend test before undertaking coating and that if the reinforcing bar fails in bend test, it shall be rejected.

Reinforcing bars to be coated shall be fresh from rolling mills as far as possible. If

the bars are rusted in quality before providing FBEC, the same shall be rejected.

10.9.3 Coating on Bars with FBEC

10.9.3.1 SURFACE PREPARATION

The surface of the steel bars to be coated shall be cleaned using shot blasting near to white metal .The surface profile shall be free from mill scale, rust and foreign matter.

10.9.3.2 The Coating shall be applied to the cleaned surface as soon as possible after cleaning. In no case the coating be delayed beyond 8 hours after cleaning.

10.9.3.3 The FBEC coating shall be done confirming to I.S. 13620 as well ASTM A775/775M.

10.9.3.4 The Fusion Bonded Epoxy Coating shall be carried out by an authorized FBE coating agency approved by Engineer.

10.9.3.5 Patch-up materials shall be procured in sealed containers with certificates from coating agency for supply of such patch-up material.

10.9.3.6 The Quoted rate for FBE coated bars shall include the use of PVC coated GI wire (Binding Wires) of 1.6 mm dia.

10.9.4 Tests for FBE Coating on Reinforcing Bars

10.9.4.1 The contractor shall produce certificate from the FBE coating agency that the quality of powder epoxy material and other components of FBEC conform to I.S. 13620 as well ASTM A775/775M. Such certificates shall accompany each delivery challan of coated bars. The Engineer may carry out such tests at plant to confirm use of proper quality of coating material.

10.9.4.2 The Coated reinforcement bars shall be tested for following properties at a specified frequency. Following tests on coated bars shall be as per I.S. 13620 at the specified frequency on routine basis and Test reports shall be jointly signed by authorized representatives of contractor and the coating agency:

Thickness of coating: One full-length bar for every twenty bars for each size of bars

Continuity of coating: One full-length bar for every twenty bars for each size of bars

Adhesion of coating: As per following frequency based on dia of bar

- Upto 16 mm dia: - 1 for every 1 tons
- Above 16mm and upto 25mm dia: - 1 for every 2 tons
- Above 25 dia: - 1 for every 4 tons

10.9.4.3 Inspite of conducting above tests and test certificates produced by the contractor and coating agency, Engineer reserves the right to carry out independent tests at coating plant for cross checking. The contractor's agreement with coating agency shall include the provision for Engineer's cross checking and that if the coating quality is not approved by the Engineer, the decision of the Engineer to reject or repair the coating shall be final and binding on all parties.

10.9.4.4 Thickness of Fusion Bonded Epoxy Coating shall be 250 (+/- 50) microns.

10.9.4.5 Holidays in coating shall not be more than two holidays per linear foot (six holidays per meter) of coated bar. All the damaged coating incurred during handling & fabrication, to the point of shipment to the job site shall be repaired. Damaged coating on a bar is permitted to be repaired if the amount of damaged coating does not exceed 1 % of the total surface area in each 0.3 m length of bar. The limit on the amount of repairable damaged coating does not include sheared & cut ends of the bars that are required to be coated with patching material. Repaired areas of damaged coating shall have a minimum coating thickness of 250 microns.

10.9.4.6 The Coating shall also meet all other requirements specified in IS 13612 as well ASTM A775/775M.

10.9.5 Handling

10.9.5.1 The coated bars shall be carefully handled in order not to drop them, not to rub them on hard surface or against another coated bar while conveying, stacking, placing or stacking of fabricated bars. For this purpose, wooden packing batons shall be used at spacing of not more than 60 cms.

10.9.5.2 The Coated bars shall be tied to make bundles with PVC binding material to avoid damages to coating.

10.9.5.3 The cut ends of bars shall be touched up with special touch up material of the same specifications as provided by coating agency. There shall be minimum time gap to repair the cut ends and damaged portions with touch up materials and that failure to do so may cause complete rejection of the coated bars. The cut ends and damaged portions shall be touched up with repair patch-up material within four hours time gap. All damages to coating in handling etc. shall be repaired irrespective of their size. This stipulation supersedes provision of clause 13 of IS 13620.

10.9.5.4 The Contractor will be paid for the same quantity of reinforcement bars used in the work and paid under relevant item.

10.9.5.5 While bending the bars, the pins of workbenches shall be provided with PVC or plastic sleeves. It is preferable that contractor install bar bending machines suitable for FBE coated bars and that each bending operation is done in a time of not less than 90 secs.

10.9.5.6 The coated steel shall not be directly exposed to sun rays and rains and shall be protected with opaque polythene sheets or such other approved materials.

10.9.5.7 While Doing concreting, the workmen or trolleys shall not directly move on coated bars, wooden planks shall be placed on the bars for movement of workman & trolley of material, by the contractor.

10.9.5.8 In spite of all test certificates, if the coated bars are roughly handled by the contractor either during transport, fabrication, stacking, placing and concreting etc. or handled in such a manner as to damage the coating for area or portion more than reasonable, the Engineer reserve the right to reject the FBE coated bars and such rejected bars shall be removed by contractor from work site within three days. The decision of Engineer will be final as to reject the bars with damage coating or to allow repairing the coating, or to get it recoated entirely at the contractor's cost.

10.9.6 STORAGE

10.9.6.1 The Bars shall be stored as close as possible to the area of the structure where they will be placed (fixed) to keep handling operations to a minimum. Deliveries of the coated bars to the job site should be well coordinated to avoid any long term storage at site when stored in open. If circumstances or other conditions make it necessary to store FBE coated bars outdoors for an extended period of time, the coated bars should be protected from sunlight & salt spray, and sheltered from the weather.

10.9.6.2 FBE coated bars shall be stored above ground on protective timbers, supports shall be provided at regular interval to avoid sagging of the bundle. Such wooden or padded contact shall be at spacing of not more than 60 cms.

10.9.6.3 If a relatively large quantity of FBE coated bars is to be stored in a small area, bundles of straight bars shall be stacked with adequate blocking between the layers of bundles.

10.9.6.4 FBE bars shall be covered with opaque polythene sheets or other suitable protective material. The protective cover shall be draped over the sides of the bundles around the perimeter of the stack. The cover shall be properly secured with provision of air circulation to minimize the condensation under the covering.

11. REINFORCEMENT, SPLICING AND MECHANICAL FASTENERS & MECHANICAL COUPLERS

11.0 SCOPE

These specifications cover threaded couplers to be used for joining reinforcement bars, in lieu of laps/welding/mechanical splicing.

11.1 GENERAL

The couplers shall be of standard parallel square thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that thread diameter is not lesser than the parent bar to be joined. The

material of the coupler shall be of same quality or of superior quality than the quality of material of the parent bars (i.e. reinforcement bars to be joined). The joint shall have guaranteed bar break i.e. when the joint is tested in universal tensile testing machine, the bar shall fail away from the coupler i.e. not within the coupler as well as within 2 times the diameter of bar from the ends of the coupler, which can be considered as affected zone. The Guaranteed Bar break condition is not mandatory, if the failure load of coupled specimen is higher than 1.15 times of its minimum specified yield stress. The coupler shall be qualified as per ASME, Section III, and Div.2. Additionally it shall meet all the requirements of "Class H" type coupler as specified in IS 16172. The safety margin in coupler design shall be such that guaranteed bar break is ensured even if 15% of the total threads length are out of coupler during installation.

The hand tightening of coupler shall be sufficient in the field and no mechanical means shall be essential for tightening. During testing, the coupler should only be hand tightened.

The process of manufacturing of the coupler, cold forging and threading including testing shall be carried out as per ASME approved quality assurance programme. The manufacturer of coupler shall hold a valid Quality System Certificate (QSC) from ASME. Installation of the coupler and supervision shall be done by the qualified personnel.

11.2 MANUFACTURING OF COUPLERS

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number, heat number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties.

11.3 THREADING OF ENDS OF THE REINFORCING BARS

This threading activity shall preferably be done at site. The various stages involved in threading are as given below

11.3.1 CUTTING

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain end surface, perpendicular to the axis of the bar.

11.3.2 COLD FORGING & THREADING

After cutting, the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done, preferably on lathe machine.

The threads shall be square parallel type, to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic caps, before taking the bars out of the shop.

11.3.3 QUALITY CONTROL IN MAKING OF THREADS

The work in shop shall be fully supervised by the Manufacturer representative. Double forging of bars is not permitted. In case of improper cold forging, the forged end of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges.

For threaded coupler systems, every prepared bar end shall undergo a load test prior to actual use. The minimum test loading shall be equivalent to 80% of specified yield strength of bar. For this purpose contractor shall deploy the machine having facility of integrated load testing. The "Integrated" means that the testing operation is performed automatically by the same machine used to prepare the bar ends. A positive indication shall be punched on the rebar to indicate that this operation has been carried out and bar end has qualified for specified strength.

11.4 INSTALLATION OF COUPLERS IN THE FIELD

The installation of couplers in the field, for joining reinforcing bars, shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned with acetone or any other solvent, just before installation.
Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached & then cleaned before joining the next bar.

11.4.1 The contractor shall arrange for a suitably qualified manufacturer's representative, experienced in mechanically connecting reinforcement, to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary.

11.4.2 The contractor shall submit to the Engineer, for his acceptance, a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

(a) requirements for cleanliness
(b) equipment for threading bars
(c) method of locking the connections on both rebars

(d) method of verification of final rebar alignment and coupler integrity.

11.4.3 Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance standards shall be completely removed and the bars re-connected, as required.

11.5 QUALIFICATION TESTS

The splices shall be qualified as per ASME Section III Div-2, IS 16172 and by conducting following tests:

11.5.1 STATIC TENSILE TEST

Mechanical connections shall be tested in all reinforcing rebar sizes. All rebar transition connectors shall also be tested. For each rebar size, a minimum of six connections in each load direction shall be tested in accordance with ASTM A 370. A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength.

- The average tensile strength of the splices shall not be less than the followings:

  a) 90% of the actual tensile strength of the reinforcing bar being tested.
  b) 100% of the specified minimum tensile strength

- The tensile strength of an individual splice system shall not be less than the 115% of the specified minimum yield strength of the spliced bar.

11.5.2 CYCLIC TENSILE AND COMPRESSIVE TEST

Cyclic tensile and compressive test: Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return. The test shall be performed as per Annexure D of IS 16172.

11.5.3 PERCENTAGE ELONGATION

The minimum uniform elongation (Elongation at maximum force) in the reinforcement bar outside the length of mechanical splice as measured as per Annexure B of IS 16172 shall be 3 % before failure of test piece.

11.5.4 SLIP TEST

The total slip value when measured in accordance to test procedure described in Annexure C of IS 16172 shall not exceed 0.10 mm.

11.5.5 TEST FOR AVOIDANCE OF STAGERRING

The strain measured over the full length of the splice at 90% of the specified minimum yield strength of the bar shall not exceed that of a bar that is not mechanically-spliced by more than 50%. The test shall be performed for all diameter of couplers.

11.5.6 LOW CYCLE FATIGUE TEST

The mechanical splice shall withstand 10000 cycles of alternating tension & compression load, when tested as per Annexure E of IS 16172.

11.5.7 HIGH CYCLE FATIGUE TEST

The mechanical splice when tested accordance to Annexure E of IS 16172 shall withstand 2 million cycles (2000000 Nos)of varying axial tensile load with a stress range of 60 MPa with upper stress in the test equal to 0.6fy.

11.5.8 PRODUCTION TESTS & ACCEPTANCE CRITERIA FOR A LOT

Static Tensile tests, as per ASTM A370, shall be conducted on each bar size & grade for each lot as follows. The criteria mentioned below are in variance with the above referred codes.

Sr No	No of Coupler in the Lot	No of sample to be tested	Acceptable Defective couplers
1	Upto 500	14	NIL
2	501-1200	20	NIL
3	1201-3200	32	1
4	3201-10000	50	2
5	10001 and above	50+ 2 for each 1000 Nos beyond 10000	Not more than 4% of the samples tested

The lot is defined as the group of couplers which are of same size, type, class, material traceable to same cast and manufactured under similar conditions of production. All the tests shall ensure guaranteed bar break at a load not lower than the specified tensile strength of the bar. The quoted rate shall be inclusive of carrying out above tests and no separate payment shall be made for these tests.

11.5.9 The Contractor shall submit to the engineer for acceptance a report on these Proving Tests, within seven working days of the tests. The report shall provide full details including:

(a) Results of all tests
(b) Details of dimensions, geometry.
(c) Details of test procedures
(d) Description of test rig/load cell
(e) Description of load monitoring, strain measurements
(f) Calibration certificates.

11.5.10 From each test on the coupler and control bar specimens, the following information shall be provided:

(a) Stress-Strain (or Load Displacement) curves
(b) Yield Load & Yield Strength
(c) Elongation of the mechanical connection
(d) Ultimate load & Ultimate Tensile Strength
(e) Mode of failure
(f) Gauge length used for strain measurement and statement of how gauge length was determined.

12 PILING WORKS

12.0 SCOPE

This specification covers the works involved for bored cast in situ reinforced cement concrete (RCC) piles including all specific requirements for installation/casting of pile, testing (initial, routine and other NDT) and analysis of the various test results to assess their vertical, horizontal and pull out load carrying capacities, confirm pile integrity, apportion skin friction and end bearing capacity of the pile and arrive at dynamic properties of soil-pile system. *All the piles within the scope of this tender needs be toe grouted. The procedure for Toe grouting shall be finalized by the contractor in consultation with Engineer.*

12.1 CODES, STANDARDS & SPECIFICATION

12.1.1 Latest Indian Standards on Piles

IS 2911 : Part 1: Sec 2 Code of practice for design and construction of pile Foundations: Part 1 Concrete piles, Section 2 Bored cast-in-situ piles
IS 2911 : Part 4: Load test on piles
IS 5121 : Safety code for piling and other deep foundations
IS 9716 : Guide for lateral dynamic load test on piles
IS 14362 : Pile boring equipment - General requirements
IS 14893 : Non Destructive integrity testing of piles-Guidelines

12.1.2 **Latest ASTM**

ASTM D 4945: Standard Method of test for High Strain Dynamic Testing of Piles
ASTM 6760: Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross-hole Testing
ASTM D 5882: Standard Test Method for Low Strain Integrity Testing of Piles

Reference to any code shall always mean reference to the latest revised edition of the code including all its amendments up to date, unless otherwise specified. In the event of any conflict between the requirements of this specification and those of the referred codes, the former shall govern.

12.2 DESCRIPTION

12.2.1 **GENERAL**

Specifications to be followed for providing RCC bored cast in situ piles wherever required as per design . The scope in general consists of constructing the RCC bored cast in situ pile foundation .

The testing of piles shall be carried out by the contractor in line with relevant BIS codes, and / or ASTM codes, as specified above and procedures to be developed by the contractor/Vendor and approved by NPCIL. Initial and Routine (static and dynamic) tests shall be carried out on test piles and working piles, respectively as per provisions of BIS/ASTM and as approved by NPCIL.

The work involves but is not limited to the following:

1. Construction of Pile foundation .
2. Conducting Initial, Routine Load tests (Static and dynamic) on designated Test / working piles namely Vertical, Lateral, Pull out and Dynamic load tests.
3. Conducting Non-Destructive Testing (NDT) to assess pile integrity.
4. Toe grouting of pile

The contractor shall submit the work procedures for different items of piling works in line with IS/ASTM, Technical Specification herein under and get it approved from Engineer.

Upon completion of the piling work, all casing equipments, construction tools, protective covering and debris resulting from the piling operations shall be removed from the works site with the permission of the NPCIL.

12.2.2 **MINIMUM REQUIREMENT OF PILING EQUIPMENT**

The equipment & accessories should be compatible with the type of sub-soil, method of construction, type of founding strata & required penetration in the founding strata. The capacity of rig shall be adequate so as to bore up to required depth with specified diameter. Rig shall be equipped with suitable chisel to penetrate through any local obstruction/ hard strata.

Hydraulic self-propelled rotary piling rigs complete with adequate torque capacity and crowd value shall be deployed to complete the entire job as per the time schedule and specifications provided in this tender document. The Contractor shall mobilize adequate spares; cutting tools (e.g. flat teeth bits, round shank bits, holders, etc.) to avoid any stoppage of work.

The Contractor shall provide all the equipment, tools and plants required for the work.

12.2.3 SURVEYING AND LAYOUT

It is the sole responsibility of the contractor to bring to site all surveying instruments necessary for the marking out, fixation of levels, etc. and conduct these survey operations with utmost accuracy. The contractor shall put-up stable bench marks etc. as necessary for the work. NPCIL will provide benchmark location and elevation with respect to plant grid. The contractor shall be entirely responsible for accurate setting out of the work and he shall at his own expense make good any defects arising from errors in line and levels.

12.2.4 BORING

The boring shall be done as per specific requirements of soil strata and the procedure / methodology shall be approved by Engineer-In-Charge.

The Contractor, while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classifications, these shall be immediately reported to the Engineer. Rig register and weekly report as per the format, approved by NPCIL shall be submitted to Engineer-In-charge of the project.

12.2.5 CLEANING OF PILE BORE

After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/bored material etc. Necessary checks shall be made to confirm the thorough cleaning of the pile bore as per the recommendations of IS 2911-Part1-section 2.

Pile bore spoil shall be disposed of from site within 1 Km. away as directed by the Engineer.

12.2.6 DEWATERING

The dewatering for the area will be carried out by the Purchaser through some other agency.

12.2.7 INFORMATION TO BE SUBMITTED AS PART OF THE TECHNICAL BID

If piles are envisaged in the structure, bidder shall submit the following information along-with the bid:

1. Number of the piling rigs proposed to be deployed.
2. Full Technical details of piling rigs and accessories in the form of catalogues, data sheets, etc.
3. Piling procedure, piling program and accessories to be mobilized by the contractor.
4. Complete Construction Methodology. However, work procedures and quality assurance plan (QAP) for the work will be required before start of the work. The contractor shall use only Ready mixed concrete from the batching plant for the proposed piling works.
5. All data sheets, rig register, test reports, Soil profile data.
6. Details of toe grouting to be done for all piles.

12.3 REQUIREMENTS

All work shall be carried out in accordance with this specification and contractor shall ensure meeting of all the requirements as laid down hereunder:

The work shall include supplying and providing necessary materials, mobilization / demobilization & operation of all necessary equipment, consumables providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labor etc. as required to carry out the complete piling work, and submission of records & reports as per schedule.

The Contractor shall confirm the "Safe Load" capacities by conducting both initial and routine load test on piles.

It is essential that all equipment and instruments are properly calibrated at the commencement of test so that they represent true values. The instruments shall be re-calibrated at the frequency as per manufacturer's specification. Certificates to this effect from an approved institution/National Accreditation Board for Testing and Calibration Laboratories (NABL) shall be furnished to the Engineer. If the Engineer desires to witness such tests Contractor shall arrange to conduct the test in his presence.

The contractor shall assure the quality of piling work including cleaning of pile bore, quality of concrete, integrity of piles, etc.

Each pile shall be identified with a reference number. Sequence of piling shall be such that there is no damage caused to the concrete recently laid in the adjacent pile and as per approved drawings. Construction of piles shall be done in accordance with the priority of construction of various buildings. The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed pile. Sequence of piling shall be approved by the Engineer.

12.3.1 TERMINATION OF PILES

The casting of piles shall start from levels strictly as per approved construction drawings. In no case casting of piles should start from levels higher than those indicated in the approved drawings. The top of the pile shall be cast above the cutoff level so as to permit removal of all laitance and weak concrete before embedment into raft. The pile top shall be terminated at minimum 600mm above Pile cutoff level. The same will be chipped off up to cutoff level before the commencement of pile-raft construction to progress the job further.

12.3.2 SAFE LOAD CARRYING CAPACITY

The contractor shall conduct the tests as specified in the drawing or as per the direction of Engineer and determine the minimum safe load for the piles constructed for Vertical Compression/Lateral/Uplift.

12.4 MATERIALS

Materials shall conform to specifications for materials included in the specification of 'normal concrete', 'reinforcement' and 'coupler' in this tender document.

12.4.1 CONCRETE

The concrete shall be of M35 grade or as specified in the approved drawings. The minimum cement content shall be 350 kg/m^3 (including fly ash as defined in technical specifications for plain and reinforced cement concrete) and allowable slump shall be between 150mm to 180mm as specified in IS 2911 Part 1/Sec 2. The tests on concrete for piles shall be tested as per the relevant specification given in this tender. Suitable cylindrical cover blocks with center hole shall be used to maintain the specified cover as per the approved drawings. The re-steel ties used for holding cover blocks for re-steel.

12.4.2 REINFORCEMENT & COUPLERS

Reinforcement & couplers shall conform to relevant technical specifications given in this tender.

12.4.3 STABILISING MUD/BENTONITE/POLYMER

The drilling mud for stabilizing the borehole in bored piling work should have properties and quality control conforming to the requirements of IS 2911-(Part1-Sec-2). In case polymer is used, the specification and methodology for its use shall have prior approval from NPCIL.

The bentonite / polymer slurry and the cuttings, which are carried to the surface by the rising flow of the slurry, shall pass through setting tanks of adequate size to remove the sand and spoils from the slurry before the slurry is re-circulated back to the boring. The bentonite slurry mixing and re-circulation plant shall be suitably

designed and installed. The bentonite slurry shall be maintained at 1.5 m above the ground water level during boring operations and till the pile is concreted. When DMC (Direct mud circulation) or RMC (Reverse mud circulation) method is used the bentonite slurry shall be under constant circulation till start of concreting.

For tremie concreted piles, a sample of drilling fluid shall be taken from the base of the borehole by means of an approved sampling device in the first few piles and at a suitable interval of piles thereafter. The concreting operations shall not be taken up when the fluid density is more than 1.25g/ml.

After completion of piling work, area around piles shall be restored with compacted soil-cement mix after removal of bentonite slurry /muck, at no extra cost to NPCIL.

12.5 CONSTRUCTION

12.5.1 Construction of piles shall be carried out only after excavating ground up to the desired founding levels/levels as per requirement of ground improvement technique to be adopted and as per the approved drawings.

12.5.2 Pile shall be constructed by using temporary casing up to required depth as per site conditions. This is to ensure not only the stability of side soil and also to ensure good quality concrete in the entire length of pile. Adequate bentonite mud / polymer or any other suitable material (if required) may be used during the boring below temporary casing. The contractor shall ensure the stability of bore by adopting suitable combination of temporary casing pipe and bentonite/ polymer slurry for stabilization.

12.5.3 Immediately before placing of reinforcement and concreting, the bored hole shall be cleaned of all the loose material and debris. The pile tip zone shall be thoroughly cleaned by flushing the bore with fresh bentonite slurry/polymer to completely replace the old bentonite slurry / polymer used during the previous operations. This shall be carried out for about 45 minutes in two stages. Cleaning for about first 30 minutes shall be done before lowering of reinforcement cage & cleaning of about second 15 minutes after lowering the reinforcement cage.

12.5.4 The time interval between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs the pile bore shall be abandoned. However, the Engineer may allow concreting provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth and clean the pile bore.

12.5.5 The soil profile and design requirements shall dictate length of temporary casing pipe for construction purposes and shall be withdrawn during casting of the pile. The temporary guide casing shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

12.5.6 Cut-off level of the piles shall correspond to those given in the approved drawings. To ensure dense and sound concrete up to cut-off level, concreting shall extend minimum 600 mm above cut-off level. The vertical reinforcement shall project above the cut-off level as per the approved drawings.

12.5.7 In case the reinforcement cage is made up of more than one segment, the same shall be assembled by threaded couplers before lowering. Reinforcement as required shall be made into stiff cages with stiffener rings of appropriate diameter at suitable spacing to withstand handling without any damage or distortion.

Borehole shall be thoroughly cleaned to make it free from sludge or any foreign matter before lowering of reinforcement cage. The full length of reinforcement cage should be in place before start of concreting. Reinforcement shall be placed immediately after cleaning and inspection of the bottom of bore holes. The reinforcement should be supported away from the sides of the shaft by means of suitable spacer blocks to ensure concentric alignment in the shaft. Care shall be taken to preserve correct cover and alignment of reinforcement and avoid damage to it throughout the complete operation of placing concrete.

12.5.8 Concrete shall be so placed as to fill the entire volume of the tube or bore without the formation of voids caused by the faulty consolidation or entrapped air. Proper care shall be taken to ensure that the fluid alluvial soil does not penetrate the concrete.
Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS: 2911 (Part1-Sec2). Concrete shall be placed by means of tremie pipe, which will be suitably closed at bottom at the start of concreting. The tremie pipe must extend up to the bottom of the borehole at the start and may be withdrawn in sections as the level of concrete rises in the borehole; but its discharge end shall at all times be embedded in the concrete to a minimum depth of 2m. Placing of concrete should be continuous and the pile holes will be maintained full with the bentonite slurry where used throughout the concreting operation. Slurry displaced from the borehole by the concrete shall be channeled away or pumped into suitable mud pond for re-use or disposal to waste.

12.5.9 The record of volume of concrete poured in each of the piles shall be maintained. After concreting the actual quantity of concrete shall be compared with the average obtained from observations made in the case of a few piles already cast. If the actual quantity is found to be considerably less, the matter should be investigated and appropriate measures taken.

12.5.10 **Control of alignment**: Piles shall be constructed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS-2911 (part 1/Sec2).

12.5.11 **Preparation of pile head:** Before casting the piled raft, the excess concrete shall be cut off up to pile cut-off level as shown in approved drawings. In case sound concrete is not met with at such elevation the piles shall be cut up to an elevation where sound concrete is met. Care shall be taken not to damage the reinforcement or the concrete below cut off elevation during such stripping operations. Where chipping to be done to a level lower than the specified cut off elevation to obtain dense and sound concrete, the Piling Contractor shall build up the pile up to cut off elevation at his own cost.

The exposed part of concrete above the Cut off level shall be removed/chipped off and made square at cut off level not before seven days of casting of pile. The projected reinforcement above Cut off level shall be property cleaned and bent to the required shape and level to be anchored into the pile raft as shown in the drawing.

The pile top shall be embedded into the pile cap/raft by minimum 50 mm or clean cover to reinforcement, whichever is higher.

12.6 DEFECTIVE PILES

The Engineer reserves the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawing on account of load capacity, structural integrity, position, alignment, concrete quality, improper cleaning of borehole before concreting, etc. Piles that are judged defective shall be pulled out or left in place as decided by the Engineer without affecting the performance of adjacent piles. If the adjacent pile is affected, the contractor shall install additional piles to substitute the adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the EIC at no extra cost to NPCIL.

12.7 QUALITY ASSURANCE PROGRAMME

The Contractor shall submit and finalize a detailed Field Quality Assurance Program within 30 days from the date of award of the contract, according to the requirements of this specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of field quality plan, etc., the Engineer shall identify, customer hold points, on finalized field quality plan, beyond which work shall not proceed without written approval from the Engineer. The testing apparatus/equipment installed in the field laboratory shall be calibrated/ corrected by the qualified persons as per manufacturer's instructions to give accurate testing results.

12.8 RECORDING OF DATA

Daily site records shall be maintained by the Contractor for the installation of piles against each Rig and shall contain the number and dimension of the pile, depth bored, time taken for boring and concreting. Contractor shall maintain field bore log. When drilling mud /polymer is used, amount of bentonite / polymer needed for stabilization of bore, specific gravity of the fresh supply and contaminated mud in the bore hole before concreting shall be checked and recorded regularly. Record of concrete volume actually cast per pile against required volume shall be maintained. Detail of any obstruction encountered its nature, depth and obstruction time. Any deviation from the designated location alignment or load capacity of any pile shall be noted. Typical data sheet in triplicate for facility of recording piling data to be prepared by the Contractor before starting of actual piling operation at site and information to be recorded against each pile in the data sheet shall be signed by the contractor and countersigned by NPCIL. One copy of the data sheet shall be retained by the

Contractor and the other two copies to be submitted to NPCIL for records & future reference.

A full record of pile load test results shall be submitted in triplicate to the Engineer immediately on completion of each test. The record shall also include the plots of load settlement (for various stages of loads) characteristics of pile and also the interpretation of the pile load test curve as per criteria for safe loads mentioned in the specifications for testing concrete piles forming a part of this tender. Any special observations shall be duly explained by the contractor.

Contractor's competent supervisor (geotechnical engineer) shall always be present to record the necessary information during the installation of piles. The data to be recorded shall include:

1. Pile number and location
2. Existing ground level, cut-off-level and level of top of the casting
3. Nominal shaft and inside diameter of casing
4. Data and time of setting up of rig at the pile location.
5. Data and time of start of boring.
6. Length of casing driven and depths bored vs time.
7. Description and thickness of various strata bored.
8. Details of any obstructions encountered (depth from existing ground level, thickness and time taken to penetrate through the same)
9. Chiseling depth and time.
10. Final depth of boring (founding level).
11. Standard penetration test at the bottom of the bore hole, if any.
12. Date and time of completion of boring.
13. Data and time of start and completion of flashing of the bore hole with fresh Bentonite fluid before Concreting.
14. Time of lowering Reinforcement cage and tremie pipes with total length thereof.
15. Date and time of start of concreting
16. Level of concrete inside the bore hole and tremie pipes at various stages of concreting.
17. Concrete grade, mix proportion, water cement ratio and slump test results.
18. Empty boring length and concrete length below cut-off-level.
19. Results of tests on Bentonite slurry used.

Typical data sheets of recording piling data shall be as given in Appendix-D of IS: 2911(Part I/ Sec.2).

Any deviation from the designed location, alignment or load carrying capacity of any pile shall be noted and promptly reported to the Engineer..

On completion of each pile construction, pile record in triplicate shall be submitted to Engineer-in-Charge within two days of completion of concreting of the pile.

On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Engineer, to ensure that it is free from pile bore

spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of Engineer.

12.9 PILE TESTING

The contractor has to prepare work procedure for conducting the tests in line with IS/ ASTM, Technical Specification herein under and get it approved from Engineer before start of test .

Pile Load Test: Both initial and routine load tests shall be conducted for all the types of testing i.e. vertical, lateral and pull-out. The load tests shall be carried out after concrete attains full strength.

Non-destructive testing of piles: NDT of piles (Low strain integrity test, high strain dynamic testing and cross-hole sonic logging test as per ASTM codes) shall be carried out by expert team or by engaging an expert agency. The staff of the team shall have experience of carrying out these types of tests and knowledge of analyzing the data. Credentials of expert team/expert agency shall be submitted for acceptance by NPCIL.

12.9.1 PILE LOAD TEST DETAILS

12.9.1.1 General

1. For pile load tests, the test set up shall be as per relevant BIS, ASTM standards and specifications for testing of concrete piles.
2. The testing shall be done by specified method of loading in successive increments as per the relevant clauses of IS: 2911 Part 4.
3. Tests shall be carried out at the cut-off level.
4. Maximum test loads for different types of piles shall be as per the approved drawings.
5. All the piles shall be provided sonic logging tubes to carry out Cross hole Sonic Logging Test.
6. The number of tests (other Cross hole Sonic Logging Test) required shall be as approved by the engineer.
7. A method statement for all the load tests shall be submitted to NPCIL and testing shall be carried out after approval of the same.
8. The details of tests to be carried out on piles are presented below.

PILE TESTING MATRIX

Tests on Piles		
Initial Load Tests	Routine Load Tests	Non-Destructive Tests (Both Initial and Routine)
1. Vertical Load Test	1. Vertical Load Test	1. Low Strain Integrity Test
2. Lateral Load Test	2. Lateral Load Test	2. High Strain Dynamic Test
3. Uplift Load Test	3. Uplift Load Test	3. Cross Hole Sonic Logging Test

12.9.1.2 INITIAL LOAD TEST

Initial load test shall be carried out on separately cast test piles following purposes:

1. Confirmation of estimated pile capacities at founding level.
2. To provide guidelines for setting up the limits of acceptance for routine tests.
3. To confirm suitability of piling system.
4. To have a check on calculated load by dynamic or static approaches.

The number of tests to be conducted for each mode (vertical compression, pull out and lateral) and each type of pile and maximum test load shall be as per approved drawings.

The following initial load tests shall be carried out as per IS 2911(Part 4):

1. Initial vertical load test.
2. Initial lateral load test
3. Initial pull-out load test.
4. Initial vertical cyclic test

12.9.1.3 ROUTINE LOAD TEST

Routine load tests shall be carried out on job (working) piles as per approved drawings. Routine load tests shall be carried out for following purposes:

1. To confirm the safe load of the pile.
2. Checking safe load and extent of safety for the specific functional requirement of the pile at working load
3. Detection of any unusual performance contrary to the findings of the initial test, if carried out.

The following routine load tests shall be carried out as per IS 2911(Part 4):

1. Routine vertical load test.
2. Routine lateral load test
3. Routine pull-out load test.

For routine lateral load test the loading shall be continued till one and half times the safe lateral load or 5mm deflection, whichever occurs earlier.

12.9.2 RECORDING OF DATA AND PRESENTATION

12.9.2.1 The initial and routine pile load test data essentially concerns three variables, namely, load, displacement and time. These are to be recorded sequentially for the tests under consideration and recorded in a suitable tabular form along with the information about the pile.

12.9.2.2 The initial and routine pile load test data may be suitably presented by curves drawn between the variables and safe loads shown on the graphs. Load-displacement curve should be an essential part of presentation.

12.9.3 REPLACEMENT OF DEFECTIVE/ REJECTED PILES

During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Engineer, fresh bore holes are to be executed at a suitable new position, as decided by the Engineer, which may demand for resizing of pile raft including possible increase in reinforcement quantity due to resizing of pile raft. In all such cases the abandoned bore holes are to be filled up with plain cement concrete of grade M15 so that no cavity remains in the bore hole of the abandoned pile. No extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile raft including increase in reinforcement quantity will be accepted and same is deemed to be carried out by the contractor at his own cost.

Piles showing unsatisfactory results as per load tests shall be treated as defective piles. Piles/boring/casing that are defective shall be left in place/ pulled out as directed by Engineer without adversely affecting the performance of the adjacent piles. In case the hole from which pile is pulled out is abandoned, the same needs to be filled up with concrete of grade M 15 at no extra cost to NPCIL. No payment shall be made for extra expenditure incurred in constructing alternative piles and implementing the changes in the design of raft on account of change in location of piles.

12.10 NON DESTRUCTIVE TESTING OF PILES

12.10.1 LOW STRAIN PILE INTEGRITY TEST

12.10.1.1 GENERAL

Low strain Pile Integrity Test (PIT) is a non-destructive integrity test method to establish the Integrity of the pile along its length and to identify the deficiency in quality of pile, if any.
In PIT the impact shall be made using small hand held hammer. The evaluation of PIT records shall be conducted according to the Pulse-Echo (or Sonic Echo – a time domain analysis) analysis method.

12.10.1.2 TEST METHOD AND REFERENCE CODE

The test requires the impact of a small hand held hammer on the shaft top and the measurement of motion of the pile top in terms of acceleration or velocity. The input compression wave from the hammer is reflected from pile toe (or a defect) and returns to the pile top at a time related to the speed of travel of the wave in the pile material. The test shall be performed as per ASTM D 5882 "Standard Test Method for Low Strain Integrity Testing of Piles".

The pile top velocity is displayed as a function of time with an exponentially increasing magnitude where high soil friction forces are present, such that the pile toe reflection is enhanced. Several records with consistent signals should be averaged. The averaged, amplified velocity shall be standard result of the Pulse Echo Method.

12.10.1.3 **TEST EQUIPMENT**

The test should be performed using digital data acquisition equipment. The signal conditioning and power supply must have very high signal-to-noise ratios to discern the reflected signals for long piles (and/or piles in high friction soils). The analog to digital resolution shall be at least 16 bits, and the sampling frequency at least 25,000 Hz. Data should be stored such that additional processing or further wave analysis is possible. The data must be displayed in the field for evaluations of preliminary data quality and interpretation. The apparatus shall include a graphic display of velocity. The equipment & software used for test and its data processing shall be compliant with ASTM D5882. The equipment shall have a provision of display of data on the field for preliminary evaluation and interpretation and the field print out shall also be feasible. The test agency shall deploy adequate number of equipment & spares to meet contingencies and achieve the desired progress of work to meet construction schedule.

12.10.1.4 **TEST PREPARATION**

Integrity testing shall be performed after the concrete has cured for a minimum of seven (7) days. The pile head shall have sound concrete, free from water, dirt or other debris and reasonably flat surface. The concrete at the pile top surface must be relatively smooth with sufficient space for both attachment of the motion sensing device 300mm away from the center and hammer impact area at the center of the pile.

Piles for integrity testing shall be selected by NPCIL.

The projecting re-bars need to be bent outside for easy access within core region. Safe and reasonable access to the pile is the responsibility of the contractor.

The data supplied to expert test agency at the time of test shall include length of the pile from testing level, cutoff level of the pile, pile diameter and pile reference as well as location. Soil information available for the location or in the vicinity shall be provided for valuable interpretation of test results. Additional data like pile installation records, load test results etc., shall also be supplied to the test agency.

12.10.1.5 **DATA PROCESSING**

The data collected using test equipment shall be processed using compatible software. To ensure that the signals are clearly visible for interpretation, data shall be processed in terms of Magnification (MA to enhance the energy lost), reduce reflections from soil to evaluate concrete (HI PASS Filter), and reduce reflections from reinforcement (Wavelet Filter). The MA shall be a factor of the length of the pile and normally must

be equal to the pile length. The magnification delay shall be default 20% to avoid errors in interpretation.

12.10.1.6 **RESULT PRESENTATION**

The testing agency shall submit test report within 2 working days, after performing the field test, clearly indicating the result of test results and Pile Integrity evaluation and further recommendations. For each pile tested, the averaged, amplified velocity versus time record shall be included in the report, with a table summarizing results and conclusions. On completion of field testing, a report shall be submitted and shall clearly describe the following:

- Uniformity of pile changes in cross-section qualitatively i.e. bulge or defect due to necking, etc.
- Sudden changes in soil stratum based on soil profile and graphs.
- Concrete quality in terms of wave speed.

12.10.1.7 **ACCEPTANCE AND REJECTION**

The report shall clearly indicate that tested piles are acceptable or questionable or needs to be rejected. The comments shall generally be based on the following guidelines.

1. Piles with toe response and no defect apparent shall be classified as acceptable.
2. Piles with no toe response and significant reduction or defect above the pile toe shall be rejected and replacement or any other remedial action may be considered. The test engineer should specify the approximate location of defect in such a case.
3. Piles with a sudden major increase in resistance or impedance may not show toe response and are termed as inconclusive and a typical such pile can be selected for static / high strain dynamic test at the discretion of the Engineer.
4. Piles that show toe response but some impedance reduction / defect maybe under-rated / replaced / repaired / or subjected to additional high strain dynamic or static testing at the discretion of the Engineer.

Acceptance / rejection of piles in 3 and 4 above shall also be based on construction records.

Construction records (concrete usage, grout pressure records, soil borings etc.) may be valuable in result interpretations. Based on the Expert agency recommendation, the decision to either reject and replace, or repair, any defective pile shall be taken by the NPCIL and replacement / remedial measure of such piles at no extra cost to NPCIL shall be binding on Contractor.
If the pile top appears questionable, further pile top cut-off and retesting may be advisable.
If a majority of piles diagnose as "inconclusive", partial or even complete pile excavation or another test method may be necessary for pile acceptance.

12.10.1.8 **REMEDIAL ACTION**

Rejected or questionable piles may be replaced or retested (e.g., static load testing, dynamic load testing, core drilling, ultra-sonic logging, etc.) based on the test results and recommendation of expert agency and as approved by NPCIL.

Remedial action may include pressure grouting through core holes wherever feasible as approved and accepted by NPCIL at contractor's own cost. The repaired piles shall be re-tested and accepted subject to qualifying the test. The cost of such re-testing shall be borne by the contractor.

12.10.2 CROSSHOLE SONIC LOGGING (CSL) BORED CAST-IN-SITU PILES

12.10.2.1 GENERAL

CSL testing shall be performed by sending ultrasonic pulses through concrete from one probe to another (probes located in parallel tubes). The CSL procedure inspects the structural integrity of the pile concrete between the tubes, and extent and location of defects, if any.

This work shall consist of furnishing all materials, equipment and labor necessary for conducting CSL tests on drilled and cast-in-place piles (hereafter each noted as test piles). The contractor shall be responsible for conducting the test through approved expert agency, including supply of material and labour as hereinafter specified and including prior to, during, and after the load test.

CSL testing is a non-destructive quick test and it is intended that the test pile be left in a condition, suitable for use in further construction and may be used as part of structure.

12.10.2.2 TEST METHOD & REFERENCE CODE

The Pile shall be instrumented & Tested as per recommendations of ASTM 6760 "Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross hole Testing" unless noted otherwise.

Both the time between pulse generation and signal reception ("First Arrival Time" or "FAT") and the strength of the received signal give a relative measure of the quality of concrete between transmitter and receiver. Dividing the distance between transmitter and receiver by the FAT value yields the approximate concrete wave speed which also is a relative indicator of concrete quality. For equidistant tubes, uniform concrete between the test tubes yields consistent arrival times with reasonable pulse wave speed and good signal strengths. Non-uniformities such as contaminated or soft concrete, honeycombing, voids and inclusions exhibit delayed arrival times with reduced signal strength.

12.10.2.3 TEST EQUIPMENT

The Contractor shall supply all materials and equipment required to prepare the test pile and restore the pile to a condition suitable for use in the permanent structure, wherever specified by the Engineer. Equipment required to perform the test includes but is not limited to following:

Provide a Cross Hole Analyzer (CHA) manufactured by Pile Dynamics, Inc., or equivalent CSL equipment. The equipment shall have the following minimum requirements.

1. A computer based CSL data acquisition system for display of signals during data acquisition, with a minimum 12 bit A/D converter with a sampling frequency of at least 250000 Hz, and recording of all pulse signals for full analysis and individual inspection. (Note: Converting signals with low noise using high A/D resolution and sampling rates is important to obtain quality data and allow proper full data interpretation.)

2. Ultrasonic transmitter and receiver probes with probe centralizer and signal transmission cables as per ASTM6760 capable of generating pulse with a frequency between 30,000Hz to 100,000Hz with good signal amplitude and energy through good quality concrete. The probes shall be less than 30mm in diameter and shall freely descend through the full depth of properly installed sonic logging tubes of at typically less than 50 mm diameter, in the piles.

3. Two depth sensors to independently determine transmitter and receiver probe depths.

4. Triggering of the recording system time base with the transmitted ultrasonic pulse.

12.10.2.3.1 Sonic Logging Tubes:

All Piles required to be tested shall be provided with sonic tubes for sonic logging tests cast into it. The tubes shall be manufactured from mild steel tubes. To form a single tube the pipes to be connected with Bell Mouth – push fit arrangement only. PVC or any kind of plastic material is strictly prohibited due to different coefficient of thermal expansion with respect to concrete which may affect the test result. The tubes should be of 50mm Internal Diameter and 1 mm thick.

Tests to be conducted for Sonic Tubes assembly and desired results.

The Sonic Tubes assembly should be tested for following tests:

a) External Pressure Test

The minimum 50 mm inside diameter tube, minimum 1 mm wall thickness should be applied with external pressure up to 5 Mpa . Following are the desired results:

Description	Pressure in Mpa	Hold Time	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 5 MPa	>= 60 Sec	No Leakages from Inner Surface of Tubes and No Distortion of Tubes

Minimum 3 test results should be obtained.

b) Pull Out Test for Tubes

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 0.5 KN	No Distortion / Elongation of Tubes till test load of 0.5 KN.

c) Pull out test for Joint

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick, Bell Mouth – Push Fit Joint.	>= 0.5 KN	Joint should withstand the Pull out load of 0.5 KN.

d) Pull Out Test for tubes 'Fixing Ears'

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 0.5 KN	Fixing Ears should withstand the Load up to 0.5 KN.

e) Crush Test

For 50 mm diameter and 1 mm tick Tube following is the criteria for Crush test.

Sr. No.	Descriptions	Test	Desired Results
1	Direction tube	1500 mm	No Cracks After test 30 mm Steel ball can go through the tubes.
2	Drop Weight	4000 + 150/-0g	
3	Diameter of Drop	m	

12.10.2.4 CSL ACCESS TUBE PREPARATION

Every drilled shaft shall be equipped with sonic logging tubes to permit possible inspection by CSL. Drilled shafts with different diameters at the same site may require a different number of sonic logging tubes. Sufficient number of sonic logging tubes shall be installed in all the Piles (minimum 2 nos.) prior to concreting as given in the drawing based on the Pile Diameter. The Number of tubes shall be generally one tube for every 0.3m of drilled shaft diameter unless specified otherwise, but not less than 2 nos. in any case.

The number of piles to be tested by CSL shall be as specified in drawings. If not specified in the drawing, minimum 20% of the piles shall be subjected to this test or as decided by Engineer.

The parallel steel tubes shall be supported and braced securely so that they maintain their position during the subsequent operations. The splice connection of parallel pipes shall be of good quality, easy installation and proven water-tight performance having Bell-Mouth Socket system with rubber gasket joint unless mentioned and approved otherwise.

The couplings locations shall be properly recorded. Tubes shall be installed by the Contractor in a manner such that the CSL probes pass through the entire length of the tube without bending. Ensure that the sonic logging tubes are in plumb and verify that unobstructed passage of the probes is achievable.

The Sonic logging tubes shall be fitted with a watertight shoe on the bottom and a removable cap on the top. Tubes shall be secured to the interior of the reinforcement cage at regular intervals not to exceed (1.0m). Tubes shall be installed uniformly and equidistantly around the circumference such that each tube is spaced parallel for the full length and at the maximum distance possible from each adjacent tube. Tubes shall be spaced as far as possible from the main axial reinforcing steel. The bottom end of the Tubes shall be kept approx. 100 mm above the bottom of the drilled shaft , and the top end shall be at least (1.0m) above the top of the concrete of the Pile, and to at least (0.6 m), but not more than (1.5m) above the ground surface. Tubes shall not be damaged during installation of the reinforcement cage.

The tubes should preferably be filled with water prior to concrete placement, in any case it must be filled with water within at most 1 hour after placing concrete to prevent de-bonding of the sonic logging tubes from concrete, due to differential temperatures. The top of the tubes shall be capped to prevent debris from entering the sonic logging tubes. Excessive torque, hammering or other stresses which could break the bond between the tube and concrete when removing caps from the tubes shall be avoided.

12.10.2.5 TIMING OF THE CSL TEST

The pile shall be tested no sooner than seven (7) calendar days after placement of all concrete (having minimum compressive strength as 2/3rd fck) and preferably within

90 days after casting of pile. The concrete strength and quality generally increases as the concrete cures, longer wait times are usually desirable. After all CSL testing has been completed, and after acceptance of the pile by NPCIL Engineer, the Contractor shall remove the water in the tubes, place grout tubes extending to the bottom of the access tube, and fill all sonic logging tubes in the pile with cement sand grout.

12.10.2.6 PROCEDURE

Prior to CSL testing, the Contractor shall provide the expert test agency with a record of all pile lengths with elevations of the top and bottom, and installation dates of all piles. The sonic logging tubes shall be clearly labeled for identification. The CSL testing shall be performed with the transmitter and receiver probes in the same horizontal plane in parallel tubes.

Using the labeling established for the tubes, CSL testing shall be performed between all adjacent perimeter access tube pairs and across at least all major diagonals within the pile.

Probes shall be lowered from the top, effectively measuring the access tube lengths. Probes shall be pulled simultaneously, with CSL measurements taken at intervals of 50 mm or less from the bottom to the top of the pile. Defects indicated by late pulse arrival times and significantly lower amplitude/energy signals shall be immediately reported to NPCIL Engineer. The equipment used for test shall be properly maintained and calibrated.

The tests shall be repeated for each pair of tubes, i.e. three runs for a pile with three tubes and six runs for a pile with four tubes.

12.10.2.7 REPORTING OF RESULTS

A report shall be prepared for each pile tested. The photographic record of the oscilloscope displays shall be analyzed in detail. Any deviation from the record to be expected from a pile constructed entirely of sound concrete and without defect shall be reported. The report shall indicate the nature, location and severity of the defect and recommendations shall be made for further testing. The implication of the existence of the defect on the performance of the pile shall be evaluated.

Results of the CSL shall be presented in a written report within five (5) working days of completion of testing. The report shall include presentation of CSL logs for all tested tube pairs including:

1. Presentation of the traditional nested signal peak (e.g. “waterfall”) diagram as a function of time plotted versus depth.
2. Computed pulse first arrival time (FAT) or pulse wave speed versus depth.
3. Computed relative pulse energy or amplitude versus depth.

A CSL log shall be presented for each tube pair. The rating of the shaft integrity considers the increases in "first arrival time" (FAT) and the energy reduction relative to the arrival time or energy in a nearby zone of good concrete. Pile is classified as satisfactory/ good provided the evaluation criteria for FAT increase and energy reduction are met. Pile is classified as having minor defect or poor concrete if either evaluation criteria of FAT increase or energy reduction are met. The criteria for evaluation of the concrete from the CSL test are given below.

Pile Classification	FAT Increase relative to good concrete	Energy reduction relative to good concrete
Satisfactory / Good	0-10%	<6 db
Minor Defect	11-20%	<9 db
Poor/Flaw	21 to 30%	<9 to 12
Poor/Defect	>31%	>12

Flaws must be addressed if they affect more than 50% of the profiles. Defects must be addressed if they affect more than one profile (a profile is the result of complete investigation from bottom to top between two tubes) at the same cross section. Flaws or Defects covering the entire cross section define a full layer concern requiring repair.

Immediately after testing, a signed copy of all the raw test data of a pile shall be handed over to the Engineer.

The piles with anomalous sonic logging results shall be rejected at the Engineer's discretion unless the contractor is able to demonstrate that the pile integrity is acceptable through proof coring.

12.10.3 HIGH-STRAIN DYNAMIC TESTING OF BORED CAST-IN-SITU PILES

12.10.3.1 GENERAL

High-strain dynamic testing shall be performed by obtaining and analyzing the records of pile force and velocity under drop weight impacts for evaluations of pile load carrying capacity, structural integrity, and load-movement and pile-soil load transfer relationships.

This work shall consist of furnishing all materials, equipment and labor necessary for conducting high-strain dynamic tests on bored cast-in-place piles (hereafter each noted as test piles). The contractor shall be responsible for conducting the test, including supply of material and labor as specified and including prior to, during, and after the load test.

High-strain dynamic testing is a non-destructive quick test and it is intended that the test pile be left in a condition, suitable for use in further construction and may be used as part of structure.

12.10.3.2 **TEST METHOD & REFERENCE CODE**

The Pile shall be instrumented & Tested as per recommendations of ASTM D 4945 'Standard Method of test for High Strain Dynamic Testing of Piles' unless noted otherwise.

12.10.3.3 **EQUIPMENT**

The test shall be conducted by the contractor through an approved expert agency. The Contractor shall supply all materials and equipment required to prepare the test Pile, dynamically load the Pile, and restores the pile to a condition suitable for use in the permanent structure, wherever specified by the Engineer. The test shall be conducted using Pile Driving Analyzer (PDA) to obtain and analyze the records of force and velocity under drop weight impacts. The field results shall be further analyzed with a signal matching technique such as CAPWAP (Case Pile Wave Analysis Program) or equivalent to refine the soil parameter assumptions.

In case of uncased pile – The Pile top shall be extended using a thin walled casing or equivalent, by a length equal to two pile diameters unless specified otherwise. This top length, shall be defined as the "test area" must be exposed and ready for test. Wherever the Pile top is below grade, the Contractor must remove surrounding soil (creating a safe working environment) so as to completely expose a test area of the Pile suitable for conducting the test to the satisfaction of expert agency engaged for the test. Windows on four opposite sides of the Pile have to be cut off in the steel casing to reach the concrete. The size of the windows shall be as suiting to the requirements of test agency and as approved by the NPCIL Engineer.

The pile top concrete shall be leveled above the casing. A drop weight shall be in the range of one to two percent (1 - 2%) of the anticipated pile capacity, or as determined by the expert agency and approved by the Engineer. A guide allowing variable drop heights typically between 3 and 13 ft (1 to 4 m), or as determined by the expert agency and approved by the Engineer shall be used for test.

Pile top cushion shall consist of new sheets of plywood with total thickness between 2 to 6 inches (50 to 150 mm), or as determined by the expert agency and approved by the Engineer.
A steel striker plate with a thickness of at least 2 inches (50 mm) and an area between 70 to 90% of Pile top area but not less than the area of the impacting surface of the drop weight to be placed on top of the plywood cushion.

Surveyors' transit, laser light, or equivalent for measurements of pile set under each impact.

12.10.3.4 **PROCEDURE**

a) The test Pile shall be constructed using the approved installation techniques.

b) If a permanent casing is not required, then the upper length equal to two Pile diameters, noted as the "test area", must be cased in a thin wall tube. Casing of this test area must be made as a continuation of the construction of the Pile.

c) Wherever, reinforcing bars are protruding out, the same shall either be encased within the concrete in the test area and on successful completion of the dynamic test, the surrounding concrete can then be removed to expose the bars using the same suitable for further construction, or a steel beam or pipe (cross sectional area approximately 20% of the Pile cross sectional area) shall be supplied with sufficient length such that the ram impact will not interfere with the reinforcing bars. Steel striker plates and plywood cushion must also be sized so that they cover as much of the impact area as possible. However, either of the above option shall be finalized in consultation with expert test agency with the prior approval of NPCIL Engineer.

d) There should not be any soil contamination or non-uniformities in the concrete located within or below the test area. Pile top shall be made level to the casing and smoothed.

e) Prior to testing time, the Contractor shall make the Pile test area length completely accessible to the suit the test.

f) Prior to the test four "windows" (approximate size of 6 by 6 inches (150 by 150 mm) diametrically opposite of each other shall be located and removed from the casing.

g) In cases where casing is not present, the circumferential area where transducer is to be fixed, shall be smoothened by grinding.

h) Gauges shall be attached to the exposed concrete or steel casing in a secure manner as to prevent slippage under impact.

i) Pile top should be examined to ensure that the concrete top is flush with or above the casing in any case it should not be below the casing level.

j) Apply plywood cushion and then striker plate to the Pile top.

k) At least two (2) hammer impacts should be applied to the pile top. First drop height should be minimal to assess the testing equipment, the driving system and pile stresses. Subsequent impacts can then be applied by utilizing higher drop heights.

l) Upon completion of the test, it is the Contractors' responsibility to return the pile to acceptable condition in a manner that the same can be used as part of structure.

12.10.3.5 **REPORTING OF RESULTS**

The Expert Agency shall submit a report of the field test results with its finding. In addition to the field results, results from at least one (1) set of wave equation analysis using CAPWAP or equivalent shall be submitted. The analysis shall be performed by same expert agency involved in the testing. The report must also provide the following:

1. Wave Equation analysis results obtained prior to testing.
2. Wave equation analysis results with a match quality preferably up to 5. If match quality is less than 5, reasons must be outlined for the same before acceptance by NPCIL.
3. For each impact, the maximum measured force, maximum calculated tension force, energy transferred to the gauge location, corresponding stresses, and the bearing capacity shall be tabulated.
4. Assessment of the test results both with respect to pile capacity and integrity.

The output from the test result shall provide:

a) Static capacity of the pile at the time of testing.
b) Simulated static load test curve
c) Total skin friction and end bearing of the pile
d) Skin friction distribution along the length of the pile
e) Compressive and tensile stresses developed in the pile during testing
f) Net and total displacement of the pile.
g) Pile integrity

12.10.4 EXPERT AGENCY TO PERFORM THE NDT ON PILES

The testing method and interpretation requires expertise and through understanding of wave mechanics. The agency employed for testing shall prove its competency by submitting previous reliability studies between static and high strain dynamic tests.

Contractor shall engage an Expert Agency of national repute and shall be approved by the NPCIL, to conduct the test. The Expert Agency shall be specialist having minimum of 5 years of experience in low & high strain integrity testing as well as sonic logging testing of the piles. The expert agency shall have sound knowledge of Wave Theory used for analyzing and interpretation of test results and at least performed minimum 5 nos. of correlation studies of Dynamic Pile Load Testing with conventional load test in various strata covering friction piles. The results of the correlation studies should have been accepted by the owners of the project, for whom tests were performed. Demonstration of case studies/correlation between CSL and HSDPT or PIT will be preferred. Performance certificates for completed projects shall be submitted.
The Expert Agency is required to perform wave equation analyses (using CAPWAP or equivalent) to determine the suitability of the proposed dynamic loading equipment and an acceptable range of ram drop heights so as not to cause damage in the pile

during the test. Performance certificates for completed projects shall be submitted. CV of the personnel carrying the test shall be submitted before performing the test.

The expert agency must possess, the following testing instrumentation in addition to that outlined in ASTM D 4945 Section 5: and other ASTM, in order to meet the project schedule and to maintain the redundancy. The test agency shall deploy adequate number of equipment & spares to meet contingencies and achieve the desired progress of work to meet construction schedule.

1. Pile Driving Analyzer (PDA)
2. Pile Integrity Testing Equipment.
3. Cross Hole Testing Equipment for Sonic Logging.
4. Required nos. of calibrated strain transducers.
5. Required nos. of calibrated accelerometers.

All other test equipment required for to conduct the above tests. The equipment and sensors shall be properly calibrated and the testing agency shall be able to obtain the calibration certificates upon request or prove the internal calibration of the system on site.

The Expert Agency shall study the Bore Log Data applicable to the test location, prior to perform the dynamic test, Pile installation records, concrete properties (strength, etc.) and submit the details regarding the anticipated dynamic loading equipment.

13 GROUT/ DRY PACK

13.0 General

Grout / Dry Pack shall be provided as specified on the drawings. The proportion of Grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage.

Concrete surfaces to be grouted / dry packed shall be thoroughly roughened and cleaned of all foreign matter and laitance. Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot strong caustic solution for this purpose may be permitted.

Prior to grouting/dry packing, the hardened concrete surfaces shall be saturated with water.

Forms around base plates shall be reasonably tight to prevent leakage of grout/dry pack. Adequate clearance shall be provided between formwork and base plate, to permit grout/ dry pack to be worked properly into place.

Grouting, once started, shall be done expeditiously and continuously to prevent segregation, bleeding and within the initial setting time. Grout shall be worked from one side to the other, to prevent entrapment of air.

Water in anchor bolt holes shall be removed before grouting is started.

Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least 24 hours after placing the grout. After the removal of forms and peripheral shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least after a minimum of seven days from the date of grouting. During this period, the grout shall be properly cured.

13.1 Dry Pack

The dry pack shall consist of 1:2.5 (Cement: Sand), sand passing through 1.18 mm square hole opening standard sieve. Only enough water shall be added to produce a mortar, which will stick together when moulded into a ball by a slight pressure of hand and will not extrude water but will leave the hands just damp. Dry pack material shall be placed and packed in layers having a compacted thickness of about 10mm. Each layer shall be solidly compacted over the entire surface by use of hardwood stick and hammer. Sand for this job shall be as pure as specified for concrete making.

13.2 Grout

13.2.1 Normal Grout

The contractor shall supply and place normal grout consisting of an approved mixture of cement, normal fine aggregate, water, admixture and when specified by the Engineer, a non-shrink agent. Normal grout shall be placed as shown on the drawings or specified by the Engineer.

Grouting through holes in base plates shall be, by pressure grouting. The pressure to be used for grouting shall be as directed by the engineer. The grout proportions shall be as follows:

Mix proportion	**W/C Ratio(max)**
Mix 1:1 Cement: Sand grout with anti shrink compound	0.44
Mix 1:2 Cement: Sand grout with anti shrink compound	0.44
Mix 1:1:2 cement: sand with 6mm down stone chips and anti shrink compound	0.44

Note: If the requirement arises, mixes other than the specified above, such as mix 1:1.5, 1:1.75, 1:2.25 etc. shall be used with the approval of the Engineer.

The W/C ratio shall be as per the manufacturer’s recommendation and in no case shall exceed the values specified above.

13.3 Inspection

All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Engineer

All materials supplied by Contractor and all works or construction performed by Contractor and rejected - as not in conformity with the specifications and drawings - shall be immediately replaced at no additional expense to NPCIL.

Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying grouting materials and or producing finished grout in accordance with the specifications and drawings.

All grouting shall be protected against damage until final acceptance by NPCIL or his representative.

Upon the completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

13.4 GROUT / DRY PACK FOR EQUIPMENT BASES

13.4.1 SCOPE

Scope of work covered in this specification includes supply and place normal free flow grout / dry pack at all places below equipment base plate, structural steel base plates / bearing plates, anchor bolts, pockets and other areas. Normal cement sand grout in various proportions with anti-shrink compound, non-shrink cementitious precision grout and dry pack with cement sand in proportion of 1: 2.5 are included in this specification.

13.4.2 GENERAL

13.4.2.1 Grout/ Dry Pack shall be provided as specified in the drawings. The proportion of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage.

13.4.2.2 Concrete surfaces to be grouted/ dry packed shall be thoroughly roughened and cleaned of all foreign matter and laitance. Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material.

13.4.2.3 Prior to grouting/ dry packing the hardened concrete surfaces shall be saturated with water.

13.4.2.4 Forms around base plates shall be reasonably tight to prevent leakage of grout/ dry pack. Adequate clearance shall be provided between formwork and base plate, to permit grout/ dry pack to be worked properly into the place.

13.4.2.5 Grouting, once started, shall be done expeditiously and continuously to prevent segregation, bleeding and within the initial setting time. Grout shall be worked from one side to the other, to prevent entrapment of air.

13.4.2.6 Water in anchor bolt holes shall be removed before grouting is started.

13.4.2.7 Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least 24 hours after placing the grout. After the removal of forms and peripheral shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least after a minimum of seven days from the date of grouting. During this period, the grout shall be properly cured.

13.4.3 DRY PACK

The dry pack shall consist of cement and sand in proportion of 1: 2.5. Sand passing through 1.18 mm square hole opening standard sieve shall be used in the dry pack. Only enough water shall be added to produce a mortar, which will stick together when molded into a ball by a slight pressure of hand and will not extrude water but will leave the hands just damp. Dry pack material shall be placed and packed in layers having compacted thickness of about 10 mm. Each layer shall be solidly compacted over the entire surface by use of hardwood stick and hammer. Sand for this job shall be as pure as specified for concrete work.

In case of heavy cement sand dry pack, heavy sand shall be used in place of normal sand.

13.4.4 NORMAL GROUT

13.4.4.1 The Contractor shall supply and place normal grout consisting of an approved mixture of cement, normal fine aggregate, water, admixture and when specified by the Engineer, a non-shrink agent. Normal grout shall be placed as shown in the drawings or as specified by the Engineer.

13.4.4.2 Grouting through holes in base plates shall be by pressure grouting. The pressure to be used for grouting shall be as directed by the Engineer. The grout proportions shall be as follows:

Mix Proportion		**W/C Ratio (Max)**
Mix 1:1	Cement: Sand with anti-shrink compound	0.44
Mix 1:2	Cement: Sand with anti-shrink compound	0.44
Mix 1:1:2	Cement: Sand with 6mm down stone chips and Anti-shrink compound	0.44

NOTE:

1. If the requirement arises, mixes other than the specified above, such as mix 1:1.5, 1:1.75, 1:2.25, etc. shall be used with approval of the Engineer.
2. The W/C ratio shall be as per the direction of Engineer and in no case shall exceed the values specified above.

13.4.5 NON-SHRINK CEMENTITIOUS PRECISION GROUT

Powdered non-shrink, high strength, free flow cementitious grout complying with the requirements of ASTM C348 & C109 that expands in two stages to counteract the plastic as well as the drying shrinkage normally associated with cement grouts. Mix proportion shall be as per manufacturer's recommendations. The compressive strength of the grout at optimum W/C ratio recommended by Manufacturer shall not be lesser than 55MPa, 65MPa & 75 MPa at 3days, 7days and 28 days respectively. It shall also possess following properties:

Property	**Acceptable Limit**	**Test Method**
Workability	Flowablility:	ASTM C 230
	Instantaneous, 240mm	
	After 20 mm, 220mm	
Setting Time	Initial Set, 4Hrs	IS 4031(Pt-5)
	Final Set, 5hrs	
Compressive Strength, 28 days	75 MPa	ASTM C 109
Tensile Strength, 28 days	8.1 MPa	ASTM C 1107
Flexural Strength, 28 days	9 MPa	ASTM C 378
Coefficient of Thermal Expansion	$11X\ 10^{-6}$ / ^{0}C	
Expansion in Plastic Stage	1.25%	ASTM C 940
Shrinkage	Nil	
Pullout Bond Strength	>17MPa	ASTM D4541

13.4.6 INSPECTION

13.4.6.1 All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer**.** Grout material shall be tested for cube compressive strength both for pre-qualifications and batch qualifications at no extra cost to NPCIL. No material exceeding the shelf life will be used and all such material shall be immediately removed from site.

13.4.6.2 All Materials supplied by the Contractor and all works or construction performed by the Contractor and rejected – as not in conformity with the specifications and drawings shall be replaced at no extra cost to NPCIL**.**

13.4.6.3 Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying grouting materials and or producing finished grout in accordance with the specifications and drawings**.**

13.4.6.4 All grouting shall be protected against damage until final acceptance by the NPCIL representative.

13.4.6.5 Upon completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

14 INJECTION GROUTING

14.0 SCOPE

14.0.1 The Scope of work covered under this specification is injection grouting at the following locations:

a) Where required impermeability of concrete is not achieved.

b) Where defective concrete is suspected and observed.

c) Where water seepage is observed.

d) Construction joints for all underground basements

e) Any other location specified in the drawing or as directed by the Engineer

14.0.2 The Grouting shall be carried out at specified locations as shown in the drawing or as directed by the Engineer

14.1 GENERAL

The injection grouting shall be carried out either through threaded GI nozzles of suitable length fixed in the area to be grouted or through non-return packer type nozzles either installed in the existing GI nozzles or in drilled holes. The nozzle length and spacing shall be as specified in the drawing or as directed by the Engineer. The diameter of the nozzle shall be as per site conditions and generally 16/12 mm diameter may be adopted for cement grouts (without non return valve) and 12 mm diameter (with non-return valve) for epoxy and polyurethane based hydrophilic grouting. The entire scheme shall be duly approved by the Engineer before commencing the work.

14.2 MATERIALS

The grouting material shall be epoxy, cement based with non-shrink additive or polyurethane based hydrophilic material as specified in the drawings, specifications

or as directed by the Engineer as per site conditions.

14.3 EPOXY GROUT

14.3.1 The epoxy grout shall comprise of an injectable solvent free, aggregate free, ultralow viscosity, free flowing, two-component epoxy injection resins, which shall be pumped through the nozzles (fixed prior to concreting or drilled after concreting) under pressure and rapidly cure to a high strength material. It shall comply with ASTM C-881-1987 Type I–Grade I Class (B+C) & class F as applicable. It shall be suitable for application in both dry and damp conditions,

14.3.2 The Generic name 'epoxy resin' covers a very diverse range of chemically and physically different polymers. To achieve durable repairs, careful selection of the resin composition appropriate to the application and service condition is essential.

14.3.3 The Proposed resin injection system is required to have following characteristics. The material shall comply with the requirement of ASTM C 881 Type I Grade I Class (B+C) & class F as applicable.

f) It should be two component (resin/hardener), low viscosity, solvent free, aggregate free, injection liquid based on high strength epoxy resin and suitable for deep impregnation. The epoxy and hardener system shall be able to cure in moist/wet conditions also.

g) It should rapidly cure to a high strength, shrinkage free hardening and without embrittlement.

h) It shall possess anti corrosion property, good adhesiveness and bond with the concrete with adhesive strength both under dry and damp conditions and should be capable for use under extreme ambient conditions and remain fluid during applications.

14.3.4 The proposed resin to be used shall be of two parts preferably supplied in different containers according to the manufacturers recommended proportions indicating identifications such as base hardener, recommended proportion, batch number, shelf life, date of manufacturing, grade, type, class, quantity, etc. Each batch shall invariably carry test certificates as per table 14.1 for tests conducted in NPCIL approved laboratory. The Engineer may at his discretion, appoint his representative to witness these tests at the laboratory. No separate payment will be made for testing. The chemical composition of epoxy resin constituent of component 'A' shall have an epoxy equivalent of 160-275 g/g mole and physical requirements shall be in line with ASTM C-881. A sample of proposed material intended to be used shall be supplied by the Contractor to the Engineer to verify the required parameters. The material shall be generally used within six months from the date of manufacture or date of expiry whichever is earlier.

TABLE - 14.1

LIST OF TESTS TO BE CONDUCTED AS PER ASTM C-881

SI. No	Property	Tested as per ASTM No.	Requirement
1.	Viscosity	D – 2393	2* poise (Max)
2.	Bond Strength		
	2 days (moist cured)	C – 882	10 N/mm^2 (Min)
	14 days (moist cured)	C – 882	14N/mm^2 (Min)
3.	Water Absorption (24 hours)	D – 570	1.0% (Max)
4.	Compressive strength 7 days	D – 695	70N/mm^2 (Min)
5.	Tensile strength 7 days	D – 638	50 N/mm^2 (Min)
6.	Flexural Strength	D – 638	55N/mm^2 (Min)
7.	Full Chemical Cure	7 days at 20 ^{0}C	
8.	Slant Shear Bond Strength 7 days	C-881	18N/mm^2 (Min)
9.	VOC Content	ISO11890-2	<1.5%
10.	Elongation at break	D638	2% (Min)

* Please note that requirement of viscosity is in variance with ASTM C-881.

14.4 CEMENT BASED GROUT

14.4.1 CEMENT AND WATER

The cement shall be Ordinary Portland Cement 43 Grade conforming to IS 8112. It shall be mixed with water to achieve required consistency for pumping. The quality standards of water to be used shall be same as that of RCC works.

14.4.2 ADMIXTURES

To achieve high consistency with low water cement ratio of around 0.3, suitable water reducing admixture as approved by the Engineer may be used. Suitable anti shrinkage compound shall be added in the mix if specified or as directed by the Engineer.

Proportion of cement & water shall be as directed by the Engineer. Quantity of admixture and type of mixing shall be as per manufacturer's instructions. Compatibility of admixture with the type of cement used shall be ascertained before

use of any admixture with cement.

Typically the properties of the resulting mix shall exhibit the following properties:

PROPERTY	ACCEPTANCE VALUE	TEST METHOD
Flow Cone test using Marsh Cone	23 secs at mix time	ASTM C 939
	34 secs after ½ hr	
	39 secs after 1 hr	
Specific Gravity	2.06	ASTM C 939
Setting time using Vicat's Apparatus	4 hrs for Initial Set	ASTM C 939
	5Hrs for Final Set	
Expansion	500 µm/m	ASTM C 878
Bleed Water	0.16%	ASTM C 232
Water Retention	96%	ASTM C 91

14.5 POLYURETHENE BASED HYDROPHILLIC GROUT

The material shall be one component high grade, low viscosity polyurethane injection foam resin which expands its volume to cure to very dense foam upon contact with water. This material shall be used to arrest excessive seepage of water through the concrete. Approval of the Engineer shall be obtained for the material, before use. The typical properties of the low viscosity polyurethane grouts are as follows:

PROPERTY	**ACCEPTANCE VALUES**
Density (at 20 ^{0}C)	1.16
Viscosity (at 23 ^{0}C)	320 mPa.s
Flash Point	180 ^{0}C
Application Temperature	+5 ^{0}C to 40 ^{0}C
Max foam expansion rate@10% accelerator dosage	25-30

14.6 GROUTING OPERATIONS

Grouting operations shall normally begin after six weeks of the last concrete poured. A high-speed mechanical mixer shall be used to mix the epoxy grout as per manufacturer's recommendation. The grouting shall be done by using hand pump and pressure will be decided based upon the nature of work and grade of concrete, or as directed by the Engineer. The grouting range can be achieved by injecting the grout with initial low pressure proceeding further with increasing pressure gradually. Slow and steady increase in pressure shall be followed to produce uniform impregnation of the zone under treatment. The injection pump shall be connected to the lowest tube and the injection allowed to proceed at gradually increasing pressures until grout appears at the adjacent/higher point or refusal of further grout entry at the operating pressure. Cement grouting shall be done normally starting with lean mix and slowly increasing the richness of mix. Cubes shall be cast to test the strength of the cement grout as directed by the Engineer. After successful completion of grouting the nozzles shall be cut and ground properly and finished with dry packing. Wherever specified in

the drawing, Contractor has to make suitable arrangements for placement of nozzles prior to concreting for its rigidity, thoroughness etc. complete with or without piercing through formwork. Contractor has to arrange adequate equipment/ manpower required for the work to carryout grouting in different areas simultaneously. Contractor at his cost may appoint a specialized agency to carry out grouting works. Detailed procedure of grouting shall be prepared by the Contractor and submitted to the Engineer for approval before commencement of work.

14.7 GROUTING AROUND PENETRATION EPs HAVING DIAMETER ABOVE 300 MM

Grouting is required to be done around penetration EPs having diameter above 300 mm and some special EPs. Procedure for grouting shall be generally same as above with the grouting pressure not exceeding the specified value in the drawing. The nozzles for grouting may be placed prior to concreting and the length and diameter of the nozzles shall be as given in the drawing.

15 CAULKING AND SEALANTS AROUND PENETRATIONS

15.0 SCOPE OF WORK

Scope of work covered under this specification is caulking of expansion joints, around embedded parts, penetrations and construction joints at various locations in all buildings as shown in the drawings and as directed by the Engineer.

- Caulking and sealing around penetrations.

15.1 MATERIAL

15.1.1 Polysuphide sealing compound shall conform to BS: 4254 and PP-M-400.

15.1.2 Epoxy quartz sand caulking compound shall be as per manufacturer's specifications.

15.1.3 Bituminous sealing compound (bitumen-polymer cold mastic) conforming to IS:1834-1984 Grade-B (working temperature 155°C to 165°C and density of 1200 kg/cu.m).

15.2 DESCRIPTION

Before proceeding with caulking, the grooves shall be cleaned for dirt, dust and grease if any. The grooves shall be finished to line and level.

15.3 CAULKING WITH POLYSULPHIDE SEALING COMPOUND

15.3.1 GENERAL

The work to be done under this specification covers the supply and applying of caulking polysulphide base sealing compounds and primer, all in accordance with the

requirements of this specification together with PP-M-400. Installation of the material will be done by the Contractor as per drawing, specification and direction of Engineer.

15.3.2 REFERENCES

ASA	:	116-1
ASTM	:	D676-59T
ASTM	:	1191-52
TTS	:	227 b
ASTM	:	E42-69
BS	:	4254
PP-M-400	:	NPCIL Specifications.

Wherever, this specification is at variance with the requirements mentioned in the above references, this specification shall govern.

15.4 DESCRIPTION

Materials covered under this specification are two-package system consisting of polysulphide base compound and an accelerator compound. The compounds shall be stable separately and when properly mixed, convert to a rubber like solid, which meets the requirements specified herein. The selection of base polymers, fillers and other components shall be optional with supplier, but shall be suitable for the application intended. Properties of base polymer should be similar to Thiokol and have low molecular weight. The consistency of the compound should be plastic.

15.5 INTENDED USE

The sealing compound is proposed to be used for caulking construction joints in RCC walls, slabs and expansion joints. The caulking may also be required around some embedded parts and concrete hatch covers. Size of 'V' groove to be caulked in construction may vary in size from 12 mm X 12 mm to 25 mm X 40 mm while the rectangular gap to be caulked in expansion joints may vary from 25 mm X 10 mm to 75 mm X 10 mm thick. The sizes given above are approximate only and intended to give general idea of work involved.

15.6 CLASSES OF MATERIAL

The sealing compound shall be applied in two classes as follows:

a) Class-A (Self-Leveling): shall be compound which when properly accelerated has sufficient flow to give a smooth level surface when applied in horizontal joints at ambient temperatures between 40°F & 120°F. The compound should also permit its application in joints sloped up to 1:10.

b) Class-B (Non-Sag): shall be compound which when properly mixed permits

application in vertical joints, without sagging at ambient temperatures between 40°F & 120°F.

15.7 COLOUR

The sealing compound may be supplied in any colour as agreed upon by the supplier and NPCIL.

15.8 MATERIAL REQUIREMENTS

Application life: A properly mixed compound shall be suitable for satisfactory application for at least 4 hours when maintained at a temperature of 77° ±2°F and relative humidity of 50% ±5%. It shall also be suitable for at least 1 hour when at a temperature of 110°F.

Stability: The base compound and accelerator in original unopened containers shall be stable for at least one year from the time of delivery when stored at a temperature not exceeding 110°F. When tested at the end of one year after the time of delivery, the compound shall meet the requirements specified herein.

Temp. Range performance: Continuous exposure 40 to 175°F
Continuous exposure 40 to 250°F

Recovery: The test assemblies shall be prepared and tested in accordance with ASA 116.1. The recovery of the compound in the test joint shall not be less than 25% within 1 hour at a temperature of 77°±2°F.

Resistance to crazing: The surface of compound of test panel prepared and tested in accordance with ASA 116.1 shall not craze more than 3 mils in depth.

Staining of concrete and masonry: The staining test shall be conducted on a test mortar in accordance with ASA 116.1 and there shall be no staining on the test mortar within 14 days. Staining on the test mortar indicates that the sealant is capable of staining.

Specific gravity: 1.6 to 1.7.

Toxicity: Safe lead content should not exceed 5%.

Properties required for Class A Compounds:

Hardness, Tensile Strength and Elongation

	Shore A Hardness	**Minimum Tensile Strength psi**	**Minimum Elongation %**
Original	35 ± 2	200	350
72 hrs. at 250°F	55 ± 3	325	150

Hardness shall be tested in accordance with ASTM D 676-59T, Tensile strength according to ASA 116.1 and Elongation according to ASTM 1191-.52.

Properties required for Class B compounds:

Sag: When tested in accordance with federal specification no. TTS-227b on a bead of ½" x ¾" there shall be no sag.

Hardness, Tensile Strength and Elongation:

	Shore A Hardness	**Min. Tensile Strength psi**	**Minimum Elongation %**
Original	22 ± 3	40	420
72 hrs. at 220°F	18	48	450
24 hrs. at 30°F	-	> 100	450

The testing method for these properties shall be same as specified for Class 'A' compounds.

Cohesive Strength: Surface-to-Surface Bond

	Aluminium	**Glass**	**Steel**	**Concrete**
Tensile (psi)	45	30	23	45
Elongation (%)	375	350	270	360

Cohesive strength shall be tested in accordance with ASTM 1191-52.

Durability:

Hours in weather-meter	**Equivalent in years**	**Shore A Hardness**	**Elongation %**
1440	5 years	23	340
2880	10 years	28	260

Durability shall be tested in accordance with ASMT E42-69.

The sealing compound shall be supplied separately in two parts the accelerator and the base compound. The quantities of the two component packs shall be such that when mixed they would readily produce the compound ready for application, giving the best performance.

15.9 CAULKING WITH EPOXY MORTAR

Epoxy mortar consists of epoxy resin and hardener mixed with quartz sand in the proportions as recommended by the manufacturer. The epoxy mortar shall be mixed thoroughly and shall be caulked in grooves. Epoxy primer consisting of epoxy resin and hardener without quartz sand shall be mixed as per the manufactures

recommendations and applied on the concrete surface prior to caulking of the epoxy compound. The top surface shall be finished smooth using trowel. It should be ensured that only such quantity is mixed which can be consumed before setting.

15.10 CAULKING WITH BITUMINOUS SEALANT

The joints shall be cleaned thoroughly and made free of debris. The bitumen based primer as per manufacturer's recommendations shall be cold applied prior to caulking with bituminous sealing compound, which shall then be hot applied. Care shall be taken that the working temperature of the sealant shall not exceed 155^0 to165^0 C since overheating of the sealant may lead to loss of its properties.

TABLE 15.1
PROPERTIES OF BITUMASTIC SEALANT

SI. No.	Characteristic	Unit	Characteristic Value
1.	Adhesion • To iron • To galvanized iron • To concrete (dry surface) • To concrete (hot humid surface)	MPa	 1.0 0.6 0.8 0.6
2.	Length development at breaking	%	>700
3.	Thermal stability	°C	110

All the sealant materials must be durable and retain their physical and mechanical characteristics and properties during its entire service life.

15.11 PROCEDURE

Before proceeding with the work, a detailed procedure shall be prepared by Contractor and submitted to the Engineer for approval. The materials shall be tested in approved test houses and each batch shall accompany with test certificates. Engineer may at his discretion, appoint his representative to witness these tests. Contractor shall also supply samples of materials to the Engineer for verification of specifications. No separate payment will be made for testing and supply of samples for testing/ verification.

All the sealant materials must be accompanied by following test certificates.

a) Chemical composition of the material
b) Compliance certificate
c) Fire-safety certificate
d) Certificate for health safety
e) Work instructions for usage

15.12 INSPECTION

15.12.1 All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer. Caulking material shall be tested for specified properties at no extra cost to NPCIL. No material exceeding the shelf life will be used and all such material shall be immediately removed from site.

15.12.2 All materials supplied by the Contractor and all works or construction performed by the Contractor and rejected – as not in conformity with the specifications and drawings shall be replaced at no extra cost to NPCIL.

15.12.3 Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying caulking materials and or producing finished caulking in accordance with the specifications and drawings.

15.12.4 All caulking shall be protected against damage until final acceptance by the NPCIL representative.

15.12.5 Upon completion of caulking work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

16 STRUCTURAL STEEL & EMBEDDED PARTS

16.0 SCOPE

This specification covers the technical requirements for supply of all steel items required for the work as per drawings including design of connections, preparation of fabrication drawings, fabrication, inspection, testing and painting after necessary surface preparation, transporting and erection at site at desired location of:

a) Main Structural Steelwork
b) Miscellaneous structural steelwork
c) Embedded parts (Standard/ Non-standard EPs)

The specifications given below are a general guideline and reference shall be made to PC-E-160 for detailed specifications and requirements on Embedded Parts. Additional requirements for fabrication and erection of critical and important Embedded Parts which are over and above these specifications are covered in NPCIL Specification PC-E-00034.

All the works shall be carried as per approved QA procedures.

16.1 MAIN STRUCTURAL STEEL

a) Beams, girders, monorails made of rolled section and / or rolled sections with cover plates, and/or compound girders, and/or plate girders, and / or box type sections.

b) Columns made of rolled sections with or without cover plates and / or compound sections battened / laced and / or built up sections from plates with or without grinding at ends and at splice locations,

c) Roof structure such as roof trusses, purlins, bracings, etc.

d) Base plates for columns including grinding (where specified) on top of base plates and underside of column shafts.

e) Any other item of structural steel framing, though not specifically mentioned but required for the building(s).

f) Sheet metal work of minimum 0.8mm thick.

g) Floor rails of IRST 18 grade.

h) Any other structures as shown in the drawings for fabrication

i) Rail section

16.2 MISCELLANEOUS STEELWORK

a) Platforms and walkways with chequered plates / gratings.

b) Ladders with or without cages.

c) Handrails.

d) Miscellaneous equipment supports, rails for equipment movement and their associated connections.

e) Steel enclosures for equipment or electrical instrument panels, rooms etc.

f) Any other miscellaneous structures shown in the drawings for fabrication.

16.3 EMBEDDED PARTS

16.3.1 GENERAL FUNCTION AND DESCRIPTION

Embedded Parts (EPs) are any structural member, angles, channels, plates, pipe sleeves etc. cast in the concrete and used to transmit the load from attachment to concrete structure. Eps fall into following two categories.

(i) Penetration Eps are opening through the concrete structure for the passage of process piping, ducts and cables, materials and personnel.

(ii) Non penetration Eps are used primarily as a means of supporting items such as piping, cable trays, ducts, equipment and platforms to the concrete structure or for edge preparation of concrete.

Penetration and non-penetration EPs are of different types and their descriptions are given below.

(a) Plate EPS

Plate Eps are used to support piping, cable tray, ladders and equipment. A typical plate EP consists of a plate and anchorage welded to it. Component supports can directly be welded or bolted to these EPS.

(b) Pipe Sleeves

Theses EPs are used for passage of piping, cables etc. from one side of concrete structure to other side. Pipe sleeve Eps consists of a pipe and one or more puddle flanges, provided through the length of pipe for anchorage and also for improving leak tightness. These pipes are either projecting out of the concrete surface or flush with it depending upon the requirement.

(c) Anchor bolts

Anchor bolts are used for anchoring equipment like pumps, motors, heat exchangers, tanks, pipes rails for cranes and hoists etc. The threaded portion of anchor bolt projection out of the concrete shall be suitably protected by caps/ sleeves from any possible damage to the threads till the equipment is erected.

(d) Threaded sockets/ embedded inserts

Threaded socket Eps are used for anchoring the equipment like heat exchanger, motors, pumps, tanks rails for cranes, hoists etc. The threaded portion remains below the concrete face. Suitable protective plugs shall be inserted to prevent damage to the threads during construction phase.

(e) Rectangular Box type penetration EPs

These Eps are generally used for passage of a bunch of piping or cables. It consists of a rectangular box made of plates and anchorage welded to it. The anchors help in transferring the loads from the EP to concrete structure and also improve leak tightness. These EPs are either projecting out of the concrete surface or flush to it depending upon the requirement.

(f) Expansion anchors

A post-installed anchor inserted into the concrete that transfers the loads to or from the concrete by direct bearing or friction or by both. Expansion anchors may be torque controlled where the expansion is achieved by a torque acting on the screw or bolt or displacement controlled where the expansion is achieved by impact forces acting on a sleeve or plug and the expansion is controlled by the length of travel of the sleeve of the plug. These anchors are used only if

(i) EPs are missed or misplaced from actual support location with respect to reference drawings during construction. Civil contractor shall substitute these EPs with suitable anchors meeting the design intent and cost for these shall be borne by them.

(ii) Additional requirement of anchors are arisen after concreting is done on account of design change.

Approved type of expansion anchors (for seismic/ non-seismic loads) for respective systems/ buildings/ structure from approved vendors shall be used.

(g) Grouted Anchors

Grouted anchor is an anchorage system which has the anchor rod, bolt or bar grouted or dry packed into pockets left in the hardened concrete.

(h) Embedded Piping

These are the part of the process system piping, which are embedded in the concrete and are projecting out of the concrete surface for joining with other part of the system piping while erection.

(i) Special EPs

The configuration of these EPs are different from the EPs described above and are designed to suit the particular requirement. These may have stringent tolerances depending upon the requirement of the equipment.

Different EPs used in the work and covered in these specifications are given below.

a) Anchor bolts of different sizes and Plate embedded parts (EPs)
b) Pipe sleeves with circumferential baffle plates of various diameters in carbon steel and stainless steel.
c) Electrical Canister EPs
d) Drain hubs and penetration in walls/slabs which are not joined to buried piping.
e) All Hatch frames both on the receiving hatch opening and hatch blocks/beams
f) All other embedded parts as shown on drawings released for fabrication.

16.4 APPLICABLE CODES, SPECIFICATIONS

IS : 102	Ready mixed paint, brushing, and red lead. Non-setting, priming.
IS : 800	General construction in steel- Code of Practice.
IS:801	Code of practice for use of old formed light gauge steel structural steel members in general building construction.
IS: 806	Code of practice for use of steel Tubes in General Building Construction.
IS : 808	Dimensions for Hot Rolled Steel Beams, Column Channel and Angle Sections.
IS :813	Scheme of symbols for welding

IS:819	Code of practice for resistance spot welding for light assemblies in mild steel.
IS:822	Code of practice for inspection of welds.
IS : 875	Code of practice for Design loads, For buildings & Structures (Part 1 to 5)
IS : 919	ISO systems of limits and fits. (Parts 1& 2)
IS : 1161	Steel Tubes for Structural Purposes- Specification
IS : 1200	Method of Measurement of Building and Civil Engineering Works (Part 1 to 28).
IS: 1239	Mild steel Tubes, Tubulars and other wrought steel fittings. (Parts 1 & 2)
IS :1363	Hexagon Head Bolts, Screws and Nuts of product Grade C (Part 1 to 3).
IS:1365	Slotted counter sunk head screws.
IS : 1364	Hexagon Head Bolts, Screws and Nuts of product Grade A & B.
IS : 1367	Technical supply conditions for threaded steel fasteners (Part 1 to 20)
IS : 1477	Code of practice for painting of ferrous metals in buildings. (Part 1 & 2)
IS: 1608	Metallic materials – Tensile testing at ambient temperature.
IS :1730	Dimensions for steel plate, sheets, strips and flats for structural and general engineering purposes.
IS : 1852	Rolling and cutting tolerances for hot rolled steel products.
IS : 1893	Criteria for earthquake resistant design of structures.
IS : 1977	Low tensile Structural Steels – Specification.
IS : 1978	Line Pipe
IS : 2002	Steel plates for pressure vessels for intermediate and high temperature service including boilers.
IS : 2016	Specification for Plain washers.
IS: 3502	Steel chequered Plates – specifications.
IS : 2062	Hot rolls low, medium and high tensile structural steel.
IS : 3589	Steel Pipes for water and sewage.-Specification
IS : 3757	Specification for high strength structural bolts
IS : 5372	Taper washers for channels.(ISMC)
IS : 5374	Taper washer for I beams (ISMB)
IS : 5620	Recommendation for structural design criteria for low head slide gates.
IS: 5624	Foundation Bolts – specification.
IS : 6005	Code of practice for phosphating of iron and steel.
IS: 6623	High strength structural nuts - specifications.
IS: 6533	Code of practice for design and construction of steel chimney Part 2- Structural Aspects
IS: 6639	Hexagon Bolts for steel structures – specifications.
IS :6649	Specifications for Hardened and tempered washers for high strength structural bolts and nuts.
IS : 7205	Safety code for erection of structural steel work.
IS : 7215	Tolerances for fabrication of steel structures.
IS : 8500	Structural steel - micro alloyed (medium and high strength qualities)- Specification
IS : 8629	Code of practice for protection of iron and steel structures from atmospheric corrosion (Part I-III)
IS: 9537	Conduits for electrical installations – General requirements.

IS: 10842	Evaluation procedure for Y-groove weld crack-ability test in structural steel.
IS : 11855	Guidelines for design and use of different type of rubber seals for hydraulic gates.
IS : 12843	Tolerances for erection of steel structures
SP:6(1)	ISI Hand Book for structural engineers –1, Structural Steel Section
BS : 3139	High strength friction grip bolts for structural engineering.
BS: 4395 (I)	High strength friction grip bolts and associated nuts and washers for structural engineering.
BS : 4592	Industrial type flooring and stair treads –Metal open bar gratings
BS : 4604	The use of high strength friction grip bolts in structural steel work.
AWS D1.1.	Structural Welding Code-Steel
AERB/SS/ CSE-2	Design, Fabrication and Erection of Steel Structures Important to Safety of Nuclear Facilities
ASME Sec II, Part C	Specification for Welding Rods, Electrodes and Filler Material
ASME Sec V	Non –destructive Examination.-
ASME Sec VIII, Div 1	Rules for Construction of Pressure Vessels.
ASME Sec III, Div 2	Code for concrete Reactor vessels and containments
ASME Sec IX	Qualification standard for Welding and Brazing procedure welders, brazers and welding and brazing operators
ASTM A-36	Specification for Structural Steel
ASTM A 167	Standard specification for Stainless and Heat Resisting Chromium Steel Plates, Sheet, Strip
ASTM A 262	Standard practice for Detecting Susceptibility to Intergranular attack in Austenitic Stainless Steels
ASTM A 380	Standard Practice for Cleaning and descaling Stainless Steel Plates, Equipment and Systems
ASTM A 516	Standard specification for Pressure Vessel Plates, Carbon Steel for Moderate and lower Temperature Service.
ASTM E 94	Standard Guide for Radiographic Testing
ASTM E 165	Standard test method for Liquid Penetrant Examination
ASTM E 709	Standard Guide for Magnetic Particle Examination
PC-E-160	NPCIL Specifications for Embedded parts
British Standard	EN Series carbon steel materials like EN8, EN24

The pertinent clauses and sections of the above codes, standards and specifications (latest revision), shall apply to the material, design, detailing, fabrication and inspection of the work covered by this specification as specified in the other sections of this specification.

In the event that certain requirements of this specification, applicable drawings and above standards & codes conflict with each other. The following priority shall govern in descending order.

i) Requirement given in the drawing
ii) Requirement given in specification No. PC-E-160, for EPs, PC-E-0034 for critical and important EPs and this specification for other steel structures.
iii) Requirement given in ASME/ ASTM
iv) Requirement given in Indian standard

16.5 DRAWINGS

16.5.1 ENGINEERING DESIGN DRAWINGS

Design drawings shall show all the dimensions and if necessary, clearances of the structure, typical connection details including size & length of the weld, weld arrangement, number of bolts, size of bolts and types of bolts, size of each member, definite location of openings, to various levels, and all other information necessary to prepare drawings for fabrication and erection.

16.5.2 Fabrication Drawings

16.5.2.1 Contractor shall prepare all fabrication and erection drawings in metric units for the entire work based on the design drawings. Shop detail drawings shall show all shearing, punching, drilling, bevel cutting, bending, and all welding / bolting in complete detail. All connections and splices shall be detailed by the Contractor and clearly shown on the drawings.

EPs shall not be welded to the main reinforcement. Bill of material shall show number, size, length, weight and assembly work of each erection piece. Bill of material for each drawing shall include fasteners/ bolts, nuts, washers and other accessories complete with specification, size, length and number etc. for each erection mark and proper identification for each joint.

Bill of material shall be prepared erection mark wise, showing weight of each component part and total weight of each erection mark. All revisions after initial issue of a drawing shall be clearly indicated with issue number and date of revision. Details shown in the drawings shall be clear and legible.

16.5.2.2 Contractor shall not commence shop detailing from information on Engineering design drawings unless such drawings or part of such drawings are officially released with the stamp bearing “Released for Construction”. Contractor shall be responsible for the correctness of all shop drawings. Six (6) prints of shop drawings shall be submitted to the Engineer for scrutiny and approval. The fabrication drawings shall be revised by the Contractor to reflect all revisions in design drawings as and when such revisions are made by Engineer. Six (6) prints of the revised fabrication drawings shall be submitted to the Engineer for approval.

16.5.2.3 No detailed shop drawings will be accepted for examination by the Engineer unless they are complete and checked and approved by Contractor’s qualified Structural Engineer and accompanied by an erection plan showing the location of all pieces detailed.

16.5.2.4 Contractor should check for erection clearance and ensure that detailing of connections is carefully planned to obtain ease in erection of structures including

field-welded connection and bolting. Field connections/ splices may be welded or bolted type, as specified in drawings.

16.5.2.5 Fabrication shall not be started until Contractor has received copies of such drawings upon which Engineer has endorsed his approval. Approval by Engineer of any of the drawings shall not relieve Contractor from the responsibility for correctness of engineering, workmanship, fit of parts, details, material, errors or omissions if any and all work shown thereon. Any work done prior to approval of shop drawings will be at the Contractor's risk. The Contractor shall make such changes in the design when so directed, which are considered necessary to make the structures conform to the provisions and intent of the specifications, without any additional cost to the NPCIL. Engineer's approval shall not invalidate any claim for damages of any kind for incorrectly detailed/ fabricated steel, notwithstanding any approval of such drawings by Engineer.

16.5.2.6 Contractor shall submit design calculations, for each and every connection detail proposed by him and also for any substitution for members, desired by him and approved by the Engineer. Fabrication drawings not accompanied by calculations for the connection design are liable to be rejected.

16.5.2.7 Each lot of drawings sent by Contractor for approval shall contain a limited number of drawings and shall be in an order and manner which follows erection sequence or as required by Engineer based on priorities allocated.

16.5.2.8 Engineer will return one copy of Contractor's drawing marked with Engineer's approval/ comments. Contractor shall furnish the Engineer, Six (6) prints of all approved final drawings for field use and record purpose. Contractor shall also furnish the Engineer with one reproducible of each drawing. These reproducible shall incorporate all modifications, field changes substitutions etc. affected and shall reflect the status "as built". It should be noted that so-called sepia or similar process reproducible are not acceptable. All these reproducible are not acceptable. All these reproducible shall be submitted rolled (not folded) on the outside of regular mailing tubes.

16.5.2.9 All these drawings will remain the property of the Engineer (NPCIL). Engineer reserves the right to use them in any manner whatsoever.

16.5.2.10 Two sets of soft copies of all final approved Contractor's drawings in the form of CDs shall be furnished by the Contractor for Owner's use after incorporating the as built status.

16.5.2.11 Time consumed by the Contractor in securing approval of drawings should not be added to the time allowed for completion of contract. A period of four (4) weeks from the date of receipt of drawings by the Engineer should be anticipated for this item of procedure in the schedule.

16.6 MATERIALS

16.6.1 STEEL SUPPLY

All steel shall be procured and supplied by the Contractor, from reputed sources as

approved by Engineer and shall conform to the following:

16.6.1.1 Contractor shall use materials for fabrication as specified in the approved drawings. All materials supplied by the Contractor shall be in sound condition, of recent manufacture, free from defects such as loose mill scales, slag intrusions, laminations, pitting, flaky rust etc. The lengths/sizes of steel sections and plates shall be as supplied by the steel mills and conform to the latest issue of the relevant IS /ASME specification.

16.6.1.2 All materials required for the work shall be correlated with manufactures test certificates. In the absence of test certificates, materials shall be tested by Contractor through an approved laboratory for establishing conformance to specification's requirement at Contractor's cost, and as directed by the Engineer. All tests shall be witnessed by owner's representative.

16.6.1.3 The Contractor shall supply the mill test certificate for the materials being supplied by him.

16.6.1.4 Material supplied against these Test Certificates (TCs) should have identification stamped or stenciled on them. All such identification markings shall be authenticated by the inspection agency, which has inspected and approved the material.

16.6.1.5 The Engineer shall have the right to test random samples to prove authenticity of the test certificates produced by the Contractor at the Contractor's cost. Any material found not meeting the specification requirement would be rejected. In the absence of material specification in the drawing following guidelines are given for structural steel members:

a) Rolled sections and Bars

Rolled steel sections supplied by the Contractor shall be of following quality.

Rolled Section	: IS 2062 E 250-Quality. A
Plates below 12mm	: IS 2062 E 250-Quality. A
Plates 12mm and above	: IS 2062 E 250-Quality. B0
Plates for crane girder	: IS-2062 E 250-Quality. C

Rail section:

The Y- Groove crackability test shall be performed in accordance with IS 10842 for material of Grade E 250Quality C, having thickness 12mm and above.

b) Pipes and Pipe fittings

For pipes and pipe fittings the following standards shall apply

For pipes up to 150 mm diameter IS: 1239 Part I and II,

For pipes beyond 150m to 2000mm diameter IS: 3589.

16.7 SUBSTITUTIONS

Whenever the Contractor desires to substitute structural members, shown on the drawings, due to non-availability of requisite materials, such substitutions shall be made only after authorization in writing by the Engineer.

Engineer may also direct to make substitution, when he considers such substitution is necessary.

16.8 FABRICATION OF STRUCTURAL STEEL

16.8.1 GENERAL

All workmanship and finish shall be of the best quality and shall conform to good engineering practice and the best-approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Standard fabrication clearances as detailed in American Institute of Steel Construction Manual and IS Codes shall generally be followed unless otherwise directed/ approved. For EPs specific requirements given in para titled 'EMBEDDED PARTS' and 'PAINTING' of this specification shall be followed in case found to be in variation with other clauses of this section. Materials at the shop shall be kept clean and protected from weather. In addition

a) All care should be taken to avoid undue welding distortions.
b) Complete layout shall be prepared and got approved by the Engineer before actual fabrications are started. If needed mock-ups may also be prepared.
c) All fit ups shall be got approved from the Engineer.
d) Standard tolerances as per relevant IS specifications shall be followed in case they are not provided in relevant drawings and specifications.

16.8.2 ELECTRODES

All Electrodes and welding shall be of low hydrogen type conforming to ASME Sec II Part C. Brands approved by NPCIL shall only be used. The bidders shall submit the list of venders and seek approval of NPCIL.

16.8.3 CONNECTIONS

16.8.3.1 All connections shall be designed (In case these are to be designed by the contractor) for forces indicated on the design drawings. The contractor shall be responsible for selection of standard connections from AISC, "Manual of Steel Construction" unless specified in drawings. Where standard joints are not available,

contractor shall design connections and shall get Engineer's approval prior to fabrication.

16.8.3.2 Connections shall be effected either by welding or bolting or as specified on the drawings. Type and quality of weld/bolts shall be in accordance with relevant IS Codes and as specified in the drawings.

16.8.3.3 Where necessary, tapered washers, flat washers or spring washers shall be used with bolts. The length of the bolt shall be such that at least one thread of bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be at least three times the thread pitch.

16.8.3.4 In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, even if a longer grip bolt has to be used for this purpose.

16.8.3.5 Wherever applicable, all connections and splices shall be designed for full strength of members or loads indicated unless otherwise approved. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice. Unless otherwise specified, beam end connections shall be designed for 60% of the shear capacity of rolled sections and 80% of shear capacity for built-up sections plus additional axial forces, if any.

16.8.3.6 All members likely to collect rainwater shall have drain holes provided.

16.8.3.7 Shop connections shall be generally welded. Field connections shall be made with bolts or HSFG bolts or welding as specified on the drawings.

16.8.3.8 In general, splice joints are not permitted except where standard length of the section under consideration is not sufficient to build the full length of the member. However, under exceptional condition, not more than one shop splice shall be permitted to make up the full length of a member with prior approval of Engineer at no extra cost to NPCIL. Shop splices to make the full member lengths shall be of full penetration butt-welded type and radio-graphically tested.

16.8.4 STRAIGHTENING

16.8.4.1 Rolled material, before being worked, shall be straightened, unless otherwise required/specified. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Long plates shall be straightened by passing through a mandrel or levelling rolls and structural shapes by the use of mechanical or hydraulic bar/section straightening machines. Heating or forging shall not be resorted to without the prior approval of the Engineer in writing. In case of site fabrication, the Engineer shall approve the straightening methods in writing before commencing the work.

16.8.4.2 Checking of the straightness of the structural members like angles, channels, beams etc. shall be done by using the thread. For checking of the straightness of the column sections piano wire shall be used. The sections, which are twisted beyond repairs, shall not be used for fabrication. Heating or hammering shall not be permitted. After removal of bends, structural members shall be submitted for inspection and approval of Engineer.

16.8.5 CUTTING

16.8.5.1 Cutting may be done by shearing, chopping, sawing or machine flame cutting. All re-entrant corners shall be shaped notch free to a radius of at least 12-mm. Sheared or cropped edges shall be dressed to a neat workmanlike finish and shall be free from distortion and burrs.

16.8.5.2 Hand flame cutting shall be undertaken, only if so permitted by the Engineer and shall only be carried out by an expert in such work. Hand flame cut edges shall be ground smooth and straight, for minimum 2mm in depth to remove the oxide layer.

16.8.5.3 Edges of flange cover plates and plates used to form any sections shall be ground smooth/planed.

16.8.6 PUNCHING AND DRILLING

16.8.6.1 Holes for all connections shall be drilled accurately and the burrs removed effectively. Where several parts are to be connected, such parts shall be first assembled, tightly clamped together and drilled through. Holes in secondary members such as purlins, girts, lacing bars etc. may be punched full size through material not over 12 mm thick. Holes should be clean cut, without burr or ragged edges.

16.8.6.2 ub-punching may be permitted before assemble, provided the holes are punched 3 mm smaller in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not in such cases exceed 16 mm.

16.8.6.3 When match drilling is carried out in one operation through two or more separate parts, these parts shall be separated after drilling and the burrs removed.

16.8.6.4 Holes for turned and fitted bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to HB tolerance specified in IS: 919.

16.8.6.5 Where reamed members are taken apart for transporting or handling the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. Poor matching, over drilling and ovality in holes shall be a cause for rejection. Burning holes with gas is strictly prohibited.

16.8.6.6 Holes may be required to be drilled by the Contractor at site for installing equipment or steel furnished by other agencies. The information for this will be supplied to the

Contractor by the Engineer before or after erection of the steel. Holes should be by drilling or other machining process and not by gas cutting sets.

16.8.7 ROLLING AND FORMING

Plates, channels, RSJ, etc., for circular bins, crane girders, gantry girders etc shall be accurately laid off and rolled or formed to required profile/shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field. In the case of stainless steel materials while rolling care shall be taken to avoid direct contract of MS/CS rollers with SS material in view of iron contamination to SS materials. A detailed rolling & forming procedure shall be prepared by the contractor and Engineer approval shall be obtained prior to execution.

16.8.8 GRINDING

Column ends bearing on each other, resting on base plates, compression joints designed for bearing, base plates coming in contact with column end and cap plates shall be ground smooth to ensure 90% contact with local gap not exceeding 0.10 mm (filler gauge shall be used to check this gap), unless mentioned and approved otherwise. All ground surfaces shall be protected from dirt and mechanical damages till the assembly is completed. However the underside of base plate bearing on cement grout need not be ground smooth.

16.9 GRATINGS

All gratings shown and/or listed in the drawings shall be fabricated as a complete unit as detailed or as necessary for connections to structural steel framing. The gratings shall be capable of sustaining a safe live load of 500 kg/sq. metre of plan area unless otherwise specified on the Engineer's design drawings. Treads and landings shall be suitable for the prescribed loading and be furnished complete with a one-piece standard non-slip abrasive nosing of approved type.

16.9.1 ELECTROFORGED GRATINGS

Electro forged Gratings shall be of custom fabricated/ cut to size in shapes (rectangular/ circular etc.) as required with serrated bearing bars. Gratings shall be fixed at all elevations with clamps, siddle clip & slotted clamps including drilling, providing and fixing screws. It shall be hot dip galvanized as per IS 4759 but in no case it shall be lesser than 610GSM. Wherever, due to functional requirements Galvanizing is not acceptable the grating shall be painted with high build epoxy with minimum DFT of 200 micron (excluding primer) over 75 micron zinc silicate primer etc. The gratings shall be capable of sustaining a safe live load of 500 kg/sq. meter (unless specified otherwise) of plan area. Treads and landings shall be suitable for the prescribed loading and be furnished complete with a one-piece standard non-slip abrasive nosing of approved type. The Contractor shall submit the design and fabrication drawing to NPCIL for approval prior to procurement of gratings.

16.10 HANDRAILS

Handrails shall be provided on open sides of platform, stairways and around all openings as shown in drawings. Handrails shall be of SS/mild steel pipe as specified in the drawings of flush welded construction and ground smooth. Unless specified otherwise the handrail shall be fabricated using 32mm nominal bore medium class pipe provided with double rail, top rail about 1 meter above platform / walkway level and the intermediate rail 450 mm below top rail and pipe posts spaced not more than 1.5 metres apart and 150 mm high 6mm thick toe plate. All MS handrails shall be painted as per requirement given in the drawings.

Smooth uniform curves and bends shall be provided at stair returns and also where so ever required /specified. Posts connected to curb plates shall have a neat closure at the bottom and a 6mm thick plate nearly welded to posts for attachments to curb plate/ toe guards. All necessary fittings including inner dowels at splices, brackets, bolts, bends, flanges and chains, shoes for removable type handrails where required shall be furnished by the Contractor. Open ends of all the pipe posts shall be plugged and welded. A minimum radius of 3 times the pipe diameter shall be provided at all points of direction changes in the handrail.

16.11 CHEQUERED PLATE

Chequered plates used shall be minimum 6mm thick or as indicated in the drawings and shall be capable of carrying a minimum live load of 500 kg/sq.m unless otherwise specified in the design drawings. Chequered plate shall be fixed by 8mm diameter cadmium plated M.S. screws with countersunk heads at a maximum spacing of 400mm. Members supporting the chequered plate shall have matching holes tapped in them. Chequered plates may also be required to be welded to the structural steel framing. The decision in this regard will be given by the Engineer wherever required/ specified.

Thickness of zinc coating shall be as per IS: 4759 for structural steel plates, angles, channels etc. and as per IS: 4736 for pipe sleeves.

16.12 WELDING

16.12.1GENERAL

16.12.1.1 Welding procedure specification (WPS) shall be established and Qualification of weld procedure (QWP) shall be done in accordance with the requirements of ASME Sec IX, or AWS D 1.1 as and where specified. Welders employed shall also be qualified as per above standards prior to taking up fabrication.

Following pre-qualified welding process shall be employed for fabrication, erection and repair by:

a) Submerged Arc Welding (SAW).
b) Shield Metal Arc Welding (SMAW).
c) Gas Metal Arc Welding (GMAW).

d) Gas Tungsten Arc Welding (GTAW)

16.12.1.2 All welds shall be free from defects like blowholes, lack of penetration, undercutting, cracks etc. All welds shall be cleaned of slag or flux and show sections, smoothness of weld metal, featheredges without overlap and freedom from porosity.

16.12.1.3 50mm on either side of the surfaces on which weld metal is to be deposited shall be smooth, uniform, free from fins, tears burrs cracks and absolutely free from grease, paint, loose scale, moisture or any other substance which would adversely affect quality and strength of weld.

16.12.1.4 Machining, thermal cutting or grinding may be employed for joint preparation or removal of unacceptable work or metal. The weld edges shall be smooth & regular surface free from cracks & notches. Flame cut material above 50mm thick shall be pre-heated to 100°C prior to flame cutting.

16.12.1.5 All weld fit-up shall comply with tolerances specified in the design drawing. The parts to be joined by fillet welds shall be brought into close contact as practicable. The root gap in no event shall be greater than 3 mm for SMAW process and 1.5mm for SAW process. If the separation is greater than 1.6mm the leg of the fillet weld shall be increased by the amount of root opening. This shall apply only in the case of continuous welds. Abutting parts to be butt-welded shall be carefully aligned and correct root gap shall be maintained throughout the weld operation. The fit up of joints at contact surfaces that are not completely sealed by welds shall be close enough to exclude water entry after painting. The separation between laying surfaces of lap joint and butt joints with backing plate shall not exceed 1.5mm. Abutting parts to be butt-welded shall be carefully aligned and the correct root gap maintained throughout the welding operation. Misalignments greater than 25% of the thickness of the thinner plates or 3mm, whichever is smaller, shall be corrected and in making the correction, the parts shall not be drawn into a slope sharper than 2 degrees.

16.12.1.6 All tack welds shall be made using qualified procedure and qualified welders. Any preheat requirement specified in the welding procedure shall also apply to tack welds. All tack welds shall be examined visually for defects and if found defective, shall be removed.

16.12.1.7 Welding of temporary attachment/fixtures to retain fit up is allowed in case the parts have a nominal thickness of at least 6mm. Temporary attachments are welded to at the distance of at least 30 mm from the weld seam for construction of CS and least 60mm for welding austenitic steel. Welding of temporary attachments/fixtures into the joint slot is not allowed. All temporary fixtures to be

removed after welding by grinding them to weaken the welded portion and hammering thereafter, followed by grinding the portion of any weld remaining on the base metal. A dye check at the discretion of the quality surveyor shall be done to detect any crack/defect at the point of fixture temporary weld.

16.12.1.8 It is not allowed to turn over and carry over heavy assemblies in tacking condition in order to control the geometric dimensions to the requirements of the drawings.

16.12.1.9 Non-flatness of the facing sheets being assembled into the subassemblies in the longitudinal and transverse direction is allowed within 10mm for 1m of the length.

16.12.1.10 During the installation of the structural steel members care shall be taken to prevent damage of the sheets and of the welding seams. The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided as far as possible.

16.12.1.11 In the joints of the parts with dissimilar thickness smooth transition of one part to the other must be provided by way of the gradual decreasing of the thickness of the thicker part with the slope of the surface not exceeding 15 degree.

16.12.1.12 Welding shall not be done when the surface of the members are wet or exposed to rain or high wind velocities unless the welding operator and the work are properly protected. In joints connected only by fillet welds, the minimum size of fillet weld to be used shall be as shown in the following table unless otherwise specified in the drawing.

Material thickness of Thicker part joined (mm)	Minimum size of fillet weld (leg dimension of fillet weld) (mm)
Up to 6	3
Over 6 to 12	5
Over 12 to 18	6
Over 18 to 36	8
Over 36 to 56	10
Over 56 to 150	12
Over 150	16

16.12.1.13 Fillet welds 5 mm or larger in size for SMAW and 10mm for SAW shall be made with two or more passes. Welding rods shall be 3.15 in diameter maximum for root passes, and 4mm and above in diameter for subsequent passes. Complete penetration butt weld shall be terminated at the ends of the joint in a manner that will insure their soundness. Where abutting parts are 20mm or more in thickness,

suitable run-on and run-off plates with similar edge preparation and having a width not less than the thickness of the thicker part shall be used. These extension pieces shall be removed after completion of weld and the end of the weld made smooth and flush with the abutting parts.

16.12.1.14 In case of full penetration butt welds without backing , root weld shall be back gouged to sound metal before second side welding for complete fusion throughout the entire cross section. However, in case of square butt welds done in flat position from both sides and with thickness of parts joined less than 8mm and root opening not less than half the thickness of the thinner part, gouging can be dispensed with, if approved by the engineer.

16.12.1.15 All welded shop splices in each component part of covered plate beam or built up member shall be made before the component part is welded to other parts of the member. Long girders or girder section may be made by welding sub assemblies each made in accordance as explained above. When making these sub assembly splices, whether in the shop or field, the welding sequence should be reasonably balanced between web and flange welds. Where weld reinforcement interferes with the proper fit-up between components to be assembled for welding, these welds shall be ground flush prior to assembly.

16.12.1.16 Preheating for welding of steel shall conform to ASME Section VIII Div 1

16.12.1.17 Post weld heat treatment (PWHT) shall be carried out if the weld size is more than 50mm, unless specified otherwise. The procedure for PWHT shall conform to ASME Section VIII Div 1. No stress relief using oxyacetylene flame is permitted.

16.12.1.18 In assembling & joining parts of a structure or a built-up members and in reinforcing parts to members, the procedure and sequence shall be such as to minimize distortion and shrinkage. The fabricator shall prepare a welding sequence for a member or structure which in conjunction with WPS and overall fabrication method, will produce members or structure meeting the quality requirement specified. The welding sequence and distortion control programme shall be submitted to Engineer for comments and information before start of welding such program shall include, besides other appropriate details, full particulars in regard to the following:

a) Proposed pre-bending in components such as flanges and flange cover plates and pre-setting of joints to offset expected distortion.
b) Make up of sub-assemblies proposed to be welded before incorporation in final assembly.
c) Proposed joint forms, classification of wire and flux or covered electrodes, welding process including fit up and welding sequence with directions in which freedom of movement is to be allowed.
d) Proposed number, spacing and type of storage backs and details of jigs and fixtures for maintaining proper fit up and alignment during welding.

e) Any other special features like assembling similar members back to back or stress relieving procedure.
f) If so desired by the Engineer, mock up welding shall be carried out at Contractor's cost to establish the efficiency of the proposed programme, with any modification suggested by the Engineer in limiting distortion or /and residual stress to acceptable levels.
g) For sections made of rolled sections with cover plates, the ends of the plate shall be seal welded or alternatively flange cover plate terminated 25mm short of the full length and welded across to the beam for proper end sealing and/or as directed by the Engineer.

16.12.1.19 Welds shall be defect free and surfaces shall be thoroughly cleaned to remove all visible weld defects and extra material. All welds shall be stamped/identified with System/Joint No/Welder punch etc. as per approved procedure at a distance of 30-35 mm from the weld seam.

16.12.2 WELDING CONSUMABLES

16.12.2.1 Electrodes, filler wires and flux used for welding shall be from approved manufacturers/Suppliers. When requested by the engineer, the contractor shall furnish certification that electrode or electrode flux combination will meet the requirements of classification. The classification and size of electrode, arc length, voltage & amperage shall be suited to type and thickness of material, type of groove, welding positions and other circumstances attending work.

16.12.2.2 Electrodes, filler wire and consumables shall conform to the requirements of ASME Sec. II Part C.

16.12.2.3 Only low hydrogen electrodes to AWS E7018 shall be used for welding for all Carbon Steel material. Whenever high tensile welds are required to be employed than E-8018 electrode are to be used of approved make. These electrodes shall be purchased in hermetically sealed containers or baked by the user as recommended by electrode manufacturer. Electrode flux coating shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. SMAW electrodes shall be properly stored. Before welding, the electrodes shall de dried in a holding oven as per manufacturer's recommendations. Only limited quantity shall be issued to the welders. The electrodes shall be kept in "carry ovens" and shall not be exposed to the atmosphere.

16.12.2.4 The filler wire and flux combination for submerged arc welding shall conform to the requirements of ASME Section II, Part C. The weld metal deposited by the submerged arc process shall have mechanical properties not less than that of base material specification. The flux used for SAW process shall be dry and free of contamination from dirt, mill scale or foreign material. The flux purchased in packages shall be stored in dry place. Flux shall be dried in case of damaged package at a temperature of 260° C for 1 hour prior to welding operation. Flux shall be placed in dispensing system immediately upon opening a package.

16.12.2.5 Welding plants and accessories shall be of adequate capacity and shall satisfy appropriate standards and be of the approved make and quality. Proper safety rules shall be followed and adequate means to measure the current shall be provided.

16.12.2.6 Wet magnetic particle inspection in accordance with ASME Sec. V may be performed.

16.12.2.7 For other magnetic materials dry power magnetic particle inspection in accordance with ASME Sec V.

16.12.3 WELD REPAIR

Whenever weld repair is required, Contractor shall give prior intimation to the Engineer and permission before the repairing is taken up. When a defect is detected in a weld, it shall be removed by cutting/grinding and smooth blending of the area with parent metal without sharp edges, corners. If welding is required, the same shall be done using the qualified procedure/welder and stage inspection as per the original weld. Correction of defect in the same portion of the weld shall not be allowed more than two (2) times. Portion of the welding seams, which have been subjected to repair, must be indicated in the weld inspection reports.

16.13 ERECTION

16.13.1 GENERAL

16.13.1.1 The Contractor shall supply all erection bolts, permanent bolts and electrodes as required for the job. At all times the Contractor shall be responsible for the safety and protection of fabricated material, from loss or damage of any nature until the completion of erection work.

16.13.1.2 Structural steel work will involve the erection of columns, beams, bracing, crane girders, purlins, trusses, monorails, ladders, platforms, gratings, chequered plates etc.

16.13.1.3 The Contractor shall complete all preliminary works at site, including post concrete survey wherever required well before the arrival of fabricated structural steel, such as keeping in readiness electrical winches, mobile cranes, gin poles, compressors, all tools and tackles, welding sets, torque wrenches, impact wrenches, etc., as part of this contract and any other work that may be necessary so as to start erection immediately after the arrival of fabricated steel at site.

16.13.1.4 The Contractor shall arrange for such quantum of erection equipment, supervision staff, labour and other arrangements so as to carry out the work efficiently. The equipment and services provided by Contractor shall include but not be limited to, the supply of labour, transport vehicles, crane derricks, gin poles, winches, welding equipment and tools, compressed air if required, blocking, scaffolding, locked storage for tools, welding rods, positioners, cables etc required for site fabrication assembly and erection of the structure. If found necessary the Contractor shall also provide at hisown cost arrangements for inspection and

testing of material used in erection. He shall satisfy the Engineer regarding arrangements for various types of work to be undertaken by him.

16.13.1.5 No dragging of fabricated structural steel shall be permitted.

16.13.1.6 All fabricated structural steel shall be stored 150mm above ground on suitable packing, to avoid damage during the monsoon. Steel shall be stored in the order of erection with erection/identification marks visible. Storage areas shall be prepared and maintained by the Contractor. Any steel stored near excavations shall be removed immediately to a safe distance to avoid burial under debris.

16.13.1.7 The Contractor shall protect all existing plants, embedded parts, all permanent and temporary structures, piping, conduits, equipment and facilities against damage during erection. The Contractor shall perform his work in a manner, which in no way endangers the operations of any existing plant or structures or hinders other construction activities.

16.13.1.8 The Contractor shall arrange at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after the completion of the job. The Contractor shall also provide necessary passageways, fences, safety belts, helmets, safety shoes, lights and other fittings to the satisfaction of the Engineer and for protection of his men and materials.

16.13.1.9 All structures shall be erected as shown in drawings. The Contractor shall carry out all erection work in the sequence required/ approved by the Engineer. The methods of erection and complete erection scheme shall be subject to the approval of the Engineer and shall be modified wherever required by the Engineer. This, however, will not relieve the Contractor of the responsibility for safe and expeditious completion of the work, its quality and accuracy.

16.13.1.10 Drifts should be used only for drawing the members into position and must not be used to such an extent so as to destroy the holes. Drifts of a larger size than the nominal diameter of the hole shall not be allowed. Any damaged holes or burrs must be rectified to the satisfaction of the Engineer. Correction of minor misfits and reasonable amount of reaming, if any, shall be considered as a part of erection. Any error in shop work, which prevents proper fit even after a moderate amount of reaming and slight chipping or cutting shall be immediately reported to the Engineer. The Contractor's work shall also include straightening and repairing of materials slightly damaged and drilling some holes in members where required. This is deemed to have been included in the unit rate quoted and nothing extra shall be payable for the above operations. Non Conformance Report (NCR) shall be raised and got approved for all repairs and modification required.

16.13.1.11 In case of any faulty erection, all such dismantling and re-erection required will be at the Contractor's cost. Shim stock of mild steel plates, required for erection will be set, leveled and prepared for grouting / dry packing.

16.13.1.12 Where flat bearing beams occur, bearing plates shall be set, levelled and prepared for grouting/dry packing.

16.13.1.13 Structural Steel frames shall be erected plumb and true to tolerance indicated in the relevant clause. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracing shall be introduced wherever necessary to take care of all loads to which the structures may be subjected including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety. Proper size steel cables, slings etc shall be used to avoid any damage due to accidents.

16.13.1.14 As erection progresses, the work shall be securely bolted to take care of all dead load, wind and erection stresses. No final welding or bolting shall be done until the structure has been properly aligned and approved by the Engineer.

16.13.2 CODE

Unless specified in the relevant drawing and specification, all erection work shall be carried out in accordance with the latest edition of Indian Standard Code of Practice for use of Structural Steel in General Building Construction IS-800 & AISC code wherever applicable.

16.14 ANCHOR BOLTS & FOUNDATIONS

16.14.1 The Contractor shall carefully check the location and layout of anchor bolts embedded in foundation constructed to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/foundation shall be reported to the Engineer.

16.14.2 Anchor bolts shall be provided with two nuts of approved grade of materials as per relevant IS or ASTM standard codes on upper threaded portion, one of which may be used for levelling the column base to the required elevation and one will be a lock nut. All shim stock, required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good MS plates and shall be supplied by the Contractor at his cost .Required no of washers shall also be provided by the contractor at his cost.

16.14.3 Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. The Contractor shall carry out all grouting under column base plates or beam bearing plates, unless the grouting is specifically excluded from the scope of work.

16.14.4 HIGH STRENGTH FRICTION GRIP BOLTING

16.14.4.1 High strength friction grip bolts and nuts shall conform to IS: 3757 and/or BS: 3139/ or ASTM A325.

16.14.4.2 Installation of high strength friction grip bolts in joinrs shall comply with IS : 4000 and / or BS : 3294 and or specification for structural joints using ASTM A 325 or A490 Bolts by Research council on Rivetted and Bolted Structural Joints.

16.14.4.3 The diameter of the bolt holes will not be more than 1.5 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the bolt heads, nuts and washers shall be free of scales, burs, dirt and other foreign matters tending to inhibit uniform sealing of the joint components. However, tight mill scale and the light residual oil coating on bolts, nuts and washers need not be removed.

16.14.4.4 All fasteners in a joint shall be tightened to a tension equal to greater than the specified proof load .either by the calibrated wrench method or the turn –of- nut method.

16.14.4.5 Tightening may be achieved by use of pneumatic powered impact winches , long handled manual torque wrenches with or without torque multiplier or electric wrenches . A hardened washer shall be placed under the element being turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges.

16.14.4.6 When using the calibrated wrench method, adjustable power impact wrenches and manual torque wrenches shall be calibrated to induce the bolt tension of 5% in excess of the proof load values, for each size of bolt to be used in the installation. Every wrench shall be calibrated by having it tighten a minimum three bolts of the same diameter, in a hydraulic tension measuring device. Calibration shall be repeated whenever a wrench is required to tighten a different size bolt or at least once each working day if there is no change in the bolt size. Impact wrenches shall be set so as to stall or cut at the torque effort corresponding to the prescribed fasteners tension. When manual torque wrenches are used the torque indication corresponding to the calibrating tension shall be determined and taken as the job standard. Torque measurement shall be read while the turned element is in the tightening motion. As subsequent tightening of bolts in particular assembly is liable to loosen bolts already tightened, all bolts must be ‘Touched up’.

16.14.4.7 If finger tight condition is used as a string point an extra full turn shall be taken to correspond to one half turn from the snug- tight position.

16.14.4.8 Load indicating bolts or load indicating washers may be used if so approved by the engineer in writing.

16.14.4.9 Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method and type of bolt used .

16.15 ERECTION PROCEDURES

16.15.1 The structures shall be erected by assembling in sections on the ground and hoisting successive sections into place, or they may be built up in place by individual

members at the option of the Contractor. The staging in different sections already erected shall be self-sufficient in stability for all conditions or stresses including those caused by wind. If erected by assembling in sections, not less than 50% of all bolting in place shall be done in each section before starting another section.

16.15.2 All bolts shall be drawn up tight but not to such a degree as to endanger the strength of the bolts and nuts shall be locked in place with lock nuts. Only wrenches approved by the Engineer shall be used on the work and the use of any wrench, which may deform the nut, will not be permitted. At least ten percent of the bolts in each connection as directed by Engineer shall be tested for tightness by calibrated wrenches or other approved methods free of charges. If any bolt in any connection is found to be not sufficiently tightened, all bolts in that connection shall be re-tightened and tested again without claiming any extra.

16.15.3 The Contractor shall take all precautions for the safety of labourers at the time of erection. Safety belts shall be provided to workers while working at all levels for the erection of tower. The erected structure shall be well secured and protected at the close of the day to avoid any damage to the structure and workman.

16.16 TOLERANCES

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852 for indigenous steel. The tolerances for fabrication of structural steel shall be as per IS: 7215. Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb. The tolerances specified below do not apply to steel structures where the deviations from true position are intimately linked with and directly influence technological process. In such cases, the tolerances of process technologists//suppliers which will be indicated in the drawing.

16.16.1 **Columns**

Deviation of column axes at foundation top level with respect to true axes

(a)	In longitudinal direction	:	± 5 mm
(b)	In lateral direction	:	± 5 mm

16.16.2 **Deviation in the level of bearing surface of columns at foundation top w.r.t. true level : ± 5 mm**

Out of plumbness (verticality) of column axis from true vertical axis, as measured at column top:	
(a)For columns up to and including15 meters in height:	± 1/1000 of column height inmm
(b)For columns exceeding 15 meters in height:	± 1/1000 of column height inmm or ± 20 mm whichever isless
Deviation in straightness in longitudinal and transverse planes of column at any point along the height:	± 1/1000 of column ht in mm or ± 10 mm.

Difference in erected position of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance.	± 10 mm
Deviation in any bearing or seating level with respect to true level	± 5 mm
Deviation in differences in bearing levels of a member on adjacent pair of columns both across and along the building	± 10 mm

16.16.3 **Connection of Members**

Beams up to 600 mm in depth - 1.5 mm
Beams over 600 mm in depth - 1.5mm every 600mm depth to a max. of 3mm.

Where abutting parts are to be joined by bolting through cleats or end plates, the connection requires closer tolerance.

Permissible deviation from the squareness of the end is
For Beams - 1 mm per 600 mm of depth up to a max. of 1.5 mm.

16.16.4 **Depth of Members**

Acceptable deviation from the specified overall depth is
For depth of 900 mm and under - +/- 3 mm
For depth over 900 mm and under 1800 mm- +/- 5 mm
For depth of 1800 mm and over - +8 & - 5 mm

16.16.5 **Trusses and Beams**

Shift at the centre of span of top : ± 1/250 of height of truss in mm

Chord member with respect to the : ± 15 mm whichever is less
Vertical plane passing through the centre of bottom chord.

Lateral shift of top chord of truss at the : ± 1/1500 of span of truss in mm

Centre of span from the vertical plane or : ± 15 mm whichever is less
passing through the centre of supports of the truss.

Lateral shift in location of truss from its : ± 10 mm
true vertical position

Lateral shift in location of purlin true
position : ± 5 mm

Deviation in difference of bearing : i) ±20 mm for trusses
levels of trusses or beams from ii) for beams :

the true difference	Depth < 1800 mm : ±6mm Depth > 1800 mm : ±10 mm
Deviation in sag in chords and diagonals : of truss between node points	1/1500 of length in mm or 10mm whichever is smaller
Deviation in sweep of trusses, beams etc.: in the horizontal plane	1/1000 of span in mm subject to a max. of 10 mm

16.16.6 **Crane Gantry Girders & Rails**

Shift in the centre line of crane rail with respect to centre line of web of crane gantry girder	: ± 5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	: ± 5 mm
Difference in alignment of crane rail in plan measured between any two points 2 metres apart along rail	: ± 1 mm

Deviation in crane track with respect to true gauge

(a) For track gauges upto and including 15 metres	:	± 5 mm
(b) For track gauges more than 15 metres	:	± [5 + 0.25 (S-15)] where S in metres is true gauge

Deviation in the crane rail level at any point from true level	:	1/1200 of the gauge distance or ± 10mm whichever is less
Difference in the crane rail actual levels between any two points 2 metres apart along the rail length	:	± 2 mm

Difference in levels between crane track rails at

(a) Supports of crane girders	:	± 15 mm
(b) Mid span of crane girders	:	± 20 mm

Relative shift of crane rail surfaces at a joint in plan and elevation	: 2 mm subject to grinding of surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in mm	: 1/1000 of track gauge S in mm subject to maximum of 20 mm

16.16.7 **Towers:**

Out of plumbness (verticality) from the true vertical axis	:	1/1000 of the height of the chimney or tower in mm .

16.17 MARKING OF MEMBERS

16.17.1 After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The match mark shall be punched on both sides of the member and the erection mark on the face of the member. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

16.17.2 All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

16.17.3 Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

16.17.4 In case of embedded parts, identification mark shall be visible on the exposed surface after embedding in place.

16.18 STORAGE

16.18.1 The Contractor shall have proper arrangements for storage. He shall identify the storage area where raised platform will be constructed by him. The materials will be identified area-wise and quantity-wise with proper identification marks.

16.18.2 Covered storage (Storage of fabricated materials): The Contractor shall make storage arrangements category-wise for storing fabricated materials and these materials shall be available for erection whenever called for. Fabricated materials should be stored separately according to different categories viz. embedded parts, pipe sleeves, angle frames, gratings and fabricated structural shapes. All the above materials when stacked should have proper access for inspection either by the Engineer or his authorized representatives.. The fabricated materials should be properly identified by giving identification marks. Similar precautions shall be taken to prevent the above material from rusting or any damage during the storage. Any fabricated EPs/material damaged/rusted during storage shall be rectified/repaired at Contractor's own cost.

16.19 INSPECTION, TESTING & REPORTS

16.19.1 Contractor shall give due notice to Engineer in advance of the materials or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for Engineer's approval/inspection. The fact that certain material has been accepted at Contractor's shop shall not invalidate final rejection at site by Engineer if it fails to be in proper condition or has fabrication inaccuracies which prevents proper assembly. No material shall be painted or dispatched to site without the inspection and approval by Engineer unless such inspection is waived in writing by the Engineer.

16.19.2 Shop inspection by Engineer or his authorized representative or submission of test certificates and acceptance thereof by Engineer shall not relieve Contractor from the

responsibility of furnishing material conforming to the requirements of these specifications, nor shall it invalidate any claim which the Engineer may make because of defective or unsatisfactory material or workmanship.

16.19.3 Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified. Contractor's inspection work shall be under the control of competent Chief Inspector whose primary responsibility is inspection (reporting to Management) and not to production department.

16.19.4 For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. The inspection and testing shall be conducted in a manner satisfactory to Engineer. Fit ups shall be examined by the quality surveyor as per the approved QA plan prior to welding the joint .All welds shall be inspected for flaws by the method described under the relevant Clause The inspection and testing on structural steel members shall be as set forth below:

16.20 MATERIAL TESTING

16.20.1 All materials conforming to a particular Indian/ASTM or any other standard as called for shall be tested as required by such standard. Proof in the form of certified test reports or mill certificates indicating the required tests have been carried out as per specification at the source as acceptable. In case these are not available, then the Contractor at his cost shall perform these tests.

16.20.2 Engineer has option to specify additional inspection or testing as he deems necessary and the additional cost of such testing will be borne by the Engineer.

16.20.3 The Contractor shall maintain records of all inspection and tests, which shall be made freely available to the Engineer and shall be submitted to the Engineer at completion of each stage of work.

16.20.4 If mill test reports are not available for any steel materials, the same shall be got tested by Contractor to Engineer's satisfaction to demonstrate conformity with the relevant specification at his own cost.

16.20.5 The tests are restricted to as per Indian/ASTM or any other standard for a particular material as required by such standard. If any additional tests are required to be done actual expenses shall be reimbursable.

16.21 INSPECTION OF WELDS

The following methods are used for the quality control of welded joints. All weld shall be grinded and thoroughly cleaned before taking up the inspection

16.21.1 Visual Inspection

Visual inspection shall be performed prior to and during and after non-destructive testing. The completed welds should be checked for correct size and profile. All weld surfaces shall be free from slag, creators, abrupt ridges and vallies, arc strikes. Prior to fabrication proper included angle, route opening, route face, alignment and cleanness of joint shall be checked and ensured. All weld shall be visually inspected to ensure the welding performed are within the acceptable limits.

16.21.2 Magnetic Particle Test (MPT)

Wherever specified, all MPT shall be as per ASTM- E709. Defects if found, shall be repaired and retested.

16.21.3 Dye Penetrate Inspection

MPT may be substituted by Dye Penetrate Inspection where the former is not feasible due to configuration. All surfaces of the welds to be inspected by DPT shall be free from scale, flux, ridges etc. The testing should be in accordance with ASTM-E165. Defects, if found, shall be repaired and retested. The cost of demagnetizing after testing shall also deemed to be included in the quoted rates of the Contractor.

16.21.4 Radio-graphic Examination

Wherever specified, Full penetration butt welds shall be radio-graphed or spot radiographed as shown in drawings /QA plans in accordance with ASTM: E-94 and as specified.

16.21.5 Ultrasonic Testing

Wherever built up sections for crane runways girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing as per ASME, Sec-V, Article 5.

16.21.6 Acceptance Standard

The acceptable standards for weld inspection shall be as per ASME Sec VIII - Div I.

16.22 DIMENSIONS, WORKMANSHIP AND CLEANLINESS

All the fabricated embedded parts of Structural Steel members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment and surface finish are in accordance with the requirements shown on the approved Contractor's shop drawings and/or Engineer's drawings.'

16.22.1 The dimensions of the fit ups shall be maintained as specified in the fabrication drawings.

16.22.2 Raw material with cracks, seams, laps, lamination and heavy pitting are not acceptable. Ultrasonic testing of plates above 50 mm thick or as per the material specification shall be carried out for the soundness of material.

16.22.3 The cut edges of plates more than 25 mm for fillet weld, butt welds, and the plates used for tension flanges and webs -100 % MPT / DPT shall be carried out.

16.22.4 Welding shall be carried out as per approved WPS and QWS by qualified welders.

16.22.5 Macro etch test on welds shall be carried out 1 per structures for built up girders, columns and other heavy structures for penetration.

16.22.6 For 100% weld length, MPT / DPT on root & final pass for thickness equal to or greater than 25mm for butt welds.

16.22.7 For 100% weld length, RT shall be carried out for thickness equal to greater than 32 mm butt welds.

16.22.8 For 100% weld length RT for butt welds of rolled sections having a depth greater than 600 mm shall be carried out.

16.22.9 Minimum 10% of Fillet welds length, for either plate thickness is up to and inclusive 25 mm or fillet size is less than 10 mm (inclusive 10mm), root & final pass MPT /DPT shall be carried out.

16.22.10 On 100 % weld length, MPT/DPT shall be carried out on root & final pass, for either plate thickness greater than 25mm or fillet welds is more than 10 mm size.

16.22.11 Dimensions of all the assemblies and sub-assemblies shall be as per fabrication drawings within the tolerances specified in IS 7215.

16.22.12 For full penetration welds, DPT shall be carried out after back gouging before second side welding.100% MPT shall be carried out on low alloy steel, flame cut edges for thickness greater than 12mm.

16.22.13 Wherever built up sections for crane runways girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing as per ASME, Sec-V, Article 5,

16.22.14 The contractor shall maintain records of all inspection and tests, which shall be made freely available to the Engineer or his authorized representative and shall be submitted to the Engineer at completion of each stage of work.

16.22.15 The contractor shall ascertain that materials conforming to the requirements of this specification only are used.

16.22.16 The contractor shall check that the welding procedures (including the electrodes, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

No	Type of defect	Acceptance criteria	Remarks
1	Cracks	Not acceptable (NA)	
2	Incomplete or lack of fusion	Not acceptable (NA)	
3	Misalignment of butt welds	0.25 x T maximum of 3 mm	T: Thickness of thinner plate

4	Reinforcement	Max reinforcement of 2 mm for t < 10 mm 3 mm for t > 10mm < 15 mm. 4 mm for 15 mm and greater	
5	Undercut	0.25 mm deep max	
6	Sharp edges	Min radius of 2 mm	

16.22.17 **Inspection of Test Failure**

In the event of any failure of structural, steel members to meet inspection or test requirements, the Contractor shall notify the Engineer or his authorised representative. A Non Conformance Report (NCR) has to be made and got approved from the Engineer or his representative before repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by Engineer. Contractor shall maintain records of all inspection and testing which shall be made available to the Engineer or his authorized representative, for three years from the date of completion of the contract.

16.23 EMBEDDED PARTS

16.23.1 General

The details furnished below are in addition to general requirements of material supply, fabrication, inspection, testing etc specified in the earlier clauses of this specification. In general, reference shall be made to PC-E-160 for detailed specifications and requirements on Embedded Parts.

16.23.2 Material

Contractor shall supply/ use materials for fabrication as specified in the drawings. In the absence of material specification in the drawing, following guide lines are given.

Design	Spec	Remarks
Plates for pipe sleeves of wall thickness less than 20 mm	IS-2062Grade E-250, Quality –B0	
Flanges and plate EP's and threaded fasteners of 20 mm thk/ dia and more	IS-2062, Grade E-250, Quality – B0	
C.S Pipes up to 150 mm NB	1S-1239 Heavy Grade	
C.S. Pipes of sizes 200 mm NB and above	IS-3589 Grade FE 410	
Stainless Plates	ASTM-A-240 type 304L	IGC tested
Stainless pipes	ASTM-A-312 type 304L	Seamless or seam welded by automatic or manual

		process. Inspection as per specification.

Rolled sections and Bars

Rolled steel sections supplied by the Contractor shall be of following quality.

Rolled Section	:	IS 2062 E 250-Quality. A
Plates below 12mm	:	IS 2062 E 250-Quality. A
Plates above 12mm	:	IS 2062 E 250-Quality. B

16.23.3 Electrodes

All electrodes and welding wire shall be low hydrogen type conforming to ASME Sec II Part C. Brands approved by NPCIL shall only be used.

16.23.4 Material test certificate shall be in original.

16.23.5 Material supplied against these TC's should have identification stamped or stenciled on them which can be correlated with the TC's

16.23.6 All such identification markings shall be authenticated by the inspection agency which has inspected and approved the material.

16.23.7 The contractor shall furnish to the Engineer duplicate copies of all purchase order copies covering the material ordered by him for this project and also test reports.

16.23.8 The Engineer shall have the right to test random samples to prove authenticity of the test certificates produced by the Contractor.

16.23.9 Fabrication of EPs

Fabrication of EPs shall be done as per the relevant drawings and specification to avoid any possible damage to the threading on the anchor bolts before erection of the equipment, suitable protective plugs are inserted. In some cases, internally threaded sockets are embedded with top of the socket kept flush with the concrete face.

16.23.10 Welding

All welding procedures and welder performance qualification shall be carried out as per ASME Section IX supplemented by ASME Sec. VIII Div 1 / Div 2 or ASME Sec.-III as and when specified. The welding and other fabrication requirements shall be as per PC-E-160.

16.23.11 Inspections and Testing

All fabricated EP's shall be inspected as per approved QA plan. The inspection shall cover visual examination, MPT, LPT, RT and UT such that these EP's are free from burrs, cracks, nicks and surface irregularities as per previous clauses of this specification. . The DP and Radiography examination and Air Hold Test shall be carried out as per specification No. PC-E-160.

16.23.12 Air hold test / Vacuum box test

All pipe and sleeve EPs of safety systems meant for sustaining pressure or otherwise specified shall be tested for leak tightness. The test pressure/holding time shall be as per the approved Drawings. Air pressure/vacuum shall be held minimum for 10 minutes to detect leakage and pin holes.

16.23.13 Rectification

Any rework / rectification on the EP's required due to improper placement after concreting shall be carried out by the Contractor to the satisfaction of Engineer without any extra cost. This shall also include any additional inspection requirements as decided by Engineer.

16.24 PAINTING

16.24.1 Contractor shall follow the best method of surface preparation and painting system. In order to achieve the maximum durability, one or more of the following methods of surface preparation shall be followed, depending on condition of steel surface and as instructed by Engineer. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system:
Manual or hand tool cleaning
Mechanical or power tool cleaning
Blast cleaning.

16.24.2 Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. The minimum acceptable standards in case of manual or hand tool cleaning shall be St2 or equivalent, in case of mechanical or power tool cleaning it shall be St3 or equivalent, in case of blast cleaning it shall be Sa 2 ½ or equivalent as per Swedish Standard SIS-055900 / ISO-8501-1.Where highly corrosive condition exists, then the blast cleaning shall be Sa3 as per Swedish Standard. Prior to surface preparation all other contaminants, oil, grease etc. Blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceeding 85%. Engineers reserve the right to instruct the type of surface preparation depending upon the condition of material.

16.24.3 Irrespective of the method of surface preparation, the first coat of primer must be applied on dry surface immediately and in any case within 4 hours of cleaning of surface. However at times of unfavorable weather conditions, Engineer shall have the liberty to control time period, at his sole discretion and /or to insist on recleaning, as may be required, before primer application is taken up. In general during unfavorable weather conditions, blasting and painting shall be avoided as far as possible.

16.24.4 Surfaces shall not be coated in rain, wind or in environment where injurious airborne elements exist, when the steel surface temperature is below 5^0C and the humidity is greater than 85%.

16.24.5 To the maximum extent each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spot or areas missed in the application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet & dry film thickness.

16.24.6 Paint manufacturer's instructions shall be followed strictly at all times. Particular attention shall be paid to the following.

16.24.7 Instructions for storage to avoid exposure as well as extremes of temperature.

16.24.8 Surface preparation prior to painting, Mixing and thinning, Application of paints and the recommended limit on time intervals between coats.

16.24.9 Painting shall be carried out preferably by spraying. Brushes may be used sparingly at certain locations only and the brushes used for painting shall be of a style and quality that will enable proper application of paint. Type of brush shall be chosen according to its application and there shall be a minimum of brush marks left in the applied paint. Engineer reserves to instruct type of application of paint.

16.24.10 Joints to be site welded shall have no shop paint for at least 50 mm from the welding zone. Similarly steel surfaces shall not panted in areas where connection is by use of friction grip bolts. On completion of joint the surfaces shall receive the painting as specified.

16.24.11 Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling. As such it is recommended that the primer and finish paint shall be from the same manufacturer.

16.24.12 Contractor shall furnish all the characteristics of paint material along with the test certificates. All paint material shall be of first quality.

16.24.13 All Structural steel surfaces except EPs shall be given the first coat of primer at shop and the second coat after it is erected in position. Further, any abraded surface of the first coat during transport from shop to site and during erection shall be provided with a touch-up coat of the primer. The field primer shall be compatible with the shop primer.

16.24.14 The surface of steelwork to be painted shall be thoroughly cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by grit blasting to white metal in accordance with IS 1477 –Parts I & II./ Swedish Standard SIS 05-5900. At places where grit blasting is not feasible, one coat of suitable approved anti-corrosive paint shall be applied.

16.24.15 The paint treatment specified shall be applied soon after completion of pre-cleaning or pre–treatment in order to prevent contamination of the surfaces in any way, either by brushing or by spraying on the thoroughly cleaned and dry surface as desired by the Engineer. Airless spraying shall be carried out unless specified otherwise by the Engineer.

Sl. No.	Structure	Surface preparation	Primer	Finish coat
1	All steel structure	Clean off dirt, rust, weld spatter & loose mill scale by shot blasting	1 coat of epoxy based approved zinc silicate primer to a film thickness of 75 microns	Hi-build Epoxy paint conforming to relevant specifications to a DFT of 200 microns

SS members shall be painted with the peel able paint, which shall be removed at the time of passivation.

16.24.16 Acceptance Criteria

a) All painted surfaces shall be uniform & pleasing appearance.
b) All epoxy and enamel painted surfaces wherever finish paint is specified shall be of uniform texture and high glossy finish.
c) All storms, splashes & spatters of paints shall be removed.
d) Surfaces shall meet the minimum specified DFT for their respective systems.

16.25 SPECIFICATION FOR FABRICATION OF STAINLESS STEEL EMBEDDED PARTS

16.25.1 SCOPE

This specification covers the requirements for the supply fabrication, inspection, testing and transportation of stainless steel embedded parts.

16.25.2 SPECIFICATION

Mechanical Engineering Drawing Standards - IS 696 (latest)
Assessment of surface roughness - IS: 3073 (latest)
Liquid penetrant inspection of metallic surfaces – ASME SEC V.
Ultrasonic Inspection of Metallic Surfaces – ASME sec V
ASME Boiler and Pressure Vessel Code Section IX Welding (Qualifications)

16.25.3 a) MATERIAL AND WORKMANSHIP

Materials which are not specifically covered & which are necessary for fulfillment of this specification shall be procure by the contractor. He shall be responsible for the correct procurement and performance of these materials, & shall replace at no extra cost to NPC any material failing to meet the requirements of the drawings & specifications.

b) WELDING ELECTRODES

Use of S.S. 308L or S.S.347 electrodes for welding SS 304L is recommended. Electrodes used on the work are to be approved by the Purchaser.

c) WORKMANSHIP

Workmanship shall be in accordance with high standards and adequate, to achieve accuracies and surface finish as shown on the approved drawings and this specification is to ensure satisfactory operation and service life of the liners.

16.25.4 WELDING

Weld shall be made by the weld procedure and welders qualified by tests in accordance with IS: 817 & 1181 and ASME Section IX as specified by the Purchaser. Welding procedure shall be prepared by the Contractor and submitted to the Purchaser for approval before the start of welding.

16.25.5 a) INSPECTION OF WELDS

All services and facilities related to testing and inspection to be provided by the Contractor. The inspection work shall be under the control of a competent Chief Inspector whose primary responsibility is Inspection and reporting to Management. Inspection by NPC or their authorised representative shall not relieve the Contractor of any of the inspection duties called for herein.

All welds including fillet welds shall be subjected to Liquid Penetrant Test.

b) OTHER INSPECTION

The Contractor shall conduct 100% inspection & maintain record for all components and final grids system in accordance with the Approved drawings & Specification. This shall include inspection of the following:

Dimensional accuracy, surface finish, hardness, fit and alignment, workmanship, cleanliness and lubrication, completeness.

16.25.6 TRANSPORTATION

After completion of segmented fabricated line grid, it shall be thoroughly cleaned, protected from dirt, corrosion and damage and suitably braced and packed for transportation**.**

16.26 QUALITY SURVEILLANCE FOR STRUCTURAL STEEL & EPS

16.26.1 General

The Engineer shall subject all works and materials covered by this specification to inspection.

The Contractor shall provide free access in his shop during working hours for the inspection staff, designated by the Engineer, at all phases of the work and assist them where necessary in conducting the inspection. The Contractor shall expeditiously furnish all gauges, instruments and other necessary measuring equipment required for inspection of the work in the shop. The shop inspection by the inspector is intended to ensure that the material and workmanship are in accordance with this specification, but it will be not relieve the Contractor of any of his responsibilities for the product. The inspector’s inspection will include, but not

be limited to, the following:

16.26.2 Material

The inspector will ascertain that only materials conforming to the requirements of this specification are used.

16.26.3 Dimension and Tolerances

The Engineer will ensure and check that the structural members conform to the dimensions and tolerances as set out on the drawings and as required by the specification.

16.26.4 Welding Procedure

The Engineer will witness the welding and testing of any procedure qualification tests that are required by this specification. The Engineer will also check that welding procedure (including the electrode, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

16.26.5 Welding Equipment

The Engineer will check the welding equipment to be used for the work to ensure that it is in such condition as to enable qualified welders to follow the procedures.

16.26.6 Welder & Welding Operator Qualifications

The Engineer will permit welding to be performed only by welders and welding operators who are qualified by tests in accordance with ASME – Section IX.

When the quality of a welder or welding operators' work, appears to be below the requirements, the Engineer may require testing of his qualifications by necessary tests.

16.26.7 Welds

The Engineer will ascertain that the sizes, length and the location of all welds conform to the requirements of this specification and the approved fabrication drawings. Temporary welds used for the works shall be removed and ground flush with the original surface.

The Engineer will identify with a distinguishing mark of all parts of the joints that has been inspected and accepted.

The Contractor shall comply with all the demands of the Engineer to correct improper workmanship and to remove and replace, or correct as instructed, all welds found defective or deficient.

In the event of faulty welding or its removal for rewelding results in damage to the base metal in the judgement of the Engineer, or its retention is not in accordance with the intent of the plans and specification, the Contractor shall remove and replace the damaged materials at his own cost.

17 FIRE PROOFING OF STRUCTURAL STEEL MEMBERS USING INTUMESCENT PAINTING

17.0 SCOPE

This specification covers the requirements in general that needs to be followed for thin Intumescent Coatings used as Passive Fire Protection measure on Steel Structures of defined fire ratings, wherever applicable. The specification in general covers the requirements for selection of coating, testing, application & quality control measures which shall be followed to use the Thin Intumescent Coatings. Wherever Intumescent Paint is proposed to be used in radiation area, the adequacy of same shall be established prior to its use.

17.1 INTUMESCENT COATING SYSTEM

The system shall comprise the 3 layers i.e primer, basecoat and seal top or decorative coat. The Primer & Seal/Top coat shall be compatible with base coat. The product proposed for use shall be manufactured by a reputed & experienced company having In-house R&D & fire test facility, unless approved otherwise.

The Coating shall be certified from reputed agencies like UL (USA) & Warrington (UK) etc. The certifying agency shall be well recognized and acceptable to NPCIL.

Unless approved otherwise, the Primer, Intumescent base coat , seal coat or decorative top coat should be sourced from the same manufacturer, to assure their compatibility.

The coating system should be such, where recoating of the coating shall be feasible if required, with approved top / seal coat for asthetic reason. It shall also be feasible to repair the same as per approved procedure from Manufacturer in case of damage to Intumescent coating.

17.1.1 PRIMER

A protective coating, usually anti-corrosive, is applied to the substrate prior to application of the basecoat. It shall also provide adequate adhesion to base coat in case of fire.

For site applied Intumescent coatings, the primer is the only part of the total system that would normally be applied in shop and balance base coat & Seal Coats are applied a site.

17.1.1.1 PRIMER SELECTION

The choice and thickness of primer shall depend on

- the In-service environment, which affect the degree of anti-corrosive protection required.
- where the primer is to be applied, and subsequent Intumescent basecoat application requires a significant delay between steel preparation in shop and final erection and completion of coating at site, the primer needs to have suitable weathering properties and durability, it must be suitable for over-coating with the intumescent coating after the appropriate time interval, and it should be sufficiently tough to be transported with minimum mechanical damage. In such cases the primer may be applied in 2 stages, if recommended, by coating manufacturer.
- the primers having poor heat resistance, and likely to have a detrimental effect on the performance of the intumescent in a fire shall not be used.
- primers based on weaker solvents than the (solvent based) intumescent, may exhibit defects such as rivelling and/or wrinkling when over-coated, and therefore shall be avoided.
- the primer shall be compatible with base coat and generally manufactured by same manufacturer, In case primer from different producer, if used with prior approval, before application of the Intumescent basecoat, the confirmation from the Intumescent manufacturer shall be obtained in writing, such that the primer and Intumescent basecoat are compatible in both ambient and fire conditions. In such case the technical data sheet for the primer, the actual primer thickness and information regarding the length of time the primer has been applied should be shared with base coat material supplier, who should then be able either to give approval for use of the primer, or to provide alternative advice.

17.1.1.1.1 COMPATIBILITY OF INTUMESCENT COATINGS WITH ZINC RICH PRIMERS

Wherever Zinc rich primers, are used to avoid problems of inter-coat adhesion. It is essential that the zinc salts, if exist due to prolonged exposure prior to application of base coat, are completely removed by washing down with clean fresh water. Where full removal of zinc salts cannot be guaranteed, the option to remove the zinc coating and re-prime the steelwork shall be followed.

Formation of Zinc salts can be prevented by applying a tie-coat over the primer at the fabrication stage. The Intumescent coating can then be applied to the tie-coat.

The application of water based intumescent coatings(if approved to use) directly over zinc rich primers is not recommended.

In all cases, the intumescent coating manufacturer should be consulted to confirm the compatibility of the priming system with the intumescent system and, where applicable, the tie coat.

17.1.1.1.2 COMPATIBILITY OF INTUMESCENT COATINGS WITH EXISTING PAINT LAYERS

Steelwork requiring refurbishment will usually be treated with an existing coating system. The existing paint coatings are likely to be old and their adhesion to the substrate, or between layers of the system, may be poor.

In such cases earlier coating shall be completely removed and the application of a primer/primer system compatible with the new Intumescent system shall be applied. The old paint shall be preferably blast cleaned to Sa 2½ standard as defined in BS EN ISO 8501-1. The blasted surface provides a suitable base for the application of the new priming system.

In situations where site conditions may make abrasive blast cleaning impractical or unacceptable, the use of manual cleaning methods may be considered. Impact tools such as chipping hammers, needle guns are reasonably effective in removing old paint coatings . Power rotary wire brushes may also be used to remove the existing paint, where a compatible surface tolerant primer is used. When using power tools care should be taken to avoid polishing the surface, and to achieve an acceptable profile or anchor pattern.

The Intumescent system manufacturer should be consulted to provide advice about surface preparation standard, with appropriate supporting evidence.

Where a manufacturer wishes to demonstrate that compliance can be achieved by the application of an Intumescent system over existing painted surfaces of known generic type and thickness, fire test evidence should be available to provide a technical justification. Agreement should be reached with NPCIL about the applicability of the test data to the circumstances which prevail on the specific site.

17.1.2 BASE COAT

The base coat shall be Solvent based Intumescent Coating of approved Dry Film Thickness, unless approved otherwise.

The Intumescent coating (Base Coat) shall be fit for use for given "In service environment exposure condition". The coatings proposed to be used in exterior condition shall be specifically certified for its suitability for exterior use. Wherever, coatings of interior members needs to be left exposed, while erection for a reasonable period of time prior to completion of enclosure, the same shall be adequately protected with suitable seal coat to avoid any damage to base coat from moisture etc.

Wherever unusual conditions given below are likely to arise, the advice of the coating manufacturer about suitability of coating, should be sought:

- If environment change in the foreseeable future.
- If some form of local pollution present. For example, high levels of sulphur dioxide could produce acidic conditions and this in turn may influence the type of seal coat required.

- If conditions vary within the building. For example, roof spaces (of an air conditioned building) subjected to periodic condensation.
- If some elements of the construction particularly vulnerable to impact damage.
- If any unusual processes likely to cause localised special conditions, such as splashing, water pooling, localised high temperatures etc.

17.1.3 SEAL COAT OR TOP COAT

A Polyurethane coating of specified thickness shall be applied over the basecoat to prevent the basecoat from environmental degradation and abrasive damage as seal coat.

17.1.4 FIRE TESTING OF COATING

Fire protection systems for steel structures are tested for their ability to retard the rate at which the steelwork heats up in a fire.

If desired by NPCIL, the coating system (Inclusive of all 3 coats, as proposed to be used) shall be independently evaluated by performing the fire testing in independent approved laboratory, before acceptance of product. The number of test samples shall be decided based on variability of coating thickness proposed to be used in the project and with mutual consent of NPCIL & Contractor. Generally, for a given fire rating and coating thickness the member having highest Hp/ A (Heated Perimeter/ Cross-sectional Area) shall be most critical and selected for testing. The cost of testing upto 2 samples are deemed to be included in the coated rate . In case if it is decided to test more than 2 samples, the cost of such additional tests (Beyond 2 Samples) including materials & labour shall be reimbursable to the contractor on actual expenditure, If the product is successfully tested and qualified. However, in case of failure of coating on testing, the cost of testing shall be compulsorily borne by the contractor.

17.2 FIRE RATING

It is defined as the ability of an element of building construction/ component for structure to fulfill, for a stated period of time, the required stability, fire integrity and or thermal insulation and/ or other expected duty in a standard fire resistance test.
The fire resistance requirement for a building is defined in terms of the fire resistance period and stated in terms of minutes (15, 30, 45, 60, 75, 90 or 120 minutes) based on standard time temperature curve as per ISO 834 / IS 3809.
The fire rating of the members shall be derived, based on relevant codal provisions or from Fire Hazard Analysis. The fire rating for each member shall be as specified and approved by NPCIL.
Wherever specified, the ability of a component or material to achieve the required fire resistance period is demonstrated by subjecting it to a standard fire test as defined in BS 476-20 /21 or BS EN 1363-1 or ASTM E119 as approved from NPCIL.

In case of Intumescent Coating the adequacy of the system under test, shall be decided based on the fulfillment of requirement, that the substrate temperature does exceed the critical temperature when heated for rated duration as per standard time temperature curve given in IS 3809.

17.3 CRITICAL TEMPERATURE

Unless specified otherwise, the critical temperature for member with 4 side exposure & 3 side exposure shall be 550 deg C and 620 deg C respectively.

17.4 FILM THICKNESS OF INTUMESCENT SYSTEMS

Primer, Base Coat and seal coat / decorative top coat thicknesses shall be as specified and approved by NPCIL.

Unless specified otherwise, the thickness of primer & seal coat shall not vary with size of member, for a given fire rating. However, the thickness of base coat may vary as per its Section Factor, fire rating, critical temperature & exposure condition etc.

17.4.1 PRIMER FILM THICKNESS

The thickness of primer shall be as specified and approved by NPCIL. In no case, the primer thickness shall exceed the upper limit, if any, specified by the coating certifiying agency or by the coating manufacturer, above which the performance of the intumescent may be impaired in a fire situation.

Wherever, steelwork delivered to site is treated with a primer applied elsewhere in shop, the compatibility of the primer applied shall be ensured with Intumesecent coating by the coating manufacturer. The correct thickness of the primer applied in shop shall be properly documented and informed to Base coat applicator, to work out the thickness of base coat from combined thickness measured after application of base coat. In case, such records are not available, the site applicator must conduct a primer thickness survey prior to commencement of intumescent application to the satisfaction of NPCIL.

17.4.2 BASE COAT THICKNESS

Unless specified otherwise, the DFT of base coat shall be derived based on charts of proposed coating material, certified from the reputed agencies like UL (Under Writer Laboratories, USA) & Warrington, UK etc. The base coat thickness shall be derived based on critical temperature of the member, its desired fire rating, its section factor , no of sides exposed to fire etc. using above certified charts. The correct film thickness must be determined for each section, in order to produce a list of section sizes with their associated film thicknesses for the entire project.

The contractor shall prepare a painting schedule of primer, intumescent coating & seal coat thicknesses required to provide fire protection to each of the steel sections to achieve the specified fire resistance periods. This schedule shall be submitted to the NPCIL for review and approval, prior to commencing the works. The schedule must include, but not be limited to, the following.

(i) Fire resistance period(s) required.
(ii) Steelwork references as noted on general drawings.
(iii) Steelwork section sizes and section factors.
(iv) Details of any partial fire protection, if provided by concrete floor slabs etc.
(v) Name of intumescent product(s) specified / selected.
(vi) Method used to determine required coating thicknesses.

The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

17.4.3 SEAL COAT FILM THICKNESS

The coat thickness shall be as specified and approved by NPCIL.

17.4.4 PAINT THICKNESS ON BOLT HEADS AND STEEL TO STEEL CONNECTIONS

Where structural steelwork is treated with intumescent in shop and erected in finished condition, special provision has to be made for the coating on site of bolt heads and other surfaces not previously fire protected. As per recommendations of BS 5950 Part 8, the protection coating thickness on bolt heads and connections should be the same as that on adjacent steel sections.

Where the coating operation is delayed for any reason or where the bolts/ connections are made of a special material proper cleaning prior to coating shall be carried out. In such case a special adhesion primer may be required before application of the intumescent in consultation with coating manufacturer and approval of NPCIL.

17.4.5 FILM THICKNESS DETERMINATION

The correct thickness of intumescent coating system applied on the members shall be confirmed before proceeding to application of the decorative topcoat, as any deficiency in intumescent thickness can be best corrected at this stage.

The average DFT of the primer coat shall be properly recorded and verified in the shop. If same is not available it shall be measured physically at site. prior to application of Base Coat. After application of the intumescent basecoat, the average primer thickness should be subtracted from measurements taken on the basecoat, to establish the true intumescent thickness.

The thickness of topcoat must be confirmed in the same way as for the intumescent basecoat above.

Where decorative appearance is important and requires additional coats of finish, or where additional topcoat thickness is required to protect from severe environmental

conditions, the intumescent manufacturer should be consulted to confirm that the additional thickness will not inhibit the fire resistance of the system.

17.5 IN-SERVICE ENVIRONMENT

The nature of the environment to which the coatings will be exposed may affect their durability or their performance in a fire situation, and must therefore have a major influence on the properties required of them. Environment may have a significant bearing not only on the choice of intumescent basecoat, but also on the type and thickness of anticorrosive primer and on the type and thickness of seal coat.
For steel protection generally, BS EN ISO12944-2:1998(7) defines a number of environments in terms of 'corrosivity', based on relative corrosion rates of carbon steel, as follows:
Category C1 Very low
Category C2 Low
Category C3 Medium
Category C4 High
Category C5-I Very high (Industrial)
Category C5-M Very high (Marine)

ISO 12944 relates these categories to the composition and thickness of different protective coating systems required to provide short, medium or long term protection against corrosion, but only categories C1 and C2 would be considered typical of most thin film applications.

Examples of typical environments for each category are given in Table 17.1 below.

For C1 environments (the most common for fire protection) corrosion protection may not be strictly necessary but for site-applied intumescent coatings an anticorrosive primer may still be specified to provide temporary protection .

For all other environment categories some degree of corrosion protection would normally be included, but the specifier must also consider the type and thickness of seal coat that may be necessary to prevent degradation of the intumescent by moisture from humid atmospheres, condensation etc.

TABLE 17.1: CLASSIFICATION OF ENVIRONMENT TYPES

Corrosivity Category	Corrosion/ Exposure Rating	Examples of typical environments in a temperate climate (information only)	
		Exterior	Interior
C1	Very low	N/A	Inside heated or air-conditioned buildings with clean atmospheres. Low relative humidity and no likelihood of damp or condensation e.g. offices, schools, shops, hotels.
C2	Low	Atmospheres with low level of pollution and fairly dry climate. Mostly rural areas. Intumescent use mainly in sheltered locations e.g. under canopies.	Occasional damp or wet conditions. Unheated buildings where water leakage or condensation may occur, e.g. unheated warehousing, sports halls, plant rooms etc and in roof voids.
C3	Medium	Urban and industrial atmospheres, moderate sulphur dioxide pollution. Coastal areas with low salinity. Examples would include exposed car parks.	Constant damp atmosphere, but may be warm and well ventilated. Production rooms with high humidity and some air pollution, e.g. food processing plants, kitchens, laundries, breweries, dairies.
C4	High	Industrial areas with high sulphur dioxide pollution and coastal areas with moderate salinity. Typical areas include tank farms, petrochemical installations etc or exposed exterior surfaces of any structure in a polluted environment.	Interior of chemical plants subject to continual injection of chemical vapours or steam in the atmosphere. Constant warm and high humidity conditions such as in swimming pools. Coastal ship and boat yards.
C5-I	Very high	Industrial areas with high humidity and aggressive atmosphere. Thin film intumescents should only be used with manufacturer advice.	N/A
C5-M	Very high	Coastal and offshore areas with high salinity. Thin film intumescents should only be used with manufacturer advice.	N/A

17.6 STORAGE

The storage of all material(s) should be strctly in accordance with the manufacturer's recommendations . As a general guide, the storage temperature for all material(s) will be within the range of 5 -30°C, and any water based materials in particular should always be protected from frost. Material containers should remain unopened until needed and should be used in date order (FIFO).

All materials delivered to site must be used within the manufacturer's stated shelf life, or otherwise be approved in writing by NPCIL, if declared suitable for use by the original manufacturer.

17.7 APPLICATION OF COATING SYSTEM

17.7.1 PREREQUISITES

Application must not proceed, if the prevailing environmental conditions are outside the limits set out in the manufacturer's technical data sheets.

As a general rule, environmental conditions – air and steel temperatures, humidity and dew point – should be determined before commencement of work in the morning, afternoon and evening (if appropriate), and at other times if conditions show a noticeable change (e.g. if it starts raining). All measurements should be logged and be available for inspection at all times.

Prior to site application, all surfaces to be coated should be in a clean, dry condition and any areas not requiring fire protection or which may be exposed to overspray should be appropriately protected by masking.

The applicator should ensure that all equipment required to carry out the surface preparation and application of all components of the intumescent coating system, according to technical specification, are available and in good working order.

The applicator must ensure that all relevant Health and Safety data sheets, application instructions and method statements are available and are fully understood.

Where required, mixing should be carried out in accordance with the manufacturers' instructions. Materials taken from store should attain the temperature recommended for use before being applied.

The scheduling of the works should be such that sufficient areas are made available, allowing free access for the applicator of the intumescent coating system to apply the material to the required specification.

All work should be scheduled to ensure that the conditions required by the manufacturer (temperatures and humidity, over-coating times etc) can be met.

It is particularly important that where application is to be carried out in a partially clad building (i.e. not theoretically open to the elements), the contractor ensures that the building is water-tight and that areas where coatings are to be applied are not directly exposed to external weather conditions at any time.

17.7.2 MONITORING OF ENVIRONMENT CONDITIONS

No application should take place on site when environmental conditions – air and steel temperatures, relative humidity, dew point – are outside the limits laid down by the coating supplier, to avoid any detrimental effects on both film formation and integrity of the coating (especially water based systems) as well as on long term performance.

Typically, steel temperatures should be more than 30 C above the dew point to ensure that no (visible or invisible) moisture or condensation is present on the surface during application.

The applicator's shall monitor these conditions in accordance with the specification, and to maintain auditable records to demonstrate compliance.

17.7.3 SURFACE PREPARATION

Steel surfaces should be prepared by removing scale and rust using abrasive shot blasting to a minimum standard of Sa2½ as defined in BS EN ISO 8501-1: 2001 "Preparation of steel substrates before application of paints and related products"

Prior to the commencement of blast cleaning all steel surfaces should be clean and dry. Oil and grease contaminants, if present, should be removed by the use of suitable emulsifying degreasers, suitable clean organic solvents or steam cleaning before the commencement of blasting.

A surface profile shall be within the range of 35 – 75 micron in general suiting to primer and as specified by the Coating Supplier and shall not exceed 100 microns.

All dust and spent abrasive must be removed from the prepared steelwork by blowing down with clean dry compressed air.

17.7.4 APPLICATION OF PRIMER

The primer of specified thickness should be applied before the blast cleaned surface deteriorates.

Where the steel sections are (more normally) blasted and primed in shop, the same surface preparation standards as above would be specified, but after transportation and site storage further measures need to be included to ensure cleanliness of the primer prior to over-coating with the Intumescent basecoat. In such case the primer may be applied in 2 stages, if recommended, by coating manufacturer. The first stage primer shall be applied in shop to protect the shot blasted surface till final painting, and second coat of primer shall be applied prior to application of

Intumescent Coating in consultation with coating manufacturer. The necessary surface preparation at each stage shall be carried out in line with coating manufacturer recommendations. The next stage of coat shall be applied after minimum curing time of previous coat and shall also be completed before the end date if specified by the coating manufacture.

The coating manufacturer shall ensure and certify that the primer & process followed in such a way shall not adversely affect the performance of the coating.

The primer should be applied to the specified dry film thickness and the thickness measured in accordance with the approved procedure.

When thicknesses are found to be outside the specification, the advice of the designer and/or primer and intumescent coating manufacturer should be sought and remedial action carried out as necessary.

Because different structural steel sections may require different intumescent basecoat thicknesses, it is important to ensure that all sections are correctly marked or otherwise identified for application and record purposes. Marking is best carried out after completion of priming and should not interfere with the application or operation of the intumescent coating system.

Where unprotected elements meet fire protected elements in a structure, it is normally considered good practice to overlap the fire protection onto the adjoining 500mm of 'unprotected' structural steel to limit heat transfer into the protected substrate.

17.8 QUALIFICATION OF APPLICATOR

The fire performance of a product, component or structure is dependent on satisfactory site application and maintenance. Competence in application requires an understanding of the importance of such factors as surface preparation, data sheet limitations for conditions during applications, achievement of film thickness etc. Such competence is important for any coating operation, but for intumescent paints the potential consequences of coating failure make the standard and control of application quality even more critical. Therefore, these coating shall be applied by experienced persons who know and understand not only the practicalities of coating application, but also the importance of attention to detail in the installation process. The applicator shall be certified by the Intumescent Coating Manufacturer, which shall provide confidence in the appropriate standard of workmanship being provided.

17.9 APPLICATION METHODS

The application of all coatings should be carried out fully in accordance with manufacturers' technical data sheet requirements and the applicator's method statement approved by NPCIL. These in turn must reflect fire test and assessment conditions.

While airless spray is generally the preferred method of application for most coatings, the use of this method on site may be restricted, in such cases either provision to protect adjacent buildings and the surrounding environment from

overspray shall be made, or brush/ roller application may be followed if permitted as per coating manufacturer recommendations.

Where spray is not possible, a larger number of coats by brush or roller may be required, and minimum and maximum over- coating times must be observed. In such case he recommended thicknesses provided on manufacturer's data sheets, along with the maximum achievable thickness per coat by the different methods may be used as basis of application.

17.10 THINNING AND EQUIPMENT CLEANING

Thinning of Intumescent product may be permissible to aid application characteristics with prior approval of NPCIL, particularly where ambient temperatures affect product viscosity and make a good quality finish difficult to achieve. However, excessive thinning can create sagging, drying and film formation problems, particularly where high film thicknesses are involved, so all thinning is subject to approval by the manufacturer in writing. Only thinners approved by the manufacturer may be used, if approved.

Wherever, solvent is used for equipment cleaning, the same should be approved by the coating manufacturer as being compatible with the coating system, as incompatible gun-washes left in equipment overnight can give rise to film formation defects if mixed in with the coating.

It should be noted that thinning with solvent will invalidate the wet to dry ratio given on the product data sheet and may significantly affect the VOC (Volatile Organic Compound) content of the coating, and hence its use should be limited so that it does not adversely affect compliance with environmental legislation and does not causes any health hazard to the applicator and surroundings.

17.11 HANDLING, TRANSPORTATION AND STORAGE OF SHOP-PRIMED STEELWORK

The primers used for the shop priming of structural steelwork shall be fairly tough ,resilient, and shall be resistant to mechanical damage . Further, the contractor is required to implement protective measures and appropriate care during the transport, storage and erection of steel structures.

Coatings should be sufficiently dry before handling and members should be lifted at designated lifting points or by using lifting brackets where available. The use of lifting chains in contact with coated steel is preferred to strops/webbing slings as the former cause only minimal damage that is normally easy to rectify. Member shall be preferable lifted in single lift.

The loading of trailers should be carefully planned, with timber supports positioned, where possible, in uncoated contact areas (e.g. areas to receive bolted connections). Where contact of supports with coated areas is unavoidable, members should be supported on their toes to minimise the contact area. Where thin-film prefabrication primer only has been applied in shop, members which may fill with water should be

prevented from doing so by the use of covers to avoid premature breakdown under immersion. Loads are best secured with the careful use of clean chains and it is advised that the loaders wear overshoes and where possible avoid walking on coated surfaces in order to minimise contamination.

Where site storage is unavoidable, similar care should be taken in the handling and support of the coated steel using the same lifting and support points as those used in transportation. Where possible members should not be stacked and water ponding should again be avoided using localised protection where necessary. The contractor should be made fully aware of the importance of good handling practice and storage areas should be roped off with signage clearly explaining the need to avoid contamination and mechanical damage to the coating finishes.

Similar care should be taken during the erection phase, with any lifting activities making use of strategically positioned holes, lifting lugs and brackets etc to minimise damage to the body of the paintwork.

17.12 TREATMENT OF SHOP-PRIMED STEELWORK AT SITE

17.12.1 REPAIR OF TRANSIT DAMAGE

Despite the contractor's efforts to be careful, some damage to the coating will inevitably occur during handling and transportation. Further damage may occur as a result of site modifications, welding etc prior to the application of the intumescent basecoat.

The nature and extent of primer repair required will vary, dependent on

- The scale of damage incurred.
- The degree of deterioration of the damaged surface.
- The type of exposure – i.e. the service environment and the importance of the primer in providing long-term anticorrosive protection.

Even where damage to the primer is extensive, provided that the exposed steel surface has not badly corroded it may be sufficient to re-prepare the surface to an acceptable standard prior to application of the intumescent basecoat overall i.e. without reinstating the primer. This might be acceptable, for example, where conditions during application are acceptable and subsequent exposure is to an environment of corrosivity category C1, provided the intumescent coating manufacturer agrees.

17.12.2 Repair of weld damage area

In cases where on-site welding, cutting or grinding has been necessary, all affected areas must be re- prepared to a standard agreed with the intumescent manufacturer, and cleaned down to remove any resultant contamination.

In general, site welding would be carried out prior to application of the intumescent basecoat, and the welds and heat-damaged areas then re-prepared by suitable mechanical means such as power discing and/or grinding prior to reinstatement of the

primer. Where welding is carried out after application of the intumescent basecoat, any heat-damaged coating should be cut back to a sound coating (distance) prior to re-preparation and reinstatement of all coats in the area of repair.

Where subsequent service is to be in an environment subject to damp or wet conditions – e.g. humid buildings without air conditioning, swimming pools etc – the anticorrosive coating may be important to the long term performance of the system and a good standard of surface preparation and reinstatement of the full anticorrosive primer thickness may be necessary. In all cases, the advice of the intumescent manufacturer should be followed.

17.12.3 Contaminated and corroded primer

Where a thin coat of primer is specified to provide protection of the blast cleaned steel during the transport and erection stages only, any delays in the build programme may result in some breakdown of the coating and consequent corrosion (rust rashing) of any exposed steelwork. In such cases if decided by the Engineer, re-preparation shall carried out by the contractor. Depending on the extent of corrosion and the nature of the intended service environment, the decision may range from no re-preparation to manual re-preparation of affected areas followed by immediate application of the intumescent basecoat overall, or manual preparation to BS EN ISO 8501-1 St3 standard, followed by re-application of primer prior to completion of intumescent coating. Wherever, the primer forms a functional part of the long term protective system and to be used under severe exposure environment re-preparation at site shall be required.

Where the primer is in good condition but in a contaminated state, it be cleaned using suitable methods such as washing using detergent and/or fresh water pressure washing and allowed to dry before application of the intumescent basecoat. The decision of NPCIL in this regard shall be final.

17.13 SEALING OF INACCESSIBLE AREAS

If some gaps are present in structures, where moisture ingress may occur and if not sealed may cause problems such as blistering or degradation of the intumescent coating after application. Such areas need to be sealed prior to application of the intumescent basecoat, with a moisture resistant intumescent mastic or equivalent, prior to the application of intumescent basecoat.

Areas like interface between the top flange and concrete decking, may allow moisture to penetrate and this will take a long time to dry out, even if environmental conditions are satisfactory for paint application.

17.14 REPAIR PROCEDURE

During the application process and after completion of the work, repairs may be necessary to ensure that the standard of fire protection, surface integrity and finish is in accordance with the original specification. The cause of the damage or degradation should be addressed prior to carrying out the repairs, to avoid any repetition.

Before carrying out on-site remedial works, a written Method Statement for repair procedures shall be prepared by the contractor and submitted to the NPCIL for review and approval.

The contractor shall be responsible for identifying all areas requiring remedial works and for rectification in accordance with the coating manufacturer's recommendations. Issues such as compatibility, effectiveness and adhesion of combined thicknesses etc shall be considered while taking the decision.

In case, where the intumescent coating has detached due to mechanical damage, or suffered localised degradation due to water ingress, the normal repair procedure of mechanical removal of the damaged or denatured coating to a firm (unaffected) edge, followed by reinstatement of the system to the original, specified thickness shall be followed.

17.14.1 Repair of film thickness deficiencies

If the dry film thickness of the intumescent basecoat or topcoat, does not comply with the nominal dry film thickness stated in the schedule of thickness, work shall be undertaken to bring the affected area up to the required thickness.

Where a decorative finish has been specified, the contractor shall make provision for the removal of all visible dirt from the surface of the coating, following erection of the steelwork.

17.14.2 Repair of damage to completed Intumescent coating systems

Remedial work on complete fire protection systems will depend on both the extent of the damage and whether or not a seal coat was applied to the original coating.

Minor damage, such as chips and scrapes, will not normally affect the performance of the material unless the service environment is wet or exposed, in such case damage may allow moisture ingress and lead to degradation of the intumescent. It is therefore recommended that minor damage should be repaired with the approval of NPCIL at the earliest opportunity, following the procedure given below:

a) In cases of damage to the basecoat, the damaged area should be cut back to a firm edge. If the primer coat is damaged, any corrosion products which may have formed should be removed and the steelwork "patch primed" using a suitable compatible primer.

b) If only the basecoat is damaged, fresh basecoat or approved repair material should be applied to match the existing thickness, taking care not to excessively overlap onto the surrounding intact seal. When the dried intumescent material matches the surrounding thickness, the recommended seal coat (if any) should be applied either to the patch repair or overall.

c) If only the seal coat is damaged, fresh seal coat should be applied, either to the localised area, or over the whole section.

In the unlikely event that major repairs are required (i.e. due to water or chemical attack), the intumescent coating manufacturer should be consulted for expert advice and repair shall be carried out as per approval of NPCIL.

17.15 HEALTH AND SAFETY PROVISIONS

Products used on site shall comply with the recommendations of manufacturers' health and safety data sheets, and that the safety of all personnel in the vicinity of the application is protected. During and throughout the application process, full compliance with all relevant Health and Safety and Environmental legislation must be demonstrated. As a minimum this includes

- Observance of all precautions and conditions for use of the coating system, as defined in the manufacturer's Product Safety Data Sheets.
- Compliance with relevant Site Storage Regulations.
- Compliance with all applicable relevant Waste Disposal Regulations, in particular for the Hazardous Waste.

17.16 DESIGN LIFE AND LIFE TO FIRST MAINTENANCE

In general the intumescent systems along with seal coat should not require maintenance before 15 years, other than for decorative purposes or where mechanical damage has occurred and shall be guaranteed for same. The thickness of the seal coat shall be decided according to above requirements.

The Coating shall be regularly and frequently inspected of the condition of the fire protection. A schedule of regular maintenance shall be prepared in service. Wherever, there is any doubt about the capability of a thin film intumescent system to provide the required long term durability, a thick film system may be advised.

17.17 QUALITY PLAN, INSPECTION CRITERIA AND METHODOLOGY

17.17.1 QUALITY PLAN

Competent contractors and applicators shall have in-house systems in place to control site work and to demonstrate compliance with specification requirements. The quality plan shall cover the sequence of activities required to deliver the specified quality of finish. This plan shall also identify the inspection stages and hold point in the process, and shall be submitted to NPCIL for approval prior to commencement of the work.

17.17.2 Measuring Equipment

The following fully calibrated and certificated measurement equipment to be available on site

- Where steel surface preparation is to be carried out at site, pictorial standards for blast cleaning and for manual / mechanical surface preparation as supplied with EN ISO 8501-1:1988 should be available to ensure the correct standard is being achieved.
- Comparator plates or Testex tape and micrometer are required to determine the blast profile, where relevant. EN ISO 8503-1:1988 and EN ISO 8503-5:2004 apply.
- Ambient temperature thermometer.

- Minimum – maximum thermometer.
- Steel temperature gauge, preferably electronic.
- Whirling hygrometer, together with a relative humidity and dew point calculator as included in EN ISO 8502-4:1999, or electronic equivalent.
- Instruments which provide ambient and substrate temperatures, relative humidity and dew point calculations automatically.
- Tape measure to check steel section sizes, if necessary.
- Wet film thickness gauges.
- Dry film thickness gauges having a measurement range appropriate to the specified dry film thickness. Ideally the instruments used should have the capability to record thickness readings in batches, and it would aid the completeness of records if the readings were also downloadable to computer.

17.17.3 Site inspection criteria

Typically, the inspection criteria shall include the following

1. Surface preparation

- Surface preparation standard – as specified, usually against EN ISO 8501-1 or equivalent
- Surface profile minimum and maximum – as specified (EN ISO 8503-2) or equivalent
- Dust or other contamination – visual or EN ISO 8502-3

2. Application

- Air temperature, substrate temperature, relative humidity and dew point (throughout the application process) – as specified or as manufacturer's data sheet.
- Batch numbers of all products used
- Dates and times of application and compliance with recommended over-coating times from manufacturer's data sheets
- Wet film thickness checks

3. Dry film checks

- Dry film thickness survey and records
  (i) at primer stage
  (ii) after application of intumescent basecoat and
  (iii) on completion of coating

  Thicknesses at each stage should be in accordance with the specification.
- Visual appearance – as specified or in accordance with agreed standard.

  NB: Dry film thicknesses should always be checked against the approved film thickness schedule, which defines the required thickness for each individual steel

member. Drawings or tables showing the correct thickness for each member must therefore be available to the inspector (contractor's QA representative or NPCIL representatives) prior to a dry film thickness survey.

17.18 INSPECTION METHODOLOGY

17.18.1 WET FILM THICKNESS

Wet film thickness measurements should be taken during application using a wet film gauge. These readings will provide a guide for the applicator to ensure that the required dry film thickness of the primer/basecoat/seal coat will be achieved. Wet film thickness measurements indicate the thickness of an individual coat. Care should be taken when applying subsequent coats, as readings may be misleading due to the gauge sinking into a softened previous coat.

Information on the wet film thickness necessary to give a specified dry film thickness should be obtained from the relevant intumescent manufacturers' technical data sheet(s).

17.18.2 Dry Film Thickness (DFT)

17.18.2.1 MEASURING GAUGES

The method of Dry Film thickness determination shall use a gauge employing the electro-magnetic induction principle. Such instruments shall have a range appropriate to the specified dry film thickness and shall be calibrated on a smooth plate prior to use. Calibration should use shims appropriate to the specified film thickness.

If feasible, the instruments should be capable of storing data. Ability to print and/or download to computer.

17.18.2.2 Thickness measurement

Primer thickness may be determined either after application in shop, or on site prior to commencement of application of the intumescent basecoat.

Allowing for the thickness of primer applied, the total dry film coating thickness of the intumescent basecoat should be determined prior to the application of any specified protective/decorative topcoat(s). Measurement at this stage will more easily facilitate any subsequent corrections which may prove necessary.

If the total intumescent dry film coating thickness, allowing for the underlying primer, is found to be within specified tolerances, application of the next coat (usually a decorative and/or protective coat) can proceed.

If the total intumescent dry film coating thickness is found to be outside the specified tolerances, the procedure outlined in section 19.4 should be followed.

Indentation of the coating by the measuring instrument probe indicates insufficient hardness of the coating and measurements should be deferred. However, if programming requires coating to precede urgently, with prior approval of NPCIL,

a shim of known thickness can be used to spread the load of the probe tip on the coated surface, allowing measurement to proceed before the coating has fully hardened. The dry film thickness of coating and shim together can then be measured and the shim value deducted to give the coating thickness.

Application within the specified tolerances shall also be ensured by careful monitoring of material usage and the elimination of surface defect prior to application.

When taking dry film thickness readings, it is recommended that no readings are taken within 25mm of the edge of an I section or within 25mm of the join of flange to web of an I section.

Taking the above into account, readings should be taken randomly over the remaining areas of the section with a frequency as described in clause 19.3 below.

17.18.3 Frequency of measurement

Sections should be measured in accordance with the following guidelines

A) For first 10% members or till consistent performance to the satisfaction of NPCIL is achieved, whichever is later, the thickness measurement shall done as per following frequency.

(i) I Sections, Tee Sections and Channels
Webs: Two readings per metre length on each face of web
Flanges: Two readings per metre length on the outer face of each flange
One reading per metre length on the inner face of each flange.

(ii) Square and Rectangular Hollow Sections and
Angles: Two readings per metre length on each face.

(iii) Circular Hollow Sections
Eight readings per metre length evenly spread around the section

Where members are less than 2m in length, three sets of readings shall be taken, one at each end and at the centre of the member. Each set shall comprise the number of readings on each face given by (i), (ii) or (iii) above, as appropriate.

Following guidelines for setting out a film thickness survey shall be followed.

- The contractor must provide suitable and adequate means of access, including to difficult and / or partially inaccessible areas. It is therefore important that surveys are scheduled when the fullest possible access is still available on site.
- All equipment used must be correctly calibrated, and if more than one party is carrying out thickness checks, agreement regarding calibration of all instruments must be reached before commencing.
- At least 10% of steel sections should be measured in accordance with the frequency set out in 19.3 A) above. These should include a representative mix of section sizes, and difficult access sections as well as those that are easiest to access.

- All other sections should be measured with reduced frequency with prior approval of NPCIL, unless the detailed survey (of 10% of sections) identifies a recurrent problem of thickness.
- If the detailed survey reveals a trend of unacceptable thickness, this should be taken into account when planning the remainder of the survey.
- In the worst case scenario, a full and detailed survey according to 18.3 A) above may be adopted.
- If certain faces of the sections are repeatedly found to be unacceptable (e.g. top flange or one face known to be difficult to access), the remainder of the survey should include detailed measurements of that face as well as random measurements of other faces.
- Where no unacceptable trends are identified, the remainder of the survey should consist of random readings taken at a frequency of 4-5 readings per metre length.
- Unacceptable low areas should be marked up for remedial coating by the inspector.

17.18.4 Acceptance criteria

The coating thickness acceptance criteria shall be as follows, assuming that the specified thickness is a nominal value:

(i) The average dry film thickness applied to each element shall be greater than or equal to the specified nominal value.

(ii) The average measured dry film thickness on any face of any member shall not be less than 100% of the specified nominal value.

(iii) Dry film thickness values less than 80% of the specified nominal value are acceptable, provided that such values are isolated and that no more than 10% of the readings on a member are less than 80% of the specified nominal value.

Where any single thickness reading is found to be less than 80% of the specified nominal value, a further two, or where possible three, readings shall be taken within 150 to 300 mm of the low reading. The initial reading may be considered isolated if all the additional readings are at least 80% of the specified nominal value. If one or more of the additional readings are less than 80% of the specified nominal value, further readings shall be made to determine the extent of the area of under thickness. In such cases, low thickness areas identified should be brought up to the required thickness before proceeding to the next application stage.

(iv) The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

17.19 CORRECTION OF DEFECTIVE OR INADEQUATE COATINGS

17.19.1 THICKNESS CORRECTION

Wherever inadequate thickness is identified, the deficient area shall be identified and further coat(s) of intumescent product to bring the overall thickness up to acceptable standards shall be applied, prior to application of the final seal coat / decorative top coat.

However, if low thickness is not detected until after the seal coat / decorative top coat has been applied, detailed guidance must be sought from the intumescent coating manufacturer. In some circumstances – and with supporting test evidence – it may be possible to remedy the situation by the application of further coats of intumescent paint, but in the other extreme it may be necessary to remove previous coatings in order to build up the necessary fire protection from scratch.

Wherever the intumescent coating thickness exceeds the limits stated in the manufacturer's recommendations, guidance should be obtained from the manufacturer.

17.20 RECORDS AND REPORTS

Where appropriate, site records should contain the following information

17.20.1 VERIFICATION OF PRODUCT AND SPECIFICATION

Confirmation of product testing and certification, preferably in accordance with a third party certification scheme.
In addition, any contract specific requirements regarding product or specification should form part of the site records. For example, where appearance of the finish is important, and where sample paints or panels have been approved by the NPCIL, these should form part of the product dossier.

17.20.2 Contract documentation covering the fire protection product and its installation

- Substrate type (i.e. section sizes and shape, orientation, Hp/A value, etc.)
- Substrate location
- Surface preparation (i.e. degreasing, blast cleaning, etc. and standard)
- Identification of any primer and information concerning compatibility with intumescent coating.
- Evidence of third party product certification, including proof of specific testing for cellular beams and fire-engineered situations, giving relevant report reference etc.
- Declarations of Supply covering the fire protection products used.
- Batch numbers of products supplied.
- Thickness of intumescent coating required for the specified fire resistance period.
- Any variations or concessions agreed during the course of the contract.

- Design review to confirm any design changes and their effect on the specification, prior to commencement of application.

17.20.3 Quality Control Records

- All records should identify the areas inspected with reference to the relevant drawings, and should include
- Environmental conditions – air and substrate temperature, relative humidity and dew point.
- Dry film thicknesses per coat and for the full fire protection system, for each element of the structure. Measurements should include

- the member identification mark
- the number of readings taken
- maximum coating thickness recorded
- minimum coating thickness recorded
- average coating thickness
- any supplementary readings taken to establish if low readings (below 80% of specification) are limited and isolated areas.

- Variations, corrective actions or concessions carried out in relation to environmental conditions or dry film thicknesses.

17.20.4 Site Remedial Work

Where dry film thicknesses are checked after application of each coat, it is a fairly simple procedure to correct low thickness as this can be achieved by simply applying an additional coat (or part coat) before proceeding to the next stage of the specification.

If film thicknesses are not carried out with the required regularity, or if low thicknesses are not detected until the application process has been completed, it will be necessary to seek the manufacturer's advice regarding the best method of bringing the coating up to the required level of protection.

Advice may vary from complete removal of applied coatings, to selective removal of seal coat or, if supporting test evidence is available, to building up the thickness of the intumescent base coat (on top of the seal coat) followed by re-application of further seal coat.

In all cases, records must show the nature of defect, source of remedial advice and the full extent of remedial work carried out at site.

18 PRECAST CONCRETE

18.0 GENERAL

All concrete for precast concrete work shall comply with specifications for general concrete work and with the following additional requirements.

18.1 TOLERANCES

All units shall be cast as per detailed drawings furnished by the Engineer and to the tolerances indicated thereon. In the absence of any such indication, the dimensions shall not vary by more than ± 3 mm.

18.2 PLATFORM

All precast units shall be cast on a suitable yard, bed or platform with firm foundation and free from wind. The platform shall be fenced and shall have a curing tank of adequate size. The Contractor shall be responsible for the accuracy of the level or shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or printed on each unit. Each unit shall be concreted in one operation.

18.3 FORMS

The forms shall be steel forms with rigid steel frames or plywood forms if specifically approved by the Engineer. All component parts of formwork shall be so held that during concreting, there is no deformation of the form resulting in the concrete units not conforming to dimensions indicated on the drawings.

18.4 STRIKING FORMS

Side shutters shall not be struck in less than 24 hours for ordinary Portland cement after depositing concrete or as specified by the Engineer.

18.5 IDENTIFICATION MARKS

The surface of the underside or upper side, which is reinforced, shall be distinctly marked.

18.6 CURING

The blocks shall be kept at not less than 90% humidity immediately after manufacture for 24 hours and thereafter wet cured for a period of 10 days at a temperature of not less than 16°C. Rapid drying at the end of curing period shall not be permitted. Therefore they shall be stored under a safe and shaded enclosure/area. During this period, the blocks shall be handled carefully without causing any damage to corners, edges, surfaces etc.

18.7 HOISTING

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal

takes place, the Contractor shall satisfy the Engineer or his representative that the methods he proposes to adopt for these operations will not overstress or otherwise affect seriously the strength of the precast units. Lifting hooks shall be embedded in correct position of the unit as shown in the drawings to facilitate erection. These shall be burnt off and finished after erection if directed so, by the Engineer. The units shall be incorporated in the work in accordance with details shown on drawings or as directed by the Engineer. Cracked or damaged precast pieces during, before or after erection shall be removed and replaced with good ones at the Contractor's expense.

18.8 JOINTING

The joints shall be filled in with cement mortar 1:3 unless otherwise specified on the drawings. After jointing, the joint shall be cured for a minimum period of 10 days. All sharp and abrupt ridges and marked depressions shall be removed by grinding or filling with cement mortar properly bonded to the concrete.

18.9 PRECAST CONCRETE HATCH COVERS

All concrete for hatch covers shall comply with specifications for general concrete work and with following additional requirements.

18.9.1 All Hatch covers shall be cast as per detailed drawings furnished by the Engineer and to suit the openings as built. The tolerances in dimensions shall be + 0 or – 3 mm unless otherwise noted on drawings. No two adjacent hatch covers shall differ by 2 mm in elevation. However, before concreting hatch covers, site measurements of actual openings at the final location of hatches shall be taken. Clearance around hatch covers shall be maintained, if required, by adjusting their overall dimensions to suit actual size of opening.

18.9.2 As far as possible these hatch covers shall be cast very near to their final locations to minimize handling of these hatch covers.

18.9.3 Each Hatch cover cast for a particular location/opening shall be properly identified by use of metal plates as indicated in drawings.

18.9.4 Each Hatch cover shall have MS edge protection angle frame along its perimeter, and vertical connecting angles, as given in detailed drawings. The frame shall be fabricated taking into consideration, the actual size of opening at its final location.

18.9.5 Care shall be taken while concreting to ensure that this framework does not get distorted during/after concreting.

18.9.6 All Formed surfaces of the hatch cover shall have F3 finish and unformed surfaces shall have U3 finish.

18.9.7 The Hatch covers/blocks will have to be transported and placed in final location by the Contractor. Rectification of hatch covers or blocks will have to be carried out by the Contractor if tolerances as specified are not achieved. The unit rate for this item

shall include casting, curing, transporting to final location, erection, rectification and re-erection after painting at final location. Hoisting shall be done as per relevant clause for precast concrete given above.

18.10 SAMPLING, TESTING AND STRENGTH

Prior to manufacture trial mixes shall be prepared. When suitable mixes have been established, a sufficient number of blocks shall be cast to permit the Engineer to check the density and surface finish. If accepted these shall be standardized for all blocks to be manufactured. Provisions of IS: 1199 (Method of sampling and analysis of concrete) shall apply in addition to the requirement of this specification. The compressive cube strength of cured concrete blocks shall not be less than the specified strength at 28 days after casting.

19 MASONRY AND ALLIED WORKS

19.0 SCOPE

This chapter includes concrete block masonry, brick masonry, stone masonry, plastering, rubble soling for floors on grade, expansion and separation joints, sealing of joints, PVC/ GI water stops, flooring, skirting and dado, general area painting, steel doors, fire doors, sewer and plant drains, sanitary and plumbing items and other finishing works of the main plant structures.

19.1 APPLICABLE CODES

19.1.1 INDIAN STANDARD CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

IS: 277 Galvanized steel sheets (plain and corrugated)-specification

IS: 383 Specification for coarse and fine aggregates from natural sources for concrete

IS: 513 Cold reduced low carbon steel sheet & strip

IS: 702 Specification for Industrial bitumen

IS: 712 Specification for Building Limes

IS: 777 Glazed earthenware wall tiles

IS: 782 Specification for Caulking Lead

I.S: 1038 Specifications for Steel Doors, Windows and Ventilators

I.S: 1200 Methods of measurement of building and civil engineering works

IS: 1081 Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators

IS: 1443 Code of practice for laying and finishing of cement concrete flooring tiles

IS: 1834 Specification for hot applied sealing compounds for joints in concrete

IS: 1838 Specifications for Preformed Fillers for Expansion Joint in Concrete Pavement and Structures(Non-Extruding and Resilient Type)

Part I Bitumen Impregnated Fiber

IS: 2116 Specifications for Sand for Masonry Mortars

IS: 2185 (part-1) Concrete masonry units — specification; part 1 hollow and solid concrete block

IS: 2212 Brick Works - Code of Practice.

IS: 2508 Specification for low-density polyethylene films

IS: 2645 Integral waterproofing compounds forcement mortar and concrete— specification

IS: 2932 Enamel, synthetic, exterior a) Undercoating b) Finishing - Specification

IS: 2933 Specification for Enamel exterior a) Undercoating b) Finishing

IS: 3462 Specification for Unbacked flexible PVC flooring

IS 3495 Methods of tests of burnt clay building bricks

IS: 3614 (Part-1)Fire-check Doors, Part I: Plate, Metal Covered and Rolling type

IS: 4351 Steel door frames - Specification

IS: 4671 Specification for expanded polystyrene for thermal insulation purposes

IS: 6248 Specification for Metal rolling shutters and rolling grills.

IS: 9862 Specification for ready mixed paint, brushing, bituminous black, lead-free, acid alkali, water and chlorine resisting.

IS: 12894 Pulverized Fuel Ash-Lime Bricks - specifications

IS: 14811Rolled copper plate, sheet, strip and foils for general engineering purposes - specification

19.2 CONCRETE BLOCK MASONRY

In general, concrete block masonry shall be used in the work. Concrete block masonry shall be of solid concrete blocks having minimum average compressive strength of 5 $N/MM^2$and density shall not be less than 1800 kg/m^3.Precast concrete block masonry shall be constructed in various sizes in cement mortar 1:4 by volume with blocks manufactured as per IS: 2185 (part-1) and as per drawings and direction of engineer using standard equipment.

If Contractor proposes to cast concrete blocks at plant site, they shall submit a detailed procedure for casting of concrete blocks and submit it for the approval of the Engineer. Work shall start only after approval of the procedure. Concrete blocks shall be tested in accordance with the provisions given in IS: 2185. Contractor shall submit inspection and test plan for approval of the Engineer. Contractor shall develop proper casting yard with curing facilities for casting concrete blocks as per direction of the Engineer.

For construction of concrete block masonry, code of practice for brick works i.e. IS 2212 shall apply.

19.2.1 MATERIAL

The following are the materials to be used in the concrete block masonry work.

19.2.1.1 CEMENT

Cement shall be as covered in per specification titled ‘Plain and Reinforced Concrete’.

19.2.1.2 SAND

The sand shall consist of natural sand from an approved source. The sand shall be hard, durable, clean and free from adherent coatings, mica, shale organic matter and appreciable amount of clay. The sand shall not have deleterious impurities such as iron pyrites, alkalis, salts, coal, mica, shell etc. Sand for masonry mortars shall have particle size grading conforming to IS: 2116 – latest edition. The grading of sand for use in mortar for unreinforced and reinforced brickwork shall be within the specified limits for respective works. The fineness modulus of sand for mortar used in brickwork shall be between 2.9 and 2.1. Where grading of the sand falls outside the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening and or blending.

19.2.1.3 WATER

Requirement of water shall be as covered in the specification for 'Plain and Reinforced Concrete'.

19.2.2 STORAGE, HANDLING OF MATERIALS, CONCRETE BLOCKS, CEMENT, SAND, ETC.

Concrete blocks shall not be dumped at site & they shall be stacked in regularities, even as they are unloaded to minimise breakages and defacement of blocks. The supply/ manufacture of blocks shall be so arranged that at least fifteen days requirements of blocks are available at site at any time. Blocks selected for different situation of use in the work shall be stocked separately.

Cement, sand etc. shall be stored as stated in specification for 'Plain and Reinforced Concrete'.

Concrete shall be as per the specification for 'Plain and Reinforced Concrete'.

19.2.3 MORTAR

Mix for mortar shall be as specified in Schedule of Quantities. The cement and sand shall be mixed dry in specified proportion and then thoroughly mixed to proper consistency. No mortar that has stood for more than half an hour shall be used.

19.2.4 LAYING AND WORKMANSHIP

a) Blocks of same dimensions will be used on the same work except otherwise specially permitted by the Engineer. All blocks shall be sufficiently soaked but not excessively wet before laying. All blocks shall be soaked in water for a period of two hours before use and no blocks shall be used until there is complete cessation of bubbles when immersed in water. Concrete surfaces in contact with block masonry shall be hacked to remove the laitance and the surface roughened to the satisfaction of the Engineer for proper bonding.

b) All dirt and dust shall be removed from the block and the surfaces shall be moist at the time of laying.

c) No bats or cut blocks shall be used in the work unless absolutely necessary around irregular openings for adjusting the dimensions of different courses and for closers, in which case full block shall be laid at corners, the bats being placed in the middle of the courses.

d) The blocks shall be laid on a full bed of mortar and to line, level and shapes shown on the drawings. When laying, the blocks shall be slightly pressed so that mortar can get into all the pores of the brick surface to ensure proper adhesion. Cross-joints and wall joints shall be properly flushed in packed with mortar so that no hollow spaces are

left. Blocks shall be handled carefully so as not to damage their edges. They should also not be thrown from any height to the ground but should be put down gently.

e) All courses shall be laid truly horizontal and all vertical joints made truly vertical. Vertical joints in one course and the next below shall not come over another and shall not normally be nearer than 1/4 of block length. Fixture, plugs, frames etc. if any, shall be built in at places shown in the drawing while laying courses only and not later by removal of the blocks already laid.

f) Care shall be taken during construction to see that edges of blocks at quoins, sills, heads etc. are not damaged. All block work shall be tightly built against columns, floor slabs, or other structural members around door and window frames with proper distance to permit caulked joints. In case of very dry weather, the surface of the block shall be kept wet to prevent drying of mortar. At the end of days work, provision shall be made to keep the surface of block work wet with water. Block work shall be added uniformly throughout so that no portion of the work shall be left more than 900 mm lower than other. Verticality of walls and horizontality of the courses shall be checked very often with plumb bob and spirit level respectively.

g) Block work shall be laid out and arranged such that a minimum of cutting and shaping is required. Where necessary to trim block work units, they shall be cut, trimmed or broken at kerbs, or where required to a neat true line without chips on exposed faces.

h) Block work one and half blocks thick or more shall have both faces in true plane. Block work of lesser thickness shall have one selected face, in true plane.

i) Bond used shall be English bond and shall be carried throughout the work. At all corners alternate courses of brickwork shall be laid header and stretcher-wise as seen in the face so as to secure good bonds. The arrangement of bonds at quoins shall be symmetrical.

j) Blocks shall be laid in joints not exceeding 10 mm in thickness and this thickness shall be uniform throughout. Joints shall be struck flush with the face at the time of laying.

k) All joints on face shall be raked to minimum 10 mm depth while the mortar is still green to provide bond for plaster or pointing.

l) The rate of laying masonry may be up to a height of 1000 mm per day or as approved by the Engineer.

19.2.5 ENCASING OF STRUCTURAL MEMBERS

Where drawings show that structural steel columns and spandrel beams are to be partly or wholly covered with block work, the blocks shall be built tightly against all flanges and webs with all spaces between the steel and the block work filled solid with setting mortar and this mortar shall not be less than 12 mm thick.

19.2.6 REINFORCEMENT AND ANCHORAGE

a) For the walls, anchors in the form of M.S. flats or rods from columns and/or beams and embedment and any other anchoring and reinforcements, shown on drawings, shall be adequately embedded in the block work.

b) For reinforced blockwork, the reinforcements shall be as specified in the schedule of quantities. All reinforcements shall be thoroughly cleaned and fully embedded in the mortar. The thickness of the joints in blockwork containing steel bars shall be increased so as to have a minimum mortar cover of 6 mm around the bar interposed between the block and the reinforcement. Overlap in the reinforcement, if any, shall not be less than 50 times the diameter of the bar. The reinforcements shall be lapped with dowels left in R.C. columns or welded to steel stanchions. Where reinforced concrete bands are provided in the block walls, such bands shall be to the full width of the wall and the concrete of grade not lesser than M-25 shall be used. Such band will be measured separately under respective items of concrete in the Schedule of Quantities.

c) All half-block partition walls shall have M.S. reinforcing bars at every fourth course of the block work and they shall be securely anchored at their ends where the partitions bond.

d) All sash and door frames, louvers and other connections requiring weather proofing, shall be built in and the outside frames shall be cleaned out to uniform 20 mm depth and filled solidly with an approved elastic caulking compound applied with a caulking gun.

e) Scaffolding will generally be double but may be single if warranted for the particular work as approved by the Engineer. Scaffolding shall generally be erected with steel pipes. The Contractor shall take all measures to ensure safety of work and the working people.

f) Contractor shall be entirely responsible for any damage to property or injury to persons resulting from defective scaffolding, ladders and materials or otherwise arising out of default in this respect. Proper scaffolding shall be provided to allow, easy approach to every part of the work. Overhead work shall not be allowed.

19.2.7 CURING

All block work shall be kept constantly wet for at least 7 days from the date of laying of block work.

19.2.8 CLEANING

Upon completion of the masonry installation, all exposed block shall be cleaned of all mortar and cement grout incrustations and concrete stains. Protruding mortar joints shall be chipped off. As the cleaning progresses, all masonry work shall be examined

and all imperfect jointing, nail holes, cracks, etc. shall be carefully pointed up and filled with mortar where required and the horizontal rakings left tooled and clean.

19.3 PLASTERING

19.3.1 WATER AND CEMENT

Water and Portland cement shall be as specified for masonry work.

19.3.2 SAND

Sand shall consist of natural sand, crushed stone sand or crushed gravel sand, from an approved source. The sand shall be hard, durable, clean and free from adherent coatings and organic matter, and shall not contain any appreciable amount of clay balls or pellets. The sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal, mica, shale or similar laminated or other in such form or in such quantities as to affect adversely the hardening, the strength, the durability, or the appearance of the plaster or applied decoration, or to cause corrosion of any metal in contact with the plaster. Total of all deleterious substances shall not exceed 5% by weight. The sand shall be properly graded and of medium size with a fineness modulus of 2.0 to 2.2.

19.3.3 STORAGE OF MATERIALS

Cement and sand shall be stored as specified in specification for 'Plain and Reinforced Concrete'

19.3.4 MIX

The Mortar for plastering shall be mixed in suitable mechanical mixer in the proportion as indicated in the schedule of quantities. Water proofing compound conforming to IS: 2645 of approved manufacturer shall be added to the mortar mix for external plastering and finishes in the proportion as specified in the specification or in accordance with the manufacturer's instructions. Cement and sand shall be mixed in a dry state and then wetted and mixed thoroughly to obtain the required consistency, including machine mixing if desired by the Engineer. The mortar shall be consumed within half an hour of mixing. Any mortar for plaster, which is partially set, shall be rejected and removed from the site. Machine mixed mortar shall be prepared in an approved mixer as approved by Engineer-in-charge. Mixing for 1-1/2 to 2 minutes is normally sufficient. Only cement sand mortar shall be used in the plastering works. Cement mortar for plastering shall have a mix in the proportion of 1 part of cement and 3 parts of sand by volume unless otherwise specified in the schedule of quantities.

19.3.5 PREPARATION OF SURFACE

All joints in the masonry shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Surface on which plastering is to be applied shall be clean and free from all dust, loose materials, grease etc. and be well wetted for at least 6 hours before plastering. Brick/ block work shall be brushed down with a steel wire brush to remove all loose dust from the joints and thoroughly washed with water. All laitance shall be removed by chipping and roughening from concrete surfaces, which are to be plastered.

19.3.6 APPLICATION OF PLASTER

In all plaster work, mortar shall be applied with somewhat more than the required thickness and well pressed into the joint and on the surface and rubbed and levelled with a flat wooden rule to give required thickness. Plaster, when more than 15 mm thick, shall be applied in two coats, a base coat followed by the finishing coat. Thickness of the base coat shall be just sufficient to fill up all unevenness in the surface. No single coat, however, shall exceed 12 mm in thickness except in foundation / plinth work. The lower coat shall be thicker than the upper coat. The overall thickness of the coats shall not be less than the minimum thickness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat of plaster. The under-coat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be “thrown on” rather than “applied by trowel”.

To ensure even thickness and true surface, patches of plaster about 100 mm to 150mm square or wooden screed 15 mm wide and of the thickness of the plaster shall be fixed vertically about 2000 mm to 3000 mm apart, to act as gauges. The finished wall surface shall be true to plumb, and the contractor shall, without any extra cost to NPC, make up any irregularity in the brickwork with plaster. All vertical edges of brick, pillars, door jamb etc. shall be chamfered or rounded off at no extra cost to NPCIL as directed by the Engineer. After the plastering work is completed all debris shall be removed and the area left clean. All corners must be finished to their true angles or rounded. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

19.3.7 CURING

All plastered surfaces after laying shall be cured for a minimum period of seven days, by an approved method, and shall be protected from excessive heat and sunlight by suitable approved means. Moistening shall be commenced as soon as the plaster has hardened sufficiently and is not susceptible to damage. Each individual coat of plaster shall be kept damp continuously, for at least two days, and then dried thoroughly, before applying the next coat.

19.3.8 FINISH

In any continuous face of a wall, finishing treatment of any type should be carried out continuously and day break made to coincide with architectural break in order to avoid unsightly patches at junctions.

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

19.3.8.1 STANDARD FINISH

Where punning is not indicated, the interior plaster shall be finished rough, otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

19.3.8.2 NEAT CEMENT FINISH

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg per sq.m and rubbed smooth with a trowel.

19.4 RUBBLE SOLING FOR FLOORS ON GRADE

The rubble shall be of approved quality. Thickness of soling shall be as shown on the drawings/schedule of quantities. The rubble soling shall be carefully hand packed as close as possible and bedded firmly with their largest side placed vertical, the broader faces downward, the smaller surface at top and voids and interstices filled in solidly by wedging with hard chips and small stones but of largest size possible to fit interstices finished with cement sand mortar 1:10 min. and thickness as indicated on drawing.

No stone shall be less than 80 mm in thickness or less than 2.8 kg in weight or more than the depth of soling in thickness and not to exceed in length or breadth twice its thickness.

When a sufficient length of soling has been laid, this shall be compacted with a three wheeler power roller and the surface shall be evened by blinding uniformly with sand not exceeding 10% silt during rolling. Places inaccessible to the roller may be compacted by hand with log hammer or mechanical tampers or by hand rollers subject to the approval of the Engineer.

19.5 EXPANSION JOINT FILLER

Standard heavy density expanded polystyrene of minimum density 35 kg/cu.m and conforming to IS:4671 shall be supplied in sizes and used in accordance with drawings. The thickness of the material shall be as indicated on drawing. Adhesive if any required to fix expansion joint filler to all forms of structure shall be supplied by

the Contractor. A sample of material shall be approved by the Engineer before it is used on site. Installation shall be carried out as directed by the Engineer. The polythene sheet used for wrapping shall be minimum 250 micron thick and shall be got approved by the Engineer.

19.6 EXPANSION JOINT SEALING

Expansion joint shall be provided with PVC water stop / hot dip galvanised strips with class 2 zinc coating of width and thickness as stated in the schedule of quantities/ as shown on drawings or as approved by the Engineer. The strips shall be bent to shape indicated on the drawings and connected properly to the structure. Expansion joints shall be continuous and where two or more strips meet they shall be lapped 75 mm and brazed or welded as the case may be. Welding shall be carried out by qualified welders and shall be subject to non-destructive testing as directed by the Engineer. For the purpose of measurement, the laps provided shall be neglected.

19.6.1 G.I WATERSTOPS

The work to be done under this specification comprises the supply and delivery of Galvanized Iron water stops and accessories for the Main Plant Civil Works, all in accordance with the requirements of this specification. The Intent of this specification is to provide water stops completely in accordance with this specification ready for installation. Installation of material will be done by the contractor.

APPLICABLE CODES

IS: 277: 2003 Specification for Galvanized Steel Sheets (Plain and Corrugated)

DESCRIPTION

The GI Water stops shall be of 3.15 mm thick fabricated in accordance with IS: 277 (latest edition) and galvanized for dry film thickness of 60-100 micron

19.7 BITUMASTIC JOINT SEALING COMPOUND

Bitumastic joint sealing compound conforming to Grade A (normal) of IS: 1834 (latest Edition) shall be supplied and used in accordance with drawings. The size of groove to be sealed shall be in accordance with drawings/schedule of quantities. A sample of material shall be approved by the Engineer before its use on site. Work shall be carried out as per manufacturer’s instructions or/and as directed by the Engineer.

19.8 BITUMASTIC PAINT FOR ISOLATION JOINTS

Bitumastic Paint Conforming to IS: 9862 shall be supplied and applied by the Contractor. Two coats of paint shall be applied over surfaces to form isolation joints.

Painting shall be performed in accordance with the manufacturer's instructions or /and as directed by the Engineer. A sample of material shall be approved by the Engineer before it is used on site.

19.9 NEOPRENE & COPPER SHEET

Neoprene & copper sheet shall conform to the following specifications and a sample of material shall be approved by the Engineer.

19.9.1 NEOPRENE PAD

The pads shall be 100 percent Chloroprene compound known as "Neoprene" and shall be cast in moulds under pressure and heat. Compositions for pads shall meet the requirements listed below.

The pads shall meet the following physical test requirements:

PROPERTY	**REQUIREMENT**	**ASTM TEST METHOD**
Durometer (Type A), Hardness	60±5	D 2240
Ultimate Tensile PSI Min.	2500	D 412
Ultimate elongation at Break Min. %	350	D 412
HEAT RESISTANCE: 70 HRS. @ 212° F in AIR Change in Durometer Hardness , %Max Change in Tensile, %Max. Change in Elongation, % Max.	 +15 -15 -40	D 573
COMPRESSION SET 22 HRS. @ 212° F,% Max	35	D 395 Method B
Compression set induced in vulcanized Rubber During Exposure to high energy Nuclear Radiation, % Max.	25	ASTM D-2309
OZONE RESISTANCE 100 pphm ozone in air by volume, 20 % strain 100 ± 2 ° F, 100 hrs, mounting procedure ASTM D 518 Procedure A	No Cracks	D 1149
TEAR RESISTANCE, (kgf/cm), Min.	45	D 624
LOW TEMPERATURE TEST Brittleness at - 40° F	Pass	D 746 Procedure B

Neoprene sheet shall be placed and cut suitably to shapes and sizes as mentioned in the drawings. Brazing shall be carried out as per manufacturer's specifications and by qualified persons, subject to testing as directed by Engineer.

19.9.2 COPPER SHEET

Copper strips of material type-"O" (annealed) conforming to IS: 14811 shall be used.

19.10 POLYETHYLENE SHEET

Polyethylene sheets 250 micron thick conforming to the IS 2508 shall be supplied and used to form separation joints. A sample material shall be approved by Engineer before its use at site.

19.11 SLIDING COVER STRIP

At the expansion joints, members like columns and beams have been duplicated on either side of the separation and provided with embedded parts for installing the sliding type cover strip to accommodate any building block movement. The cover strip shall be provided both at vertical and horizontal points in accordance with details shown on drawings. The strip element shall be of mild steel, plain or chequered as indicated, and of size and thickness shown on drawings and schedule of quantities and rates. The fixed edge shall be suitably attached to the embedded bearing plate, as provided, by plug weld or tap screw as shown or as instructed by the Engineer. At the sliding edge, the sliding surfaces of the embedded plate provided and underside of the cover strip shall be machined smooth. Adequate care shall be taken not to cause any damage to the strip.

19.12 Aluminium Door, Windows and Partitions

The type and construction of Aluminium Doors shall be similar to steel doors.

These (doors, windows and partitions) shall be of sections extruded from aluminium alloy conforming to IS: 733 . Door skin plates and stiffeners shall have a minimum 3 mm thickness. All sections shall be manufactured by Indian Aluminium Co. Ltd., All doors shall be insulated with spun mineral wool insulation for sound deadening. Doors, frames, mullions, transoms and all other exposed aluminum sections shall be alumilited, 0.015mm thickness, satin finished in natural aluminium colour. A protective transparent coating shall be applied to the sections before shipment from the factory.

Aluminium frame work for glazed partitions with aluminium glazed access doors shall be as shown in drawings, excluding supply of glass and glazing. All sections shall have a minimum 3 mm thickness and alumilited as specified above.

Aluminium door shutters, windows and partitions shall have mechanical joints with necessary fasteners.

Portions of aluminium frames which come in contact with masonry construction shall, before shipment from the factory, be protected with a heavy coat of alkali resistant, bituminous paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer.

All work shall be fitted and shop assembled to a first class job and ready for erection. Shop joints shall be made to hairlines. Work on the above, other than described, shall be carefully fitted and assembled with name joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. All drilling of structural supports to install aluminium doors and frames shall be done and included in the work. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

All work shall be erected in plumb and true to line and ready for building into masonry or other types of wall construction. Doors and frames, not properly installed or being out of line or distorted shall be reset and corrected by the contractor at his expense.

Hardware and fixtures shall be as specified under "Door/Window Schedule". All hardware shall be heavy duty and the door closers of extra heavy duty type. All exposed metal shall be satin finished aluminium. All locks shall be cylinder type. All hardware shall be approved by the Engineer before installation.

19.12.1 **Fabrication Drawings**

Before starting fabrication of all metal doors windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. Only after approval of drawings, the fabrication shall be started.

19.12.2 **Workmanship**

Workmanship shall be of best quality, free from any flaws and defects. Samples of each type shall be submitted and approval of the Engineer taken by the Contractor, before starting bulk manufacture.

19.12.3 **Transporting**

All metal doors, windows, etc., shall be packed and crated properly before dispatch, to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in undamaged condition.

19.12.4 **Sliding Door (Supply and Installation)**

19.12.4.1 Scope

This specification covers the design, supply of materials, fabrication, delivery and

erection of MS sliding doors including all accessories as herein after specified.

19.12.4.2 General Description and Construction Details

The M.S. sliding doors shall be best quality adhering to the dimensions and details shown on drawings and schedule and as directed by the Engineer.

The sliding shutter shall be made of MS sheet steel panel of 16 gauge with siffeners made of 14 gauge MS, bent sheets of sizes & shapes as shown in the drawing.

The Heavy duty CI bracket shall be fixed to the lintel by means of coach screws of proper strength but of size not less 6mm diameter with length and spacing as given in the drawing.

The Standard Track/roller guide at top shall be supported on CI bracket at spacing not more than 1500 mm. The guide shall consist of Heavy duty 4 roller trolley fixed to the shutter by standard nut and bolt assembly of diameter not less than 5 mm.

The bottom guide shall made of MS section & it shall be fixed in the floors. This guide shall have 12 mm dia MS anchors of shape and spacing as shown in the drawing welded to it. 4 nos ball bearings16 dia ,with 16 dia stainless steel pin shall be fitted at bottom of each sliding leaf of the door.

The sliding shutter shall be provided with recessed handles and lock of approved make lockable on both sides. Each sliding leaf shall also have tower bolt.

The entire assembly of door shall be such as to have smooth & easy operations by a single person.

19.12.4.3 Erection

The doors shall be erected complete with all necessary hardware, operating mechanisms, equipment, wiring etc. complete, to suit sizes of openings. Upon completion, doors shall be in best operating condition. All installation and erection work, shall be done in accordance with the manufacturer's specifications. The Contractor shall arrange to have at no extra cost to NPCIL, the services of the manufacturer's Supervisor during erection. Any drilling to or cutting of concrete, masonry etc. shall be made good after erection of shutters.

19.12.4.4 Paint and Finish

Shutters shall be painted with one coat of red lead or zinc chromate primer in shop. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat. The doors shall be given final coats as given in the schedule and/or as directed by the Engineer.

19.13 STEEL DOORS AND WINDOWS

19.13.1 DOUBLE PLATE FLUSH DOORS

a) Double plate flush doors shall conform to IS: 4351 and shall be made from best quality 18 G galvanised mild steel sheets and shall be of hollow metal construction 45mm thick. Door frames shall be from the best quality 16 G pressed steel sheets. All doors shall be insulated with spun mineral wool / polyurethane foam insulation for sound deadening. All hollow metal doors shall be flush type as shown on drawings and spot welded to reinforcing members both vertically and horizontally. Reinforcing members shall be from steel sections spaced not over 150mm apart and shall extend for the full height of doors. The members shall be strictly as shown on drawing and/or as instructed by the Engineer. The doors to be provided shall be as per the drawings and shall be as per the approval of the Engineer. Generally, the doors frames shall be 45mm x 45mm x 6mm MS angle sections, shutters made of 43mm rolled steel channel section framework with stiffeners of 40mm x 40mm x 3mm M.S. angle section spaced approximately 45cms c/c, skin plate of one face of the shutter welded to the frame and stiffeners and the other face fixed with machine screws after inserting insulation material, all other details remaining as per the drawings and specifications. The mounting of the door shutters shall ensure leak tightness.

b) Built in louvers shall be stationary inverted 'V' blades and fabricated from 20 G cold rolled carbon steel sheets conforming to IS: 513. They shall be of sizes indicated in "Door Schedule" and completely installed in doors. Doors with vision panels shall have the openings formed into the face sheets so that no glass frame is required.

c) All bolts, counter-sunk screws, adjustable, fixing lugs, sleeves, chips etc. shall be provided for proper anchorage and support.

d) Doors and frames shall be fitted and reinforced for all hardware from templates.

e) Wherever required, provisions shall be made for fixing louvers (made of 16 G steel sheets) and/or 6 mm thick sheet glass, as shown on drawings. Glazing beads where required shall be from 20 G steel and shall be removable.

f)The steel doors shall be provided with 6 mm thick clear sheet glass vision panel of 240 mm x 340mm in each leaf.

g) The finished work shall be up to the satisfaction of the Engineer.

19.13.2 DOOR THRESHOLD

Wherever required, thresholds shall be provided as shown on drawings or schedule. Doors without threshold shall have bottom tie of approved type. Finished overall dimensions for doors shall conform exactly as shown on drawings.

19.13.3 STEEL WINDOWS, SASHES, VENTILATORS ETC.

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions and as shown in the on drawings. The details as called for in the above specifications shall

be applicable for coupling mullions, transom, weather bars, pivot arrangement for ventilators, fixtures and fastening etc.

All Finished overall dimensions shall conform to exactly as shown in the drawings. Individual members shall be of adequate strength and sections as per relevant IS codes and as shown in the drawings. All welds shall be dressed flush on all exposed and contract surfaces.

Where composite unit openings are shown in the drawings, the individual window units shall be joined together with requisite transoms and mullions and/or as shown in drawings. All projected out window shall be outside glazed, fixed with putty or metal glazing beads as shown on the drawings and/or specified under Schedule of Items. Where aluminium glazing beads are specified they shall be extruded aluminium channel 17/32" X 7/16" X 3/32" unless otherwise shown on drawings.

19.13.4 FITTINGS FIXTURES AND HARDWARE

Hardware and fixtures shall be as specified in "Door Schedule" and of best quality from the manufacturer as approved by NPCIL.

The Hardware and fixtures shall be of heavy-duty type and the door closers of extra heavy-duty type. Finish shall be dull bronze finish and/or anodised aluminium as specified in "Schedule of Items", except butts for interior and door closers. Interior butts shall be prime coat finish and door closers sprayed bronze.
The Contractor shall submit samples of each type of hardware and fixture to the Engineer for approval. The approved samples shall remain with the Engineer for comparing with the actual supply and only those conforming to the approved samples shall be accepted.

The Door closers shall be from approved manufacturer with ISI certification and manufactured and installed as per relevant IS Codes and good Engineering practices.

19.13.5 SHOP PAINT

The shop paint shall be best zinc phosphate primer of approved manufacturer. Before assembly, all surfaces shall be given a coat of rust resisting paint. After assembly, all exposed surfaces shall be cleaned and smoothened and two coats of approved make enamel paint shall be uniformly applied over the surface.

19.13.6 INSTALLATION

In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081 latest edition, and as shown in the drawings and 'DOOR SCHEDULE'. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvres etc. including transom and mullions for composite units in respective places as shown in then drawings. Keeping proper lines and levels, and in approved workman like manner. The installation shall be done according to the instructions of the manufacturer, and/or as approved by the Engineer. Care shall be taken to see that

framework is not loaded with the weight of masonry or used for securing scaffolding or other temporary staging. Temporary struts may be fixed across the widths preventing sides bulging inwards, which should not be removed till brickwork is set. Care shall be taken to protect the hinges from getting embedded in the mortar while filling the gap between the frame and the masonry opening. If necessary, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take every precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor without any extra charges and finished as per original, after installation.

After installation of steel doors, windows etc. all abrasions to shop coat of paint shall be retouched and made good with the same quality of paint used in shop coat. Rates quoted shall also include minor rectification at site if required such as welding of fixtures, making screw holes and providing screw and rectification of dents formed in the doors and shutters.

19.14 FIRE PROOF DOORS

19.14.1 SCOPE

The work under this section shall include supply and/or erecting and installing fireproof doors as shown in approved manufacturer's drawing with all material complete.

The scope of work shall also include assembly and erection of composite types of fireproof doors. Supplying and/or fixing of all door accessories and hardware and are also included in the scope.

The fire doors shall be single / double leaf fire rated hollow galvanized MS pressed steel flush doors conforming to BIS : 3614 (Part-1), along with frame at all elevations, with or without removable panels and with or without panic bar having fire rating as approved. The Fire doors shall be of galvanised MS sheets for frames and leaves, mineral wool / PUF/ any other fire retardant insulation material, mastic caulking and grouting the frame, reinforcing and insulating the shutters with fire retardant material including heavy duty SS hinges, thresholds, fittings complete with frame, fittings, fixtures, handles, aldrops, latches, necessary access control hardware, necessary gaskets, drop seal, smoke seal, etc for air tightness. The vision panel shall be of borosilicate float glass or approved equivalent of size 240 mm x 340 mm or as specified in drawing with same fire rating including necessary beading, mastic cement, cleaning and also all hardware as per door schedule including one coat of approved primer and two coats of approved fire resistant / intumescent paint as necessary as per drawings, door schedules and specifications.

All the doors shall have provisions for installation of access control devices such that these devices if installed at a later date shall not impair the basic functions of the door as a fire barrier. These provisions shall be in the form of providing a separate steel plate of approved dimensions of the same material as the parent door, fixed to the

main door at an approved location.

The fire rating of the door shall be clearly embossed on the doors.

The testing of Fire proof doors shall be carried out as per BIS:3614 Part-II standards for approved fire rating, for full size door with vision panel and all fittings and fixtures shall be conducted at approved laboratory for 3 nos. of doors. One door shall be tested from the first lot before shipment to site and remaining at random from balance supply.

19.14.2 DRAWING

Fire proof doors shall be as manufactured by manufacturer qualified by NPCIL. Before starting fabrication of all fire proof doors the contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

19.14.3 APPLICABLE CODES

Following are some of the important I.S.Codes as relevant to this section:

I.S: 3614 - Fire doors
I.S: 1038 Steel door, windows and ventilators
I.S: 4351 - Steel door frames
I.S: 1081 - Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.

19.15 ROLLING STEEL SHUTTERS

19.15.1 SCOPE

This specification covers the design, supply of materials, fabrication, delivery and erection of rolling shutters with motor drives and/or manual operation including all accessories as herein after specified.

19.15.2 GENERAL DESCRIPTION OF CONSTRUCTION DETAILS

The doors shall be of best quality rolling steel service doors adhering to the dimensions and details shown on drawings and schedule.

a) Slats for shutter shall be made from tested bright cold rolled, annealed M.S. Strips, not less than 18 gauge thickness, machined, rolled at 75 mm rolling centres, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.

b) Rolling grills shall be constructed out of 6 mm dia. rods at 35 mm centres running horizontally flexible connected with vertical links spaced not more than 200mm

centres. Alternatively, rolling grills shall be made from perforated slates of approved design reinforced with 6mm dia. rods.

c) End locks shall be heavy type and provided at each end of alternate slats unless specified otherwise in the schedule.

d) Bottom bars shall be finished with two angles not less than 6mm thick for external shutters. When shown on drawings a flexible weather strip shall be applied to make tight contact with the floor.

e) Steel guides shall be of angle frames secured to the metal frames or masonry at openings. Guides shall be of such depth as to retain the shutter under a wind pressure of 150 kg/sq.m. or as specified in IS: 875 for the double rolling steel shutters a central guide which is movable by sliding by mechanical arrangement shall be provided. Material for guide channels shall conform to IS: 513 latest editions.

f) Shafts shall be of steel pipe of sufficient size to carry the torsional load with a maximum deflection of $1/360^{th}$ of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.

g) Hoods shall be formed of not less than 20 gauge steel, suitably reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision to securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as described in Schedule or as desired by the Engineer.

i) Power unit shall be suitable for 3 phases, 50 cycles 400 Volt AC power supply and shall be higher floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metres per minute. The electric motor shall be 3-phase 415V AC, 50Hz. TEFC enclosure complying with NPCIL specifications PB-E-293. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built – in overload protection, a geared limit switch and one push button station located inside the building unless otherwise stated in schedule of drawing. It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge electrically connected to stop the travel of the door on meeting an obstruction.

j) Operating chains shall be of tested quality, heavily galvanised and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength grave cast iron; machine moulded from machine cut patterns.

l) Bracket plate thickness shall be minimum 3.15mm.

19.15.3 OPERATION

19.15.3.1 MANUALLY/ MECHANICALLY OPERATED SHUTTERS

Manually operated shutters shall be easily operable by one person. In general, manually operated shutters shall be push pull type for openings up to 9 sq. m. in area. Larger shutters shall be either chain or gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as described in Schedule or as desired by the Engineer.

19.15.3.2 POWER OPERATED SHUTTERS

These shall be operable from a push button station conveniently located beside the door or as shown in the drawings. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for in schedule, externally mounted shutters shall be operated by control mechanism located inside the building. Limit switch shall also be included. The power drive shall be so designed that electric motors may be removed without affecting operation by means of an auxiliary endless chain gear operator.

Motor driven shutters shall have the following compulsory operation system. Mechanism shall be galvanised and of tested quality and shall be guaranteed to prevent chain from leaving wheel and of sufficient length to terminate approximately 600 mm above floor. Reduction gear shall be extra strong, cast without teeth for machine-finished pattern. Necessary lubrication shall be provided.

19.15.4 ERECTION

The shutters shall be erected complete with all necessary hardware, operating mechanisms; equipment, wiring etc. complete, to suit sizes of openings. Upon completion, shutters shall be in best operating condition. All installation and erection work, shall be done in accordance with the manufacturer's specifications. The Contractor shall arrange to have at no extra cost to the owner, the services of the manufacturer's Supervisor during erection. Any drillingor cutting of concrete, masonry etc. shall be made good after erection of shutters.

19.15.5 PAINT AND FINISH

Shutters shall be painted with one coat of zinc phosphate primer and two coats of approved synthetic enamel paint unless specified otherwise.

19.15.6 ELECTRICAL WORK

All electrical work shall be in strict accordance with the latest Indian Electricity Rules or other approved codes as specified by the Engineer**.**

19.15.7 SHOP INSPECTION AND TEST AT MANUFACTURER'S WORK

After completion of the manufacture of different components of the rolling shutter,

drive and other components/ accessories of the rolling shutter, arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

If desired by the Engineer tests shall be carried out at the manufacturer's works in accordance with the approved standards in the presence of the Engineer. Four copies of all the test certificates shall be submitted for approval, if required by the Engineer.

19.15.8 ACCEPTANCE TEST AT SITE

After the equipment has been installed at site the contractor shall carry out performance tests to the satisfaction of the Engineer, after which the shutters shall be accepted. The doors shall be smoothly operable under all ambient conditions. All controls and locking devices shall have fault free performance.

19.15.9 DRAWINGS

The manufacturer / supplier of the rolling shutters shall be got approved by NPCIL before carrying out the work. Prior to fabrication of rolling shutters, the contractor has to measure exact size of the structural opening at site. Fabricated door shall suit to the actual structural opening at site. The Contractor then shall prepare necessary drawings/ detailing of the rolling shutters as per specification, which they intend to supply and seek prior approval of the Engineer. The contract drawings to be furnished by the Contractor shall include but not be limited to the following:

a) Foundation and anchorage drawings for the equipment and drive and their auxiliaries with similar detailed drawings for other equipment.

b) Dimensioned assembly and sub-assembly drawings showing plans and sections of the equipment, instruments and safety devices etc. clearly indicating limiting dimensions, if any.

c) Complete assembly drawings wiring and connection diagram for all instruments, gauges and controls.

19.15.10 GUARANTEE

The design of the rolling shutter shall be made for withstanding a wind pressure of 150 kg/m2. The Contractor shall give one year's guarantee against operational and material defects and for safety against the design wind pressure.

19.15.11 APPLICABLE CODE

IS: 6248 - Metal rolling shutters and rolling grills.

19.16 CHAIN LINK FENCING AND DOOR

19.16.1 SCOPE

This specification covers the fabrication and installation of wire-link fencing and doors with necessary hardware.

19.16.2 GENERAL

The Fencing shall be constructed of M.S. pipe/ angle frame with welded wire-mesh cladding.

The chain-link doors shall have either single or double shutters of sizes as indicated in the 'Door Schedule'.

The door shutters shall be constructed of M.S. angle frame with welded wire-mesh cladding. The door frame shall be made of M.S. angles built in the wire link partition or in the brick masonry.

19.16.3 SHUTTER FRAME

The frame for door shutter shall consist of two vertical and three horizontal members securely welded together. The shutter frame shall have pivoted arrangement for swing.

19.16.4 WIRE LINK

Welded wire mesh of 50mm x 50 mm with mesh made of 3mm diameter from standard manufacturer shall be used. The mesh shall be made from high tensile wires welded at every intersection. The welded wire mesh shall be positioned inside the angles of the framework. The wire mesh shall be properly stretched and welded to the angle frame.

19.16.5 DOOR FRAME

The door frame shall be made of 80 NB GI Pipe and M.S. angles with necessary provisions to revive hardware. The finished work shall be strong and rigid, neat in appearance and free from defects. Doors shall not have more than 6 mm clearance at jambs & head and not more than 3 mm clearance at the meeting stile edges for pair door.

19.16.6 INSTALLATION

Door frames and shutters shall be assembled and installed such that frames and doors are set plumb, square, level, and at their proper location. All necessary hardware including hasp and staple for locking, pull handle, etc. shall be furnished. The frame

shall be securely anchored with hold fasts at brick masonry openings.

19.16.7 CLEANING AND PAINTING

All welds shall be dressed flush on all exposed and contact surfaces. Steel frame members, wire-mesh and welds shall be cleaned of all rust, scale, grease and other foreign matter and then given a prime coat of zinc phosphate primer.

The finished work shall be to the satisfaction of the Engineer-in-charge.

19.17 FLOORING, SKIRTING AND DADO

19.17.1 SCOPE

This specification shall include furnishing of all labour, materials, and equipment, necessary to complete the different types of flooring work as shown in the drawings. Work under this section shall include:

i) Indian Patent Stone Floor (IPS)
ii) Concrete floor with metallic hardener
iii) Tiled floor (with underbed)
iv) Glazed tiled flooring and dado
v) Vacuum dewatering floors with ironite finish
vi) Cement Skirting and dado In-situ
vii) Precast tile skirting
viii) Ceramic tile flooring and dado
ix) PVC tile floor
x) Acid and/or alkali resistant floor
xi) Kota stone flooring and skirting
xii) Vitrified polished tile flooring and skirting
xiii) Granite flooring and dado/ cladding
xiv) PVC Electro static conductive flooring
xv) Precast cement concrete interlocking paver blocks

Any integral finish to the base concrete indicated in drawing or schedule like finishes F1, F2 & F3 for formed surfaces and finishes U1, U2 & U3 for unformed surfaces shall be deemed to have been provided in the structural slab.

19.17.2 PREPARATION OF BASE

For all type of flooring, skirting and dado work, the base cement concrete slab or the masonry surface shall be cleaned of all dirt with water and hard brush. If required the base surface shall be hacked or otherwise roughened to obtain a good bond. The surface shall be clean, free from grease, oil, dust, loose particles, etc. and thoroughly soaked with water to prevent absorption of mixing water from the base course. Before placing the under bed, and excess standing water shall be mopped out. Before laying the flooring, skirting or wall finish, approval of the Engineer shall be obtained

as to the acceptability of the base.

19.17.3 INDIAN PATENT STONE (IPS)

a) Preparation of base shall be as specified above. The patent stone floor unless otherwise stated shall have a minimum thickness of 40mm. The under-bed shall consist of cement concrete with 10mm down, clean, well-graded, hard approved stone chips and clean, sharp, coarse sand. Elongated or thin flake like fragments of stone shall be avoided. The proportion of the mix shall be 1 part cement, 1parts sand and 2 parts stone chips by volume.

b) Water content shall be minimum, sufficient to give a workable consistency, which will allow finishing without excessive trowelling. Generally water cement ratio of 0.4 should suffice. The floor shall be cast in panels not exceeding 5 sq.m. in area and no side more than 2.5m long. Panels shall be made using aluminium strips. The casting sequence shall be in a chequered board fashion, no two adjacent panels being cast before the contraction of the previous one has taken place. The edge of each panel into which the floor is divided shall be supported by flat bars of steel or wood duly oiled to prevent sticking. The bars shall be removed before filling in adjoining panels. At least 48 hours shall elapse before the concreting in the adjacent bay is commenced. After laying, the under bed shall be levelled, compacted and brought to proper grade with a screed or float.

c) Then a layer of minimum 6mm thickness shall be laid over the green under bed and trowelled smooth with a mixture of cement and sand (1:1 by volume). The under bed and topping shall be completed in one operation.

d) The topping shall be trowelled smooth to the satisfaction of the Engineer. Any marks of trowel shall be mopped with a soft cloth to give a clean, even and smooth surface.

e) Where specified on drawings the thickness of the under bed shall be adjusted to make the total thickness as shown in the drawings.

f) When polishing is to be done, if specified in the drawings and/or “Schedule of Quantities” it shall be done in a manner as approved by the ENGINEER.

19.17.4 CONCRETE FLOORING WITH METALLIC HARDENER

19.17.4.1 GENERAL

The specified hardening system shall be applied by a specialist applicator certified by the manufacturer of the system strictly as per the written method statement submitted by the manufacturer.

a) THICKNESS

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth over 28 mm thick concrete base. Total thickness shall be 40 mm thick.

b) MATERIAL

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand, soluble alkaline compounds or other injurious materials. Actual samples shall be tested prior to use at site.

c) MIX

Proportion of metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction, 1 part metallic hardener shall be mixed dry with 4 parts of cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to two parts of stone chips by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

d) LAYING

The concrete floor shall be laid as per the specification of Concrete work and levelled up to the required grade. The forms, if any, shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible.

12 mm thick finish shall be laid while the concrete under bed 28 mm thick is still very green within 3 hours of laying the latter. The finish shall be of uniform thickness and free from trowel marks, pin hole, etc. The topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. The surface shall be smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

19.17.4.2 **SUBSTRATE CONDITION**

The grade of concrete for substrate should be preferably M20. At the time of construction of floor, as soon as the plasticity of the mix is reached, the surface of the freshly poured concrete shall be smoothened out and shall be flattened out with the vibrating straight edge. This concrete should be dense and compact which could be obtained by adding plasticizers like Plastiment BV 40 or equivalent (0.3% by weight of cement or it may vary due to site condition). It is preferable to use a mechanical trowel for smoothening operation.

19.17.4.3 **LAYING**

The ready mix non-metallic hardener compound shall be spread over the newly laid smooth concrete surface at a stage when a nail mark of 3-4mm shall be obtained at standard pressure. The spreading shall be done by hand or with a suitable apparatus @ approximately 6.0 kg/m² for a thickness of 3 mm surfacing.

Time should be given till the mixture has been uniformly moistened by the surface water contained in the green concrete. The surface shall be smoothened out with a mechanical trowel which shall be maintained perfectly flat, operating at a low speed.

Immediately, after the flooring surface is finished, it shall be protected from rapid drying. As soon as the floor is hardened sufficiently, it shall be kept moist for at least 3 days by wet gunny bags.

19.17.5 VACUUM DEWATERING SYSTEM OF FLOORING WITH IRONITE FINISH

19.17.5.1 GENERAL

a) Thickness, material and mix shall be as per specification on "concrete flooring with metallic hardener" included earlier in this chapter.
b) Grading of constituents of concrete and slump shall be as per manufacturer's recommendation.

19.17.5.2 JOINTS

The concreting shall be done in bays as recommended by the manufacturer. In absence of which bays of 20 M x 20 M shall be followed. Aluminum strips shall be provided for separation of panels.

19.17.5.3 LAYING AND WORKMANSHIP

All arrangements including installation of guide rail, positioning of pipes for water and drainage, shall be placed either by pump or manually. Poker vibration and tremix surface vibrators are used sequentially to obtain proper leveling and compaction. Suction mat shall be used with proper arrangement of suction holes to vacuum pump, draining line, etc. so as to achieve recommended pressure by the manufacturer on the concrete surface. Proper care shall be taken to drain out excess water from concrete. Normally concrete shall be subjected to suction for a period of 1 to 2 min per centimeter thickness depending on the particle shape of the mix. Immediately after vacuum dewatering the surface is power floated with skim floater. To obtain smooth surface skim floater fitted with troweling blades shall be used. The floating and troweling operation shall be completed within one hour for concreting.

19.17.6 TILED FLOOR WITH UNDERBED

19.17.6.1 GENERAL

The tiles shall be (a) plain cement tiles (b) plain coloured tiles, and (c) terrazzo floor tiles, conforming to IS: 1237 – latest edition and of dimensions as shown of under bed drawings. The wearing face of these tiles shall consist of plain or coloured cement for items (a) and (b) and white or coloured cement and marble chips for item (c), size, colour and proportions of which shall be as per instructions of the Engineer. All angles of tiles shall be right angles, and the colour and texture of the wearing face

shall be uniform throughout its thickness, which shall not be less than 6mm. Colour shall be non-fading and lime-proof and the face of tiles shall be plane, free from cracks, depressions and projections and reasonably parallel to the back face.

The portion of cement to aggregate in the backing of tiles shall not be leaner than 1:3. Colouring material wherever used shall not exceed 10% by weight of cement used in the mix.

19.17.6.2 **MATERIALS AGGREGATES**

a) Aggregates used for mortar for fixing the tiles shall conform to IS: 383 – latest edition.

b) The cement used for fixing the tiles and cement grouting shall conform to IS: 12269 latest edition – or white cement of approved quality.

c) Pigments incorporated in mortar or used for Pigments grouting shall be stable and non-fading.

d) Water shall be clean and free from oil, water acid, alkali and organic or vegetable matters.

e) Aggregates used for the terrazzo topping aggregates shall be marble chips of size varying from for 1mm to 20mm. The proportioning of chips of terrazzo various grades shall be as per directions topping of the Engineer. Marble powder used for the topping shall pass through IS Sieve No. 30.

f) The delivery of tiles shall be so arranged as to minimise handling. Adequate precautions shall be taken to prevent accidental damage to tiles while unloading. The tiles shall be stored under cover to prevent exposure to dampness, sun, rain, accidental injury or straining.

19.17.6.3 **LAYING AND WORKMANSHIP**

a) Preparation of the base shall be as laying specified under 1.28.2 above. The surface shall be thoroughly soaked with water after soaking with water, the under bed of thickness as shown on drawings shall be evenly as smoothly spread. The mortar for under bed shall be composed of 1 part cement and 3 parts sand. The under bed shall be well consolidated and brought to proper grade, to a level below the finished floor level equal to the thickness of the tiles. The tiles shall then be placed before the under bed has set.

b) The tiles shall be soaked in water for 10 to 12 minutes and allowed to dry for the same length of time. The under bed shall be thoroughly moist, and Portland cement shall be hand-dusted over this immediately before the tiles are laid. The tiles shall then be placed upon and firmly pressed on the under bed until exactly even with the finished floor level. The joints shall be carefully grouted and filled with cement grout

of the same colour as the matrix of the tiles. The joints shall not be more than 1.5mm wide.

c) The setting of tiles shall be so done that minimum rubbing is required later on. Initial grinding and polishing of tiles shall be done in the shop and the final rubbing and polishing shall be commenced only after the floor as well as the joints have set and done in a manner approved by the Engineer. Chequered or grooved tiles whether plain or terrazzo, shall always be polished by hand.

d) All work shall be cleaned thoroughly and left in an acceptable condition on completion. No harsh abrasive cleaning powders, acid or steel wire shall be used for cleaning the tiles. Curing shall start on the next day after laying and shall continue for 14 days. The entire work of laying, polishing, finishing and cleaning etc. shall conform for 14 days. The entire work of laying polishing, finishing and cleaning etc. shall conform to IS: 1443 latest edition. Tiles shall be selected and used, such that colour of each area of the floor remains uniform.

19.17.7 GLAZED TILE FLOORING AND DADO

19.17.7.1 MATERIALS

The glazed tiles shall be 6 mm thick premium quality tiles conforming to IS 15622 of approved shade and make. The top surface of the tiles shall be glazed with a mat finish of uniform colour and texture and free from flaws, cracks, chips craze, specks, crawling or other imperfections. These shall be sound, true to shape with true and straight edges, non-absorbing and non-fading having a texture, dense and homogenous. The edges and the underside of the tile shall be completely free from glaze so that these may adhere properly to the surface below. The tolerances shall be +1.5mm for length and breadth and +0.5mm for thickness. Before bulk supply, the contractor shall give samples of tiles to the Engineer for approval. Bulk supply shall only be adopted if it conforms in all respects to the approved samples kept with the Engineer.

White cement, sand, pigments and water shall be as specified.

19.17.7.2 HANDLING AND STORAGE OF TILES

The delivery of tiles shall be so arranged as to minimise handling. Adequate precaution shall be taken to prevent accidental damage to tiles while unloading and these shall be stored under cover in a manner approved by the Engineer.

19.17.7.3 LAYING AND WORKMANSHIP

a) Preparation of base shall be as specified. The under bed as shown in the drawings shall be laid with a mortar consisting of 1 part of cement and 3 parts of clean, sharp, coarse sand. The thickness of the under bed shall be at least 20mm thick for flooring and 10 mm thick for dado or as shown in the drawings. While still green, the under

bed shall be deeply scratched. The under bed shall be laid not earlier than 48 hours before commencing to set the tiles.

b) A mortar setting bed 6mm thickness shall be laid over the under bed to make an even and true surface; over which the tiles shall be laid. This layer consists of 1 part of Portland cement, 1 part of lime putty and 3 parts of clean, sharp, medium sand. The under bed shall be thoroughly saturated with water immediately before applying the mortar setting bed. The setting bed mortar shall be applied over such an area as can be covered by tiles before the initial set of mortar. After the mortar setting bed has been levelled, a skin of neat Portland cement shall be trowelled to the mortar setting bed immediately before the tiles are set.

As soon as the mortar setting bed has sufficiently hardened, all tiles shall be firmly secured in place and gently beaten in, with finished surface brought to desired level. When grouting the glazed tiles, special care shall be taken to prevent scratching of the glazed surface. All surplus grout or mortar shall be removed before it has set or hardened and the face of tiles left clean. The completed work shall be free from cracked, broken or otherwise damaged tiles, No joint shall be more than 1.5mm thick. The joints shall be flush pointed with white or coloured cement to match the tile surface and cured for seven (7) days.

19.17.8 CERAMIC TILE FLOORING AND DADO

19.17.8.1 FLOORING

Non-slippery ceramic tile flooring shall be laid using premium quality mat finished 6mm thick ceramic tiles conforming to IS: 15622 in approved size (minimum 300 mm X 300), make and shade. The tiles shall be laid as per approved pattern over 20mm thick cement mortar 1:4 bedding, close jointed & pointed with matching cement slurry using white cement mixed with pigment, finished to levels / slope or plumb as required including cutting of tiles, curing, acid washing etc. all complete as per manufacturer's specifications and direction of Engineer. The quoted rates shall include the provision for covering of floor tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.8.2 DADO

Ceramic tile dado shall be laid at all the elevations using premium quality ceramic tiles average 6mm thickness of approved size (Min 450mmx300mm), shade and make conforming to IS: 15622. The tiles shall be laid on walls with average 10 mm thick underbed with cement mortar 1:3 (1 cement : 3 coarse sand) and 6mm thick setting mortar, jointed with white cement slurry with matching pigment and curing, cleaning etc all complete. The final surface shall project at least 6mm beyond the plastering, but in no case shall the total thickness including under bed be less than 20mm. The surface shall be truly vertical and free from any scratched or cracked tiles. The quoted rates shall include the provision for covering the tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.9 CEMENT SKIRTING AND DADO IN-SITU

a) The height of cement skirting and dado shall be as shown in drawings and/or instructed by the Engineer. Preparation of the base shall be as specified earlier.

b) The mortar for underbed shall consist of 1 part of cement and 3 parts clean, sharp, coarse sand (by volume), mixed with adequate amount of water to make it workable (not too wet) and shall be thrown on the wall. After finishing with a wooden float, a neat cement paste of minimum 3mm thickness (6mm when polished) shall be applied and pressed to be finally finished with English trowel.

c) The total thickness shall be such that the finished surface projects 6mm beyond plastering, but in no case shall the thickness be less than 19mm or as specified on the drawing. The junction with floors and corners shall be rounded to 25mm radius and/or as instructed by the Engineer. Curing shall be done for a minimum period of seven days.

d) If polishing is specified on drawings and/or schedule of items, the surface shall be rubbed and polished as per standard practice approved by The Engineer.

19.17.10 PRECAST TILE SKIRTING

This shall be done exactly in the same way as specified above. The plaster at the upper edge of the dado shall be finished neatly as directed by the Engineer.

19.17.11 PVC TILE FLOOR

This shall include the quality of materials and the general requirements for the installation of different types of tiles manufactured from vinyl resins including cover base set with sticker on concrete or masonry base in the locations shown in the drawings.

19.17.11.1 MATERIALS

a) The type of tile shall be as indicated on the drawings, schedule and/or bill of quantities. Three types of Vinyl floor tile are covered.

i) Type - V

The tile shall be composed of 100% Vinyl from face to back with alkaline resisting colour pigments and other plastic compounds.

ii) Type VA

The tile shall be of Vinyl – Asbestos consisting of a through blend of Vinyl plastic resins, asbestos fibres, and alkali resisting pigments and fillers from face to back.

iii) Type VL

The tile shall be Vinyl-laminated consisting of a top-wearing surface of solid vinyl permanently fused to applicant, felt cushion backing.

b) Cove base shall be extruded PVC (100% putty) with moulded top-set cover, colour, and the height of the base shall be as indicated on the drawings, schedules, and/or as approved by Engineer.

c) The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or other physical defects which affect appearance or serviceability.

d) All edges shall be cut true and square. The colour shall be non-fading and uniform in appearance, insoluble in water and resistant to alkalies; cleaning against and unusual floor polishes.

e) Samples of tiles and cove base shall be submitted to the Engineer and must be approved before work is started. Samples shall bear the labels stating the colour gauge and manufacturer's name. Colour, designs and sizes shall be approved by the Engineer after submission of samples. The thickness of the tiles shall be as indicated in the Schedule of Quantities.

f) Adhesive and cements shall be furnished as recommended by the manufacturer of the tiles. The adhesive shall have a short during time and long life in addition to toughness.

g) The tiles shall be square n shape and of approved dimensions and shall conform to the requirements of IS: 3461 and IS: 3462. The tolerance in dimensions shall be +1.5mm and in thickness +0.5mm.

19.17.11.2 INSTALLATION

19.17.11.2.1 GENERAL

The tiles shall be kept in the room to be tiled for at least 24 hours prior to laying to bring them to the same temperature of the laying area. The work should not the carried out under high humidity conditions. For air-conditioned space, the flooring shall not be laid until the conditioning units have been in operation for at least seven (7) days. During this period the temperature shall neither fall below 20° C. These conditions shall be maintained during laying and for 48 hours thereafter.

19.17.11.2.2 PREPARATION OF SUB-FLOOR

a) The surface to receive this finish shall be firm, even textured but not too smooth, without undulations and other deficiencies. If an under bed is laid the same shall be cured for at least seven (7) days by keeping it moist and fully dried. Before commencing the laying operations, the sub-floor shall be examined for evenness and dryness. The sub-floor shall be broom clean and free of paint, wax, grease or oil. Cracks shall be filled with crack filler.

b) The layout of the PVC on the sub-floor to be covered should be marked with guidelines. The PVC flooring shall be first laid for trials and approval without using the approved adhesive.

c) The adhesive shall be applied uniformly by using a notched trowel to the sub-floor and to the backside and edges of the tiles and allowed to surface dry. Any adhesive squeezed out through the joints and contaminating the face of the tiles shall be removed immediately. An appropriate solvent shall be used to remove any adhesive that has hardened. The traces of solvents shall be removed and the tiles cleaned before reuse.

d) The tiles shall be laid true, level and even exactly to the approved pattern and close to each other with minimum gap between joints. It is preferable to start laying of the tiles from the centre of the area. The tiles should be lowered in position and pressed firmly on to the adhesive. After laying, the tiles shall be rolled over, in two directions, with a light wooden roller weighing about 5 Kg. to ensure full contact with the underlay. If the edges tend to curl up, weights should be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. Any undulations noticed on the tiling surface shall be rectified by removing and relaying the tiles after thorough cleaning of the underside of the affected tiles. Work should be constantly checked against guide lines in order to ensure that all four edges of adjacent tiles meet accurately. Tiles shall be fitted carefully to and around all permanent fixtures. Borders shall be fitted accurately.

e) A minimum period of 24 hours shall be given after laying the flooring for developing proper bond of the adhesive. During this period, the flooring shall not be put to service. It is preferable to take up PVC flooring work after completion of plastering, painting, false ceiling and other decorative works so as to avoid any damage to the flooring.

f) Cove base shall be firmly cemented to the walls and accurately scribed to trim and finish.

g) The exposed edges of PVC tiles are doorways and other locations shall be provided protection against damage by metallic edge strips securely fastened to the sub-floor.

h) When flooring has been laid and fixed, it shall be thoroughly cleaned of surplus adhesive. The flooring shall then be cleaned with a wet cloth soaked in ware soap solution. All scraps, packing materials and debris shall be removed.

19.17.11.3 ACCEPTANCE

Improper application of the adhesive or imperfect embedment of tile in the adhesive as evidenced by ridges in the surface, by lack of even and uniform bearing, by loose bond, or by curled loose edges will be cause for rejection. All such defects shall be remedied to the satisfaction of the Engineer prior to acceptance.

19.17.11.4 GUARANTEE

All work executed under this specification shall be guaranteed free of defects in material and workmanship for a period of one year after completion of the work. Upon written notice of any defect in material or workmanship, repairs or replacements shall be made at no expense to Corporation. Corporation shall, however, arrange for the removal and replacement of all fixtures and equipment attached to the surface on which the work will be done.

19.17.12 ACID AND/OR ALKALI RESISTANT FLOOR

19.17.12.1 MATERIALS

The Acid and/or alkali resistant tile or rolls shall be to true and straight edges, shall be non-absorbing, without stains, non-fading, and obtained from approved manufacturers.

The rolls shall be 3 mm thick Thermo Plastic Polypropylene glass lined and shall be guaranteed to resist acid and alkalies of about 30% concentration. The laying of Acid proof rolls shall be carried out as per manufacturer's recommendation strictly and by a specialised agency.

The tenderer shall specify the characteristics of the tiles or rolls and shall enclose the manufacturer's literature for the same confirming their service ability for both acids and alkalis. The Contractor shall submit samples of tiles or rolls for approval to the Engineer and the bulk supply will only be accepted if it conforms in all respects to the approved samples kept with the Engineer.

19.17.12.2 LAYING AND WORKMANSHIP OF TILES

a) The surface should be levelled, dried, cleaned of dust, and should not be too smooth (sand finish) prior to pasting of PPG roll. The PPG roll should be cut into desired size for pasting. The required quantity of pasting compound should be mixed from the two components. The hardener should be added further in this mixture. The mixture is to be applied to the surface and the back side of the PPG roll after laying the fibre mat as per manufacturer recommendation and pasted by applying dead weight by putting sand bags etc. The pressure may be applied by jacks on the vertical surfaces.

b) Thermoplastic sheets should be welded by using fusion welding technique as per manufacturer's specification.

c) The Contractor shall furnish full details regarding the materials for the different treatments described above pertaining to this flooring work as per manufacturer's specifications, and shall lay and set the rolls properly in full conformation with the manufacturer's instructions. The entire work shall be done in workman like manner to the complete satisfaction of the Engineer.

d) The Contractor shall give a guarantee for the satisfactory life of the floor for a minimum period of one year under operating conditions. All defects appearing within

this period shall be rectified to the satisfaction of the Engineer by the Contractor at no extra cost to Corporation.

19.17.13 KOTA STONE FLOORING AND SKIRTING

Kota Stone shall be of best quality and obtained from approved sources. Kota stones shall not be less than 20mm thick for flooring and 20mm thick for skirting or as specified in schedule and shall be cut to the required sizes, as approved by the Engineer. The stones shall have to be machine cut and double machine polished. The edges to be pointed shall be true to line and dressed wherever found necessary to the full depth all round. The stones shall be hard, sound, and free from cracks, veins and other defects and of uniform colour. In case of Kota stones available in different shades, the samples shall be submitted for approval of the Engineer.

19.17.13.1 LAYING AND WORKMANSHIP

Before laying the flooring the surface to laying be paved, shall be thoroughly hacked, cleaned of all mortar scales, concrete lumps, loose materials etc. Unless and until, the surface is approved by the Engineer, the paving shall not be taken in hand. A bedding of cement mortar (1:4) of 20 mm thickness for flooring shall be laid evenly and to the required slopes as directed. The stones shall then be truly and evenly set in a thin paste of neat cement applied to sides, bottom and to the prepared base. The stones shall then be tamped down with wooden mallet until they are exactly in true plane and line with the adjacent stones. All stones shall be extended up to the masonry wall and underside of plaster. The stones shall be close jointed and joints shall be as thin as possible.

The cement that oozes out thorough the joints shall be wiped clean. The joints shall then be pointed with matching cement and finished neatly. The flooring shall be cured for seven (7) days. The entire surface and flooring shall be re-polished with machine to the satisfaction of Engineer.

19.17.13.2 KOTA STONE SKIRTING

Kota stone skirting shall be laid against a bedding of cement mortar (1:3) 12mm thick to the full height of skirting to a true plane, level and plumb. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. The continuous horizontal groove at the top of skirting shall be provided as per drawing or as directed by the Engineer. No extra will be paid for grooves. The skirting shall be cured for seven (7) days. The skirting surfaces shall be re-polished with had to the satisfaction of the Engineer.

19.17.14 VITRIFIED POLISHED TILE FLOORING AND SKIRTING/DADO

19.17.14.1 FLOORING

Vitrified polished tiles shall be of premium quality of size 600mm x 600mm of approved make and shade, conforming to IS: 15622 having minimum thickness of 9

mm. The tiles shall be laid in approved pattern over 20mm thick cement mortar 1:4 bedding. The tile slabs shall be close jointed & pointed with matching pigmented white cement slurry and shall be finished to levels / slope as required. Scope of work also includes cutting of tiles to the required size , curing, washing etc. complete with all materials, tools labour etc. all complete as per manufacturer's specifications and direction of the Engineer. The quoted rates shall include the provision for covering of floor tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.14.2 DADO

Vitrified polished tile skirting/ dado shall be of approved make and shade, conforming to IS: 15622 having minimum thickness of 9 mm. This shall be laid at all elevations in approved pattern laid in skirting over and including on 12 mm thick cement mortar 1:3 (1 cement: 3 coarse sand) and jointed with neat white cement slurry with pigment of matching shade to match the shade of the tile including curing, cleaning etc. all complete as per manufacturer's specifications and direction of the Engineer..

19.17.15 GRANITE FLOORING AND DADO/ CLADDING

19.17.15.1 FLOORING

Granite slab shall be of 1st quality in approved colour and size (Minimum 600mmX600mm). Granites slabs shall be provided and laid in 20 mm nominal thickness, with inlay for the border as flooring design, laid in approved pattern over base 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand) and jointed with white cement slurry mixed with pigment to match the shade of the slab.The scope of the work shall also include surface preparation, rubbing, curing, moulding and mirror polishing complete as per manufacturer's specifications and as directed by the Engineer.

19.17.15.2 DADO

Providing and fixing 20 mm nominal thick granite slab of 1st quality as wall cladding with approved colour and size (to cover the entire height of the dado in single piece without any joint and minimum 600mm width) laid in approved pattern over a base of 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand) jointed with white cement slurry mixed with pigment complete as directed including filling the gaps between the base mortar and granite slab with 1 : 2 cement slurry and making 'V' grooves wherever required, inclusive of stainless steel fisher clamp with expansion bolts at least 2 nos. for each slab wherever necessary, including rubbing, curing and mirror polishing complete as per specifications and as directed by Engineer. Quoted rate shall include supplying and providing stainless steel clamps as necessary with expansion bolts or any other accessories required to complete the dado work.

19.17.16 PVC ELECTROSTATIC CONDUCTIVE FLOORING AND SKIRTING

19.17.16.1 FLOORING

PVC Electrostatic conductive flooring and skirting 2 mm thick shall be installed over integral concrete floors finish/IPS/ hardonite flooring. The material specification and laying procedure shall be as per NPCIL Specification No. PPE-2273 (latest Rev.)

19.17.16.2 SKIRTING

PVC electrostatic conductive skirting shall be minimum 2 mm thick and shall be supplied and installed at various elevations inside main plant buildings over concrete / plaster surfaces satisfying all the requirements laid down in NPCIL technical specification PP-E-2273. The scope shall include all accessories / material required for installation of the same such as copper grounding strips, welding rods, surface preparation / levelling of floor, adhesive etc. as per requirements and testing at site all complete as per drawing, manufacturer's specifications and direction of the Engineer.

19.17.17 PRECAST CEMENT CONCRETE INTERLOCKING PAVER BLOCKS

Precast cement concrete interlocking pavers blocks shall conform to IS 15658. Paver blocks shall be of M-40 grade and 80mm thick factory made coloured blocks made by block making machine with strong vibratory compaction. The blocks shall be of approved colour and shape. Cement Concrete paver blocks shall be laid in approved pattern over 50mm thick compacted bed of fine sand, filling the joints with fine sand etc. all complete as per manufacturer's specifications and the direction of the Engineer.

19.18 GENERAL PAINTING ON INTERIORS & EXTERIOR SURFACES

19.18.1 SCOPE

a) This specification covers general painting on concrete, plastered and steel surfaces both interior and exterior as shown in drawings, schedules or as directed by the Engineer.

b) The Contractor shall inspect the surfaces of works completed by other agencies prior to the application of paint. If surface to be finished cannot be put in suitable condition for painting by customary preparatory methods, the painting contractor shall notify the Engineer in writing or assume responsibility for and rectify and unsatisfactory finishing that results.

c) Before commencing painting, the contractor shall obtain the approval of the Engineer in writing regarding the scheduling of work to minimize damage, disfiguration or staining by other trades. He shall also undertake normal precautions to prevent damage, disfiguration or staining to work of other trades or other installations.

19.18.2 MATERIALS

a) Materials shall be of the highest grade products of well known approved manufacturer and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name, and colour shade, with labels intact and seals unbroken.

b) All materials shall be subject to inspection, analysis and approval by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade be obtained from the same manufacturing batch.

c) All paint shall be subject to analysis from random samples taken at site from painter's bucket, if so desired by the Engineer.

d) All primer coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

e) All unspecified materials such as shellac, turpentine or linseed oil shall be of highest quality available and shall conform to the latest I.S. specifications. All such materials shall be made by reputable recognized manufacturers and shall be approved by the Engineer.

f) All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

19.18.3 **STORAGE**

The contractor shall arrange for safe and proper storage of all materials and tools. The storage space if allotted within the building shall be adequately protected from damage, disfigurement and stains. Paints shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken by the Contractor to prevent fire.

19.18.4 **PREPARATION OF SURFACE**

Before starting the work the Contractor shall obtain the approval of the Engineer regarding the soundness and readiness of the surface to be painted.

19.18.4.1 MASONRY, CONCRETE AND PLASTERED SURFACE

Before taking up painting works F3 finish shall be carried out on concrete surfaces. Plastered Surface shall be wire brushed and sand papered, clean and free of all oil, grease, efflorescence, mildew, loose paint or other foreign and loose materials. Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and uniformly textured. Where this type of resurfacing may lead to the finishing paint being different in shade from the original surfaces, the resurfaced area shall be treated with minimum one coat of cement primer, which should continue to the surrounding area for a distance of minimum 100 mm.

Surface with mildew or efflorescence shall be treated as below:

a) MILDEW

All mildew surface shall be treated with an approved fungicide such as ammonia wash consisting of 7g of copper carbonate dissolved in 80 ml liquor ammonia and diluted to 1 litre with water, or 2.5 percent magnesium silica fluoride solution allowed to dry thoroughly below the paint is applied.

b) EFFLORESCENCE

All efflorescence shall be removed by scrubbing the affected surfaces with a solution of muriatic acid in water (1:6 to 1:8) and washed fully with clear water and allowed to dry thoroughly.

19.18.4.2 **METALSURFACE**

All metal surfaces shall be absolutely clean, dry and free from wax, grease or dried soap films. All steel and iron surfaces, in addition, shall be free from rust. All steel or galvanized iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction. Prime coat for steel work shall, however, be applied by the fabricator. Any abrasion in shop coat shall be touched up with the same quality of paint as the original coat.

19.18.5 PAINTING

Various types of finishing shall be done as indicated in the 'Interior Finish Schedule' and/or as on drawings. The colour shall be in accordance with 'Painting Schedule' or as selected by the Engineer.

19.18.5.1 ACRYLIC PLASTIC EMULSION PAINT

Acrylic plastic emulsion paint shall conform to IS: 15489. It shall be water-based acrylic co-polymer emulsion with rutile titanium dioxide and other selected pigments and fungicide. It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to escape without peeling or blister. The paint, after it is dried, shall be able to withstand washing with mild soap and water without any deterioration in colour, or without showing flaking blisters or peeling.

Plastic emulsion paint shall be of premier quality conforming to IS 15489. It shall be applied in minimum two coats over a coat of approved primer to interior concrete, plaster & other surfaces after cleaning / scrubbing of the surfaces with wire brushes, soft brushes, sand papers, steel sheet scrappers and mechanical grinder etc. for removing all kind of burrs, imperfections, undulations and other such defects existing in the surface including filling surface imperfections such as holes, dents, cracks by using mixture of white cement & fine sand (in the ratio of 1:3) to achieve plain & even surface. The scope of work includes spreading of suitable and clean protection covering on all exposed surfaces to protect them from staining. All surfaces

surrounding to painted area including window frames & glasses shall be cleaned to sparkling clean condition using suitable thinners, detergents, chemical cleaners etc. under the scope of the item as directed, at all elevations as indicated in the drawings including labour, materials, scaffolding, preparation of the surface, protecting & cleaning etc. all complete as per specification and direction of the Engineer.

All concrete surfaces shall be F3 finished before taking up the painting works. Quoted rates of painting shall include cost of F3 finish. Lime gauged cement plastered surfaces shall not be painted for at least one month after plastering. A sample patch shall be painted to check alkali reaction if so desired by the Engineer. Painting shall be strictly as per manufacturer's specification.

19.18.5.2 SYNTHETIC ENAMEL PAINT

Synthetic enamel paint shall be made from synthetic resins and drying oil with rutile titanium dioxide and other selected pigments to give a smooth, hard, durable and glossy finish to all exterior and interior surfaces. White and pastel shades shall resist yellowing and darkening with aging. The paint shall conform to IS: 2932 & IS: 2933. Glossy synthetic enamel paint shall be used on metal surfaces. Ready mix matt synthetic enamel paint shall be used on wall surfaces.

Synthetic enamel paint shall be of approved make and shade premium quality mat / glossy (as directed). It shall be painted in minimum 2 coats to give an even shade on steel surfaces at all elevations after erection including surface preparation and touch up with zinc phosphate primer wherever required. The scope also includes providing and removing scaffolding, all as per manufacturer's specifications, drawings and direction of the Engineer. The rate shall be inclusive of surface preparation with wire brushing and touch up with zinc phosphate primer.

Synthetic enamel paint shall be applied on properly premiered surface. Subsequently, coat shall not be applied till the previous coat is dry. The previous coat shall be lightly sand papered for better adhesion of subsequent coats.

19.18.5.3 ACID, ALKALI RESISTING PAINT

Acid and alkali resistant paint shall be of approved make and colour conforming to IS: 9862. The paintshall be applied in minimum 500 micron DFT over a coat of approved primer on prepared surfaces of flooring, ceiling and walls and other surfaces at all elevations. The scope of work includes all labour, materials, scaffolding, preparation of the surface, protecting & cleaning etc. all complete as per manufacturer's specification and das per direction of the Engineer. Primer coat shall be as per manufacturer's instructions.

19.18.5.4 POLYURETHENE PAINTING

19.18.5.4.1 GENERAL

Polyurethane painting on concrete and steel surfaces shall be done at locations

wherever specified in the drawings. Generally the external surfaces of the specified buildings shall be painted with polyurethane paint after completion of the work.

19.18.5.4.2 **SCOPE**

The scope of work covered under this specification is supply and application of one coat of primer and two coats of polyurethane finish paint of approved make for total dry film thickness of 125 microns (excluding 75 micron thick primer) on exterior surfaces.

19.18.5.4.3 **MATERIALS**

a) Primer compatible for PU paint shall have outstanding resistance properties and shall contain a high level of penetrating pigment, which renders superior performance when applied over concrete and it should be compatible when over coated with polyurethane paint.

a) The finish paint shall be two-component air-drying acrylic aliphatic polyurethane coating.

c) Suitable thinner for the above will be as per the manufacturer's recommendations.

d) Finish paint shall be glossy/ matt finish of approved shade and as specified by the engineer.

19.18.5.4.4 **DESCRIPTION**

The surface shall be cleaned of dust, loose particles, finished and cured properly. Biological growth if any, accumulated on the surface over the period shall be removed completely. Painting shall commence with application of one coat of 75 micron thick primer and finished with 125 micron DFT of polyurethane paint in two coats. The shade of the finish paint is generally light grey in colour and Contractor shall obtain prior approval of Engineer before commencement of work. Method of painting shall be either brush application or using air less spray equipmentusing a pump with nozzle tip of size 0.33 mm to 0.45 mm and more than 2000 psi pressure.The rate quoted shall cater for both methods.

A) Primer shall be two pack epoxy primer with outstanding resistance properties and shall contain a high level of penetrating pigment which renders superior performance when applied over steel/ concrete having the following properties.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Density	ASTM D 4052	g/cc	1.09 + 0.05 at 25°C
Mixing Ratio, by weigh	ASTM D 4052	ratio	100(Base): 35(Hardener)
Flexural Strength	ASTM C 580-02	Mpa	35 at 7 days

Tensile Strength	BS 6319, Pt 7	MPa	22 at 7 days
Compressive Strength	ASTM C 579	MPa	70 at 1 Day 75 at 3 Days 80 at 7 Days
Adhesive Bond Strength	ASTM D 4541	MPa	>1.5
DFT of Primer	ASTM D 1005	Micron	75

B) The two component polyurethane paint shall have the following parameters.

PROPERTY	TEST METHOD	UNIT	ACCEPTACE VALUE
Volume of Solids	ASTM D 2697	%	57±3
Pot Life	ASTM C603-90	Min	120 (at 25 deg C) 50 (at 40 deg C)
Mixed Density	ASTM D 4052	Kg/Ltr	1.2 (at 25 deg C)
Mixing Ratio, by Volume	ASTM D 4052		4(Base) : 1 (Hardner)
Touch Dry	ASTM D 1640	Min	90 (at 25 deg C)
Recoatable	ASTM D 1640	Hour	6 – 8 (at 25 deg C)
Final Curing Time		Day	7 (at 25 deg C)
Bond Strength	ASTM D 4541	MPa	>2 (Concrete Failure)
Abrasion Resistance , CS17 wheel	ASTM D 4060	Mg/1000 cycles	<125
UV Resistance	ASTM G 53	Hour	>1000
DFT in two Coats of PU Paint	ASTM D 1005	Micron	125

The acceptance criteria shall be based on Manufacturer test certificate except for Bond & Abrasion Resistance test, which shall be performed (one sample per lot) at independent approved Laboratory at the cost of contractor. The test certificate shall clearly specify the PU material as “Aliphatic”.

19.18.5.5 EPOXY PAINTING ON STEEL AND CONCRETE SURFACES

19.18.5.5.1 GENERAL

Epoxy painting on concrete and steel surfaces shall be done at locations wherever specified in the drawings.

19.18.5.5.2 SCOPE

The scope of work to be performed under this specification comprises of supply and application of heavy duty high build epoxy paint of approved make for painting of concrete and steel surfaces in various buildings and areas specified in the drawing, for walls, ceiling, floors and fabricated structural steel members as per relevant drawing and specifications to the thickness as specified in the drawings including surface preparation.

19.18.5.5.3 MATERIAL SPECIFICATIONS

For the areas, important from radiological considerations, where decontamination and

radiation resistance properties are required, the material shall conform to PP-M-1219 as applicable and as specified in the drawings or decided by the Engineer. This material shall be Polyamide cured two pack epoxy coating in mix and use form.

The areas which are not important from radiological consideration as specified or decided by the Engineer, material shall meet the requirements under relevant clause of this section.

19.18.5.5.3.1 **INTENDED USE**

19.18.5.5.3.1.1 **For areas important from radiological considerations**:

The epoxy coating would be used for painting the concrete floors, ceilings and walls. Mild steel surfaces on inorganic zinc silicate primed fabricated structural steel surfaces, construction joints caulked with polysulphide or epoxy mortar caulking compound, metallic expansion joints made from steel and copper etc. The materials used in the coating should not form radioactive isotope on absorbing neutrons. The paint should form a thick, radiation resistant, abrasion resistant, impact resistant, non-adsorbent, de-contaminable, humidity resistant, hot water and steam resistant liner.

19.18.5.5.3.1.2 For areas not important from radiological considerations:

The epoxy coating can be used for painting the concrete floors, ceilings and walls over Epoxy based compatible primer and on Mild steel surfaces over inorganic zinc silicate primed fabricated structural steel surfaces, construction joints caulked with polysulphide or epoxy mortar caulking compound, metallic expansion joints made from steel and copper etc. The paint should form a thick, abrasion resistant, impact resistant, non-adsorbent, humidity resistant liner.

19.18.5.5.3.2 **QUALIFICATION**

19.18.5.5.3.2.1 **For the areas important from radiological considerations:**

The qualification and procurement of epoxy paint shall be in accordance with PP-M-1219 as applicable. At the time of bulk supply samples shall be drawn from the batch in presence of representative from NPCIL, sealed and got tested by the contractor for batch tests in accordance with PP-M-1219 as applicable. The rate for application of paint shall include all the costs related with procurement.

19.18.5.5.3.2.2 **For the areas not important from radiological considerations:**

The Epoxy paint shall have following properties:

a) **For Epoxy on concrete floors**: The Epoxy shall be high build solvent free, self-smoothing, 4 component (Base, Hardener, Filler & Pigment) material. The DFT of coating (Excluding Primer) shall be minimum 1200 micron for its use on floors unless specified otherwise.

Property	Acceptance criteria	Reference Standard
Mixed Density	1.6+/- 0.05 kg/ liter	ASTM D14752
Pot Life	Min 40 min at 25 ^{0} C Min 15 min at 40 ^{0} C	ASTM C603
Setting time for foot traffic	15 Hour at 15 ^{0} C	ASTM D5895
Maximum Service Temperature	60 ^{0} C	ASTM 24712
Compressive Strength	24 MPa at 1 day 50 MPa at 7 days	ASTM C579
Flexural Strength	18 MPa at 7 days	BS 6319 PART 3
Tensile Strength	10 MPa at 7 days	BS 6319 PART 7
Abrassion Resistance H22 Wheel 1000 cycles – CS17 wheel	Less than 230 mg Less than 85 mg	ASTM D2240
Hardness, Shore D	Min 80	ASTM D2240
Adhesive Bond strength to concrete at 7 days	>1.5 MPa (Concrete failure)	ASTM D4541

b) **For Epoxy on concrete walls & structural steel**: The Epoxy shall be high build solvent free, 3 component (Base, Hardener & Pigment) material. The DFT of coating (Excluding Primer) shall be 250 micron for concrete walls & 200 micron on structural steel, unless specified otherwise.

Property	Acceptance criteria	Reference Standard
Mixed Density	1.48+/- 0.05 kg/ liter at 25 ^{0} C	ASTM D 14752
Volume Solids	100 %	ASTM D 2697
Pot Life	Min 60 min at 25 ^{0} C	ASTM C603-90
Setting time for foot traffic	2 days at 25 ^{0} C	ASTM D 5895
Compressive Strength	60 MPa at 7 days	ASTM C579
Flexural Strength	38 MPa at 7 days	ASTM C 580-02
Tensile Strength	8 MPa at 7 days	ASTM C307
Abrassion Resistance H22 Wheel 1000 cycles – CS17 wheel	Less than 230 mg Less than 130 mg	ASTM D2240
Hardness, Shore D	Min 80	ASTM D2240
Adhesive Bond strength to concrete at 7 days	More than 1.5 MPa Concrete failure	ASTM D4541

19.18.5.5.4 **SURFACE PREPARATION**:

Generally all surfaces to be painted shall be cleaned of oil, grease and other foreign matter. If the surface is very oily a detergent wash may be applied. The surface shall then be rubbed with No. 60 to 80 emery paper and the dust removed thoroughly with a clean cotton cloth.

19.18.5.5.4.1 CONCRETE SURFACES

Air water jet at a pressure of 7 Kg/cm2 shall be applied through a nozzle having a tip orifice of 1.5mm. The surface shall be allowed to dry. Pin holes if any exposed due to air water jetting shall be filled with cement paste and excess cement mortar shall be removed after drying by rubbing with emery paper followed by wiping with clean cloth.

In the case of floors, all laitance, stains and other deleterious substances shall be removed by using a floor polishing machine followed by a thorough air water jetting and cleaning. Oil and grease shall be removed by wiping with cloth soaked in thinner or acetone.

19.18.5.5.4.2 STEEL SURFACES

All steel work shall be cleaned of rust, scale, dirt, oil, weld splatter and other deleterious substances by shot blasting.

19.18.5.5.5 EQUIPMENT FOR PAINTING

Generally, only airless spray equipment of ratio not less than 66:1 shall be used for all painting works. Only trained personnel shall be allowed to operate the airless spraying equipment. The capacity of the equipment shall be such that it will provide maximum dry film thickness without sagging of the paint film. However, at places, where airless spray equipment cannot be used, painting with brushes shall be permitted at the discretion of the Engineer-in-charge only.

19.18.5.5.6 APPLICATION OF PAINT

General

Painting shall commence from top of walls and shall be worked down. Floors shall be painted from one corner working towards exit to avoid walking over painted areas. The paints shall be mixed and applied in accordance with manufacturer's instructions. Only approved primer coat shall be applied on the concrete or steel surfaces. The final finish paint should give a dry film thickness as specified in drawings/ specifications. The thickness shall be made up in minimum number of coats as possible.

The curing time between successive coats shall be around 16 hours unless recommended otherwise by the paint manufacturer.

On concrete surfaces, inert filler shall be applied after the first coat to cover the uneven surface. It shall be noted that inert filler material shall not be applied over the entire surface as such layer will lead to loss of adhesion of the subsequent layers of paint. After application of the inert filler the surface shall be rubbed down with Nos. 80, 120 and 140 (as the case may be) sand paper and the rubbed surfaces cleaned by air jetting followed by cleaning with soft cloth before the successive coat of paint is applied. Each coat of paint except the final coat shall be slightly roughened using sand paper to obtain good adhesion of the successive coat of paint.

The paint shall be spread uniformly without runs, sags or brush marks (in case of brushing). Care shall be taken during spraying operations to hold the nozzle sufficiently close to the surface (not closer than 300mm) being painted to avoid evaporation of the volatile constituents of the paints and loss of materials into the air. The air pressure shall be kept at the required level through the entire painting operation. Each coat of paint shall be inspected after curing for the finish and dry film thickness. Necessary compositor plates shall be fixed on to the surface during painting, for checking the dry film thickness at various intervals as may be necessary. Wet film thickness gauges shall also be used during the painting and the thickness of wet film shall be recorded.

19.18.5.5.7 APPLICATION OF SELF LEVELING EPOXY FLOORING

The floor receiving the self-leveling epoxy flooring must be sound, dry, fine-grained and load bearing, free of laitance, loose and brittle particles and shall also be free from substrate and substances which impair adhesion such as oil, grease, rubber skid marks, paint or other contaminations.

The bond strength of the substrate must be at least 1.5 MPa. Ensure the compressive strength of the floor concrete is at least 25MPa and that floor slabs directly in contact with the ground have a proper vapour barrier installed and the moisture content of substrate shall not be higher than 4% throughout.

The temperature requirements shall be in the range given below:

A] Substrate temperature: 15°C - 35°C
B] Material temperature: 15°C - 30°C

The priming is essential to seal the concrete surface prior to the application of the self-level epoxy flooring. For primer shall be applied using medium nap roller ensuring a complete coverage without holidays, if after drying the surface appears patchy due to high absorption, recoating of primer shall be done in such areas. Primer shall be allowed to dry before commencing topcoat application of the self-level epoxy floor coating.

All mixing should be done mechanically, using a slow speed drilling machine fitted

with a paddle, taking care to ensure that the mixing head is well within the material during mixing.
Applicator must wear spiked shoes during application. Mixed material shall be poured onto the primed and sealed surface and spread to full specified thickness using a pin screed or a notched trowel to achieve the specified thickness. The spread material should be immediately rolled with a spiked roller to release entrapped air and remove trowel marks. Control rolling shall be continued until all air is released well before the material starts stiffened.

19.18.5.5.8 PRECAUTIONS TO BE TAKEN

Required oil free compressed air at correct pressure shall be available with suitable compressors.

The equipment with all its accessories shall be cleaned immediately after the painting is completed with suitable thinner after painting.

All material such as paints, thinner, inert filler and Primer shall be stored safely, handled carefully and account of consumption recorded regularly. The paints used are volatile and hence proper ventilation shall be maintained in the areas of painting.

Explosion meters shall be used to constantly check the fume concentrations to avoid any explosion. The area to be painted shall be well ventilated by using fans/air blowers.

Sufficient lighting arrangements shall be ensured before start up of painting.

Proper staging and scaffolds shall be ensured while painting at heights.

Embedment, equipments pipes etc. shall be suitably masked before the painting commences.

After the painting, areas shall be cleaned of stains if any.
Care shall be taken to see that no welding/ Gas cutting is carried out where painting work is in hand or near to storage area.

19.18.5.5.9 Maintenance of records

A daily progress record shall be maintained.

19.18.5.5.10 Handling precautions

All the precautions must be taken to avoid direct contact of resin and hardener with skin. The persons handling epoxy resin and hardener must use rubber or polythene gloves. Parts of the skin, which come in contact with resin or hardener, should be washed with lukewarm water and mild soap. Manufacturer's recommendation on these aspects should be followed.

19.18.5.6 ANTI CARBONATION, ANTI CORROSIVE AND WATERPROOF COATING

19.18.5.6.1 SCOPE

The specification described here covers material description, physical and mechanical properties, testing, applicable codes and standards, acceptance criteria, surface preparation and QA requirement etc. for protective coating using Aliphatic acrylate system on external surface of buildings unless specified otherwise.

19.18.5.6.2 MATERIAL

The protective coating on the external concrete surfaces shall be pure aliphatic acrylate system. It shall be single component; solvated aliphatic acrylic resin based coating for protection of concrete from carbonation, chloride ions, weathering and industrial pollution.

19.18.5.6.3 SURFACE PREPARATION

The surface shall be clean and free from loose particles, oil, grease, or any other contamination. The concrete surface shall be cleaned with wire brush and shall be washed with clean water. The surface having oil and grease shall be cleaned with detergents.

The surface irregularities such as blow holes, honeycombs, crevices and surface blemishes shall be filled with polymer modified cement putty mortar to achieve smooth and level surface this shall be allowed to cure by spraying water for two days and to dry for one day.

The substrate shall be in dry condition before the application of protective coating for better performance. The compatibility of this system shall be checked with the existing coating system, if any.

19.18.5.6.4 APPLICATION

Prepared Concrete substrate shall be applied with a compatible coat of primer at least 2 hours before application of Coating. The Primer shall have following properties.

PROPERTY	UNIT	TEST METHOD	ACCEPTANCE VALUE
Mixed Density	Kg/ltr	ASTM D 6237	0.95
Volume Solid	%	ASTM 5201	Min 32%
Over Coating Time	Hrs	ASTM D 1005	2 (at 25 ^{o}C)

Over the primer the protective coating shall be applied using brush or roller or airless spray. The complete protective coating shall be applied in minimum one primer and two main coats. The first and the second main coat shall be applied approximately

with a gap of 24 hours at right angles to each other. At low temperature, the subsequent coat shall be applied after ensuring that the earlier coat is fully dry.

19.18.5.6.5 **CURING**

The aliphatic acrylate based protective system is naturally air cured. Hence, no separate curing is required.

19.18.5.6.6 **COVERAGE**

The coverage depends on the type of surface (concrete, plaster, masonry) and surface finish. The Engineer In Charge shall check the coverage as per the manufacturer's specification. Engineer-in-charge shall verify the quantity of material used at site along with bills from the manufacture and the coverage specified in the manufacturer's specification.

The protective coating shall be applied in two coats over a primer coat. Each coat shall have a minimum thickness of 75 microns. The total dry film thickness inclusive of Primer shall be minimum 225 microns.

19.18.5.6.7 **STORAGE AND SHELF LIFE**

The material shall be stored under cover, out of direct sun light and shall be protected from extremes of temperature. The shelf life shall be as per the manufacturer's specification.

19.18.5.6.8 **Properties**

The properties of aliphatic acrylate based protective system are as follows. The base and system shall be pure aliphatic acrylate base and single component system.

PROPERTY	UNIT	TEST METHOD	ACCEPTANCE VALUE
Density	Kg/ litre		1.10 (min)
Volume solids	%	ASTM D 5201	37% (min)
Dry film thickness (DFT) for 1 Primer in white shade + 2 Top Coats	Microns	ASTM D 1186	225 microns in 1 Primer + 2 Top Coats
Adhesion with Concrete/ plaster surface	MPa	ASTM D4541	3.0 or concrete failure
Water vapour permeability test	gm/sq.m/day	ASTM D 1653	7 gm/sq.m/day at 75% RH at 25C (max)
Water penetration test	% weight gain	IS 3085	NIL at 5 kg/cm^2 hydrostatic test

Flexibility -Standard bend test		ASTM D 522	No cracks on the surface in 1/8 inch Mandrel
QUV- condensation test	Hours	ASTM G 53 for 500 hours	Passes - No discolourisation and chalking
A.C. Impedance Test in 3% sodium chloride	Coating resistance	Using Electrochemical impedence measurement for a frequency range of 100 KHz to 0.01Hz with AC amplitude of 20 Mv.	Initial value: $9x10^9$ Ohms (min) Final value after 30 days: $1x10^7$ 0hms (min)
CO2 diffusion resistance	Equivalent air layer thickness, R	AS/NZS 4548.5 – 1999: Taywood Method	>70m
	Equivalent Concrete Layer Thickness		>170 mm

Note: A.C. impedance test for the protective coating is required for application on RCC surface. This test may not be required for application on masonry/ PCC surfaces.

19.18.5.6.8.1 **Material**

Base: Aliphatic Acrylate Solvented System
Components: Single component

19.18.5.6.8.2 **Volume Solids**

Test Method: ASTM D 5201 –97 Standard practices for calculating formulation physical constants of paints and coatings.

19.18.5.6.8.3 **Dry Film Thickness**

Test Method: ASTM-D-1186: Test method for non-destructive measurement of dry film thickness of non magnetic coatings applied to ferrous base.

Methodology for adopting on concrete/masonry/plaster surface: Cleaned steel plates shall be fixed to the concrete surface firmly at regular intervals during application of protective coating. The dry film thickness (DFT) measurement shall be carried at every 100 sq.m area or part there off.

19.18.5.6.8.4 **Adhesion with concrete/ plastered surface**

Test Method: ASTM-D-4541-02: Standard test method for Pull-off strength of coating using portable adhesion testers.

19.18.5.6.8.5 **Water Vapour Permeability test**

Test Method: ASTM-D-1653: Standard test method for water vapour transmission

of organic coating films.

19.18.5.6.8.6 **Water penetration Test**

Test Method: Water penetration resistance tested by immersing coated concrete cubes (5 cm x 5 cm x 5 cm size) for 12 days. Even at the end of 12 days, the weight gain shall be NIL to negligible.

19.18.5.6.8.7 **Flexibility- Standard bend test**

Test Method: ASTM-D-522: Standard test method for mandrel bend test for attached organic coatings.

19.18.5.6.8.8 **QUV- Condensation Test**

Test Method: ASTM-G-53: Standard practice for operating light and water exposure apparatus (fluorescent UV- condensation type) for exposure of non-metallic materials.

19.18.5.6.8.9 **Impedence Test (in 3.0% NaCl solution)**

Test method: Electrochemical impendence measurements for a frequency range of 100 kHz to 0.01 Hz with an AC amplitude of 20mV.

19.18.5.6.9 TESTING

The material shall be tested as per this specification by the contractor at no extra cost to NPCIL. Each batch of material used for the NPCIL job shall be tested in any of the approved independent laboratories. The independent test certificates along with the manufacturer's test certificate shall be submitted to NPCIL. The independent testing shall be witnessed by NPCIL representative, If felt necessary by the Engineer.

19.18.5.6.10 PACKAGING AND SHIPMENT

Materials delivered at site shall be clearly marked with legible and intact labels with manufacturer's name, brand name, product identification, manufacturing & expiry dates and batch number. The products shall be in original, unopened / sealed containers. Material shall be stored in areas where temperatures conform to manufacturer's recommendations and instructions.

19.18.5.6.11 SAFETY PRECAUTIONS

The work shall be carried out by an authorized contractors/applicator

The application shall comply with the procedure given above, all current relevant codes of practice and the Building Regulations.

All materials shall be stored clear of ground and moisture with weather protective covering. All the materials shall be kept away from sources of ignition.

The protective coating shall not be applied during inclement weather or when ambient condition is not allowing proper application.

Safety scaffolding, access ladders etc shall be provided in accordance with the current industrial safety and all the health and safety regulations shall be adhered to.

Care shall be taken during storage and use to avoid contact with eyes, mouth, skin and food stuff. The container shall be sealed after use.

19.18.6 PROTECTION

Furniture and other movable objects, equipment, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationery equipment shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as per instruction of the Engineer.

19.18.7 CLEANING UP

In addition to the provision in 'Conditions of Contract' the Contractor shall, upon completion of painting etc., remove all marks and make good surfaces, where paint has been spilled, splashed or splattered, including all equipment, fixtures, glass furniture, fittings, etc. to the satisfaction of the Engineer.

19.18.8 ACCEPTANCE CRITERIA

a) All painted surfaces shall be uniform and pleasing appearance (gloss/ matt finish).
b) All varnished surfaces shall be of uniform texture and high glossy finish.
c) The colour, texture etc. shall match exactly with approved samples.
d) All stains, splashes and splatters of paints and varnishes shall be removed from surrounding surfaces

19.19 WATER SUPPLY, DRAINAGE AND SANITATION

19.19.1 SCOPE

The specification covers the general requirements for providing and laying water supply, piping, and providing and laying drainage lines.

19.19.2 CODES AND STANDARDS

Some of the important Codes and Standards relevant to this specification shall be followed: Latest editions shall always be consulted.

The following IS Codes shall be applicable:

IS: 1172 - Code of basic requirements for water supply drainage and sanitation.

IS: 1200 - Methods of measurement of building and civil engineering works.

IS: 1239 - Steel Tubes, Tubulars and other wrought steel fittings. (Pt. I & II)

IS 16098-2-Structured-Wall Plastics Piping Systems for Non-Pressure Drainage and Sewerage –specification

IS 7634-2- Plastics Pipes Selection, Handling, Storage and Installation for Potable Water Supplies - Code of Practice, Part 2: Laying and jointing of polyethylene (PE) pipes.

IS 14333 -High density polyethylene pipe for sewerage

IS: 1742 - Code of Practice for building drainage.

IS: 5329 - Code of Practice for sanitary pipe work above ground for buildings.

IS: 3076 - Specification for Low density polyethylene pipes for potable water supplies.

IS: 4984 - High density polyethylene pipes for potable water supplies.

IS: 458 - Pre cast concrete pipes (with and without reinforcement) - specification

IS: 783 - Code of Practice for laying of concrete pipes.

IS: 784 - Pre-stressed concrete pipes.

IS: 1726 - Specifications for Cast Iron Manhole Covers and Frames.
IS: 5961 - Specification for Cast Iron gratings for drainage purposes.

IS: 5219 - Specification for cast copper alloys traps. Part-1 - ‘P' & 'S' traps.

IS: 771 - Specifications for Glazed fire-clay sanitary appliances.

IS: 772 - Specifications for general requirements for enameled cast iron sanitary appliances.

IS: 774 - Flushing cistern for water closets & urinals (Other than plastic cisterns) - specifications.

IS: 775 - Cast Iron brackets & supports for wash basins and sinks.
IS: 2548 - Plastic seats and cover for water closets – specifications.

IS: 2527 - Code of Practice for fixing rain water gutters and down-pipes for roof drainage.

19.19.3 DRAWINGS

a) Checked and approved drawings showing locations of sanitary and water supply fixtures will be furnished to the Contractor and all drawings so furnished shall form a part of this specification. The Contractor shall refer these drawings for all information contained thereon which pertains to and required for his work. He is, however, not to commence detail plumbing, water supply and drainage on the basis of drawings unless such drawings or parts of such drawings are officially released as 'Released for Construction'. Revision to drawing and any new drawings made to include additional work by the Contractor shall be considered a part of this specification and contract.

b) Unless otherwise specified, the plans and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and accordingly the job shall be carried out for completeness as required whether each item is mentioned here or not.

c) Based on line diagrams/drawings furnished by the Engineer, the Contractor will have to prepare detailed working drawings indicating the positions of fittings, valves, joints, nature, type and location of supports, connections to main lines etc. Four prints of each of these detailed drawings shall be submitted to the Engineer for approval. The drawings shall be got approved before proceeding with the execution of the work. The Contractor shall obtain permission from all local statutory authorities for all proposed works prior to commencement of execution and necessary fees, etc. shall be borne by him. The Contractor should, after completion of all works, give "as built" drawings incorporating all field changes made, for reference and use of the client. The final payment due to the Contractor will be effected only after such drawings are finalized.

d) Construction shall not be started until the Contractor has received copies of such drawings upon which the Engineer has endorsed approval. The approval of the Engineer of any of the drawings shall not relieve the Contractor from his responsibility for correctness of Engineering workmanship, fit of parts, details, materials, errors or commissions of any all work shown thereon. The Engineer's approval shall constitute approval of the design, sizes of pipes and layout only. The approval shall not invalidate any claim the Owner may make for damages on account of faulty construction.

e) The Engineer will return one copy of the Contractor's drawings marked with his approval/comments. The Contractor shall furnish the Engineer 2 prints and one reproducible of all final drawings for record purposes.

19.19.4 PIPING FOR PLANT DRAIN WORKS

a) Double walled corrugated pipes, conforming to IS:16098, Part 2

For equipment (plant) drain works underground double walled corrugated pipe conforming to IS: 16098, Part 2, stiffness class SN 8 shall be used. These pipes will be used for external buried (underground) pipe lines. Work involved includes providing, jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS : 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

b) HDPE pipes conforming to IS:4984

For equipment (plant) drains works underground HDPE pipes of higher diameter conforming to IS:4984, grade PE 100, pressure rating PN 6 shall be used. These pipes will be used for external exposed pipe lines. Work involved includes providing, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

19.19.5 PIPING FOR PLANT SEWER WORKS

a) Internal sewer works

For internal sewer works of main plant buildings under floors or against walls, HDPE pipes conforming to IS: 14333, grade PE 100, pressure rating PN 12.5 shall be used. Scope of work shall include providing HDPE pipes and fittings, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Laying and jointing shall conform to IS: 7634 (Part-2).Scope shall also include cutting and trimming of pipes, preparation of bends as per requirement at site, taking suitable supports from Ceiling and walls/ preparation of bed etc. all complete as per drawings, manufacturer's specifications and direction of the Engineer.

b) External sewer works

i) For external sewers under gravity flow underground double walled corrugated pipe conforming to IS: 16098, Part 2:2013stiffness class SN 8 shall be used.Scope of work shall include providing pipes and fittings, laying or fixing in position, including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Scope shall also include laying and jointing of pipes conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

ii) For external sewers under pressure, underground HDPE pipes conforming to IS: 14333, grade PE 80, pressure rating PN 6 shall be used. Scope of work shall include providing pipes and fittings, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Scope shall also include laying and jointing conforming to IS : 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

19.19.6 WATER SUPPLY PIPING AND FITTINGS

a) All water supply pipes shall be 'C' class (heavy duty) galvanized M.S. pipes of the specified internal diameters, conforming to IS: 1239**.** The pipes shall be fixed in longest possible lengths with all necessary bends, tees and couplings, reducing tees, etc. in perfect straight lines vertically and horizontally. For joining pipes threads of tube sand fittings shall be smeared with white lead and screwed down together with jute threads smeared with lead. Exposed surfaces of pipes shall be coated with 2 coats of oil paint if required by the Engineer. G.I. pipes shall be embedded in a chase out in internal wall chase shall be filled with cement mortar when directed at no extra cost. All G.I. pipes inside shaft shall remain clear off walls by at least half an inch. They shall be fixed with galvanized malleable iron bat clamps.

b) All brass or chromium plated fittings shall be of approved make and of the best quality, heavy cast or drawn brass, thoroughly annealed and shall be seamless.

19.19.6.1 **VALVES**

Valves shall be of best quality gun metal sluice valves unless specified otherwise, of screw down type with cast iron hand-wheel. Valves up to and including 15 mm diameter shall have threaded sockets.

19.19.6.2 **SUPPORTS**

a) Supply pipes, ladders, soil drain rain water and waste pipes etc. installed in a vertical position shall be hold firmly in place by GI/ W.I. clamps unless projecting ears with fixing holes are provided at socket and of pipes or by approved inserts wall fastened to the walls or structural framing.

b) Sleeves shall be provided for all pipes passing through walls floor and partitions, except at locations specifically forbidden by the Engineer. All sleeves shall be painted steel pipes. Pipe hangers where provided shall not be wider apart than 1.5 m on centres for cast iron pipes. General scheme for support arrangement shall be got approved by the Engineer before it is erected in position. The Engineer shall have the right to increase the number or strengthen or modify the supports at site.

c) All piping, where not concealed and where location is not specifically fixed by drawings shall run parallel and as close as possible, to wall.

19.19.6.3 **PLUMBING WORK**

The pipes before being laid shall be thoroughly cleaned specially the inside of pipes if required. Socket ends of pipes shall always face upstream of effluent flow. The drains shall run in perfect straight lines between manholes. The trenches shall not be filled in until the joints have been tested and alignment of drains and connections into and from the manhole and their positions have been examined and certified and certified by the Engineer, if required. The whole of sanitary work comprising provisions of drainage and water supply arrangements including sanitary and water fittings and fixtures complete in all respects shall be carried out in accordance with the rules and regulations of the local authority through the agency of a licensed plumber. If required, the Contractor shall have to get all materials brought on site for incorporation in the work approved by the local authority at his own expense.

19.19.6.4 **PROTECTIVE PAINTING**

All exposed wrought iron clamps, steel suspenders or brackets for fixing the pipes to the wall face in case of vertical pipes and suspending the horizontal run of pipes shall be painted with one coat of zinc phosphate primer and two coats of paint of approved make and shade.

19.19.7 **TEST AND GUARANTEE FOR WATER SUPPLY, SOIL AND VENT SYSTEM**

a) Water supply lines shall be tested to a hydrostatic pressure of 12 times the design water pressure at any point over a period of 24 hours. All soils, waster, rain water pipes and vents shall be tested under a pressure of 3 meters of water. Rain water pipes shall be tested to a height of water equivalent to the height of the building plus 3 meters to ensure no leakage in case of choking sections by first installing test plugs in all openings, erecting 3 metres stand pipe, filling the system with water or by hydrostatic plus air test. Pipes shall be deemed to have passed the test, if water level in the stand pipe remains reasonably constant for a period of one hour.

b) The Contractor shall deliver to NPC upon completion of this work under this Contract a written guarantee: -

i) That for a period of one (1) year after acceptance by the Engineer, plumbing and drainage work shall be free from defective material and workmanship;

ii) That for a period of one (1) year after acceptance by the Engineer the Contractor shall be responsible for the tightness of all joints make by him;

iii) That he at his own expense, repair and replace all such defective work, and all other work damaged thereby, which becomes defective during the term of guarantee;

iv) After the completion of the work, the Contractor shall obtain and hand over to NPC necessary certificates from the local authority/authorities concerned at no extra cost to NPC.

19.20 SANITARY FITTINGS/ FIXTURES AND TOILET REQUISITES

19.20.1 MATERIAL

All sanitary fixtures shall be of the best quality from approved manufacturers. Contractor has to obtain the approval from the Engineer, the names of the manufacturer whose product he proposes to use. All fixtures shall bear the seal of the approved manufacturer. All fittings, screws, gratings, etc. shall be chromium plated. The connecting lead pipes and bends shall weigh at least 3 kg per 25 mm diameter per metre length. After the fixtures are brought to the site, the Contractor shall arrange for their inspection by the Engineer and only after the approval, the fixtures shall be installed. All broken, damaged or rejected fixtures shall be removed from the site within two days after inspection.

19.20.2 INSTALLATION

All sanitary fixtures shall be installed to required level and plumb in the best workman like manner skilled labours and it shall be securely anchored to walls and floors.

All fixtures likely to be damaged shall be covered and protected during the progress of the building work, and uncovered after completion. Fixtures and accessories shall include all anchors and screw plates, screws, bolts, toggle bolts, expansion shields, set screws, wood blockings and plugs, lead connecting lead-pipes, etc. as required by the type of fixtures and accessories selected and by the type of construction to which they are connected. All fixtures and fittings shall be connected by water-tight joints. No dripping shall be accepted. All holes in walls and floors as required shall be made to the minimum desired size and depth only and they shall be properly made good and finished to match the existing finish. All brackets, supports, etc. shall be painted with a prime coat of anti-corrosive paint.

19.20.3 SANITARY FITTINGS &FIXTURES

The contractor has to mention the names of the manufacturers of the fixtures he intends to use. The sanitary fittings &fixtures shall be as described here under.

19.20.3.1 WATER CLOSETS

a) WESTERN STYLE

European water closet shall be of premium quality of size 710*390*765 mm of approved make and shade comprising of

(i) Double siphonic pattern coupled water closet with integral 'P' trap 180 mm roughing in and 'S' trap 250 mm roughing in,in glazed vitreous chinaware of matching colour.

(ii) 10 litres capacity PVC slim type single flushing low level flushing cistern (Dual Flush Tank white) with all fittings complete.

(iii) 15 mm NB heavy quality CP inlet connection pipe with brass unions and wiped solder joints at ends.

(iv) 15 mm NB screw down easy clean variety heavy quality CP brass angle valves with C.P. flange of superior quality.

(v) Germfree EWC solid seat cover (white) with C.P. brass hinges and rubber buffers of approved brand.

(vi) Jet spray provision with 1 Meter PVC tube (stainless steel) with 01 nos 15mm dia CP brass angle valve with CP flange as approved.

(vii) 15 mm NB heavy quality GI pipes and specials for overflow from cistern upto 150 mm above floor level, concealed in wall and terminated with 15 mm NB brass mosquito proof jali etc. all complete as per direction of the Engineer.

The European water closet shall be installed properly in all line and level as per direction of the Engineer.

b) INDIAN STYLE

Orissa type water closet shall be of premium quality of approved make and shade with 'P' or 'S' trap in vitreous chinaware best quality first grade with or without vent, having size 580mm x 440 mm or equivalent. It shall have following accessories.

(i) 10 liters capacity PVC slim type single flushing low level flushing cistern Dual Flush Tank with all fittings fitted over a pair of CI or MS bracket etc.

(ii) Lead valve loss syphon 15 mm nominal size, 32 mm NB GI flush pipe heavy quality of appropriate length with brass unions at end, wiped solder joints etc. complete.

(iii) 15 mm NB GI overflow pipe concealed in wall and brought down to 15 cm above floor level with mosquito proof jali at end as per specification.

(iv) 15 mm NB heavy type CP brass inlet connection with brass unions and wiped solder joints at ends.

(v) 15 mm NB heavy type CP brass screw down angle valve with C.P. brass flange of superior quality on inlet connection, recess concreting using 1:5:10 nominal mix as per site requirements.

The scope shall include all accessories, necessary brackets, supports, fittings, screws, gratings etc., installation including cutting and making good necessary opening chases etc. all complete as per specifications, drawing and as directed by the Engineer.

The WC pan shall be installed as per manufacturer's specifications. The W.C. pan shall be sunk in floor. The floor should slope towards the pan, care being taken not to damage the pan in the process of fixing. It shall be fixed on the proper cement concrete base taking care that the cushion is uniform and without having any hollows between the concrete base and the pan. The joint between the pan and the trap shall be made with cement mortar (1 cement: 1 sand) and shall be leak proof.

19.20.3.2 URINALS

(a) LIPPED URINAL

The lipped urinal shall be of premium quality white vitreous chinaware flat back lipped front urinal of approximate basin size 465 x 355 x 265 mm of approved make with PVC flushing cistern with all fittings, fitted on CI brackets, standard size galvanised iron flush pipe, waste pipe and CP brass spreaders with brass union, push cocks, specials, connecters & stopcock, CP brass fittings etc. and GI clamps, painting of fittings and brackets, cutting chase and making good the walls etc. all complete. The urinal shall be bowl type, flat back of angular, lipped front basin and shall be of glazed stoneware. It shall be fixed in position by using wooden plugs embedded in wall and screws of proper size.

The flushing of the urinals shall done for one urinal basin with 5 litres capacity automatic or equivalent with PVC flushing cistern. The flushing of the urinals shall done for range of two urinal basins with 10 litres capacity automatic or equivalent with PVC flushing cistern. It shall be supported on a pair of C.I. cantilever brackets which shall be embedded /fixed to wall by means of wooden plug and screws. The cistern shall be connected to urinal basin by means of C.F. brass flush pipe with fittings. The pipe shall be fixed by using proper holder – bat clamps.

The joint between the urinal basin and flush and waste pipe shall be made by means of putty or white lead mixed with chopped hemp.

(b) URINAL PARTITIONS

The Urinal partitions shall comprise of be premium quality black granite of 18mm thick with rounded exposed corners etc. as approved by Engineer. It shall be in size 600 x 1000 mm or as approved by the Engineer. The scope

shall include installation of partitions by cutting the wall & making good the same after fixing the partitions in approved pattern including all materials, labour, fittings and fixtures complete as per specification and direction of the Engineer.

19.20.3.3 WASH BASINS

(a) STANDARD WASH BASIN

The standard wash basin shall be premium quality glazed vitreous chinaware wash basin of approved make and colour having size 550 mm x 400 mm or equivalent. This shall include one pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make., 32 mm NB CP brass waste coupling heavy quality with rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved., 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, One no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm dia B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti-corrosive bituminous paint etc. and accessory required for installation and fixing of the wash basin all complete as per the direction of Engineer. The wall plaster on the rear shall be cut to overhang with top edge of the basin.

(b) OVAL SHAPED WASH BASINS

The oval shaped was basin shall be of premium quality glazed vitreous chinaware wash basin of approved make and colour having size 560 mm x 450 mm or equivalent. This shall include one pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make., 32 mm NB CP brass waste coupling heavy quality with C.P. grating, rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved., 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, One no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm diameter B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti-corrosive bituminous paint etc. and any other accessory required for installation and fixing all complete as per the direction of Engineer.

19.20.3.4 SINK

(a) VITREOUS CHINAWARE LABORATORY SINK

The vitreous chinaware laboratory sink shall be of premium quality glazed conforming to BIS 771 Part-2 of bowl size 600mm x 400mm x 200mm with

integrated drain board of approved make including all fittings, CI brackets, CP brass chain with rubber plug, angle valve and connector etc. complete with 40 mm CP brass waste fitting and 40 mm CP brass trap with necessary CP brass union, CP brass connecting pipes and any other accessory as required etc. complete as per specification and direction of the Engineer. The scope includes installation of the sink as per manufacturer's specification.

(b) STAINLESS STEEL SINK

The stainless steel sink shall be of premium quality of SS grade 304 glossy finish having size 600 x 400 x 200 mm (24"x18"x8") with edges rounded off. All fittings, fixtures, waste connection etc. shall be of standard size and appropriate for use with SS sink material. Accessories shall include: GI brackets: 32 mm NB CP brass waste coupling heavy quality with rubber plug and chain: 32 mm NB CP brass bottle trap with extension piece and wall flange: 15 mm NB CP brass inlet connection with all brass unions and wiped solders joints and all accessories such as choke stop stainer, outlet pipe upto floor trap and any other accessory as required. The sink shall be installed as required complete as per specifications and direction of engineer in charge.

19.20.3.5 **WATER CONNECTION**

Water connection to flushing cistern, wash basins and sinks shall be by means of PVC/ GI pipe connection pieces, with stop C. P. Brass cocks. The size of the PVC pipe connection and stop cock shall depend upon the size of water connection.

19.20.4 **TOILET REQUISITES**

a) MIRROR

Mirror shall be of premium quality cut edge mirror 6mm thick of overall size 600X450mm especially fabricated with superior glass (of approved quality) with designer acrylic PVC frame of approved colour and make mounted all-round with 6mm thick non-water absorbent Acrylic/PVC material backing fixed with cleats using C.P. brass screws and washers all complete as per the specifications and directions of Engineer. Scope shall include supply and fixing of mirror.

b) SHOWER SETS

Shower rose shall be of premium quality easy clean CP brass shower rose. It shall include shower arm 190mm long and wall flange of superior quality with 15 mm inlet of 100 mm diameter revolving type etc. all complete. Shower sets shall be swivel type

CP brass shower rose, complete with water valve, supply pipes, and any other accessory etc. Scope shall include supply and fixing of shower rose.

c) GLASS SHELVES

Glass shelves shall be of premium quality of size 600 x 125 mm of sheet glass 6 mm thick or equivalent with CP brass brackets and guard rails, fixed to wooden cleat with CP brass screws. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

d) TOWEL RAILS

Towel rods shall be of premium quality CP brass heavy quality of size 600 x 20mm with a pair of CP brass brackets, wall flanges etc. fixed to wall with CP brass screws, screwed on to rawl plugs. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

e) LIQUID SOAP DISPENSERS

Liquid soap dispenser shall be of premium quality of CP brass with CP brass lid and brackets fixed to wooden cleat with CP brass screws. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

f) TOILET ROLL HOLDER

Towel roll holder shall be of premium quality of size 150 mm x 150 mm or equivalent recess type in white glazed vitreous chinaware including cutting into wall and making good the same all complete. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

g) COAT HOOKS

Coat hooks shall be of premium quality CP brass two pronged hooks fixed to wall / door with CP brass screws and rawl plugs including cutting and making good the wall etc. complete. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

20 BUILDING JOINTS

20.1 EXPANSION JOINTS

20.1.1 SCOPE OF WORK

The work shall include providing and installing sealed expansion joints for various buildings in accordance with the requirements and details given in the specifications, drawings, schedule of quantities, together with the manufacturer's instructions, all to the complete satisfaction of the Engineer. The typical details of Expansion joint system are given in the enclosed drawing. The drawing given here is indicative. The contractor has to get the drawing prepared & approved before its actual use. The joints shall be designed utilizing extruded aluminum base members, self aligning / centering arrangement and support plates as applicable. The work involves sealing the Expansion Joints using properly designed extruded seals which may be mechanically fastened between extruded metal shapes, depending on the application. The design shall allow for joint movement in all direction and shall guard against water ingress. The latter shall be provided for all external joints, joints in areas in contact with water and at all other locations as directed by the Engineer. The complete details of the material proposed to be used shall be furnished to the Engineer for his approval. The material shall be used only after obtaining the written approval of the Engineer. The contractor shall furnish the necessary documents, prepared by the manufacturer of the expansion joints, to enable the Engineer to satisfy himself regarding the suitability of the materials and adequacy of the design of the expansion joints.

20.1.2 The Work shall be carried out by the manufacturer or through an experienced manufacturer approved applicator, with the prior approval of the Engineer. In case, the work is carried out by the manufacturer-approved applicator, the manufacturer will have to provide the guarantee for the successful performance of total system including material & workmanship.

20.2 MATERIALS

20.2.1 The Expansion joint materials shall be procured from manufacturers such as Sanfield (India) Ltd. / Z. Tech (India) Pvt. Ltd/ BASF or any other equivalent as approved by the Engineer and shall be installed by the manufacturer themselves and not by any distributor / agent / any other externally appointed agency so as to guarantee the quality of workmanship.

20.2.2 The Material shall conform to the following Codes / Publications.

a) Aluminum Extrusions shall conform to ASTM B221. The alloy shall be 6063-T5 or Indian equivalent IS 63400.

b) Aluminum sheet and plates shall conform to properties of ASTM-B209. The alloy shall be 6063-T5 or Indian equivalent IS 63400.

c) Steel Shapes shall conform to ASTM-A36 or Indian equivalent IS: 2062.

d) Stainless Steel shall conform to ASTM-A-479 Gr. 304 or Indian equivalent IS: 6529 Gr. 0.4Cr18Ni10.

e) **Bronze Extrusions:** Materials shall be Architectural Bronze 385 Alloy.

f) **Electrometric Compression Seal**: these shall be preformed extruded multi-web cellular section of Chloroprene (Neoprene). Chloroprene shall conform to Clause 915.1 of IRC: 83 (Part II) and satisfy the Physical properties as Durometer Type "A" Shore hardness of 55±5and a tensile strength of 2000 PSI (min).

g) **Moisture barrier**: shall be vinyl EPDM / bituminous modified moisture barrier as recommended by the joint manufacturer or an approved equivalent, all as subject to the approval of the Engineer.

h) **Fire rated joint system**: shall have independent laboratory test reports reflecting the endurance result of the materials run to time temperature curve.

i) **Elastomeric Joint Systems**: Material shall be a flexible extruded poly vinyl chloride or manufacturer's alternate material exhibiting a Shore "A" hardness of 64±5 with U.V. Stabilizer. Provide multi-cellular profile able to transfer loads to adjacent aluminum extrusions. The profile shall be flexible and exhibit a non-slip exposed surface that remains flat during all phases of movement. Block-out required for installation shall be provided at site by the contractor as per the dimensions given by the manufacturer.

j) Lubricant adhesive used shall be a one-part moisture curing polyurethane and aromatic hydrocarbon solvent mixture and shall conform to ASTM D4070.

k) **Visual seal**: shall be a flexible extruded poly vinyl chloride / santoprene or manufacturer's alternate material exhibiting Shore "A" hardness of 64±5 with U.V. Stabilizer. Other properties shall be in accordance with manufacturer's standard physical properties.

l) **Functional seal**: shall be flame retardant vinyl material.

m) **Sealant**: shall be a one-part polysulphide base synthetic rubber / Silicon sealant as per Manufacturer Specifications.

n) **Self-Centering Arrangement**: shall exhibit circular sphere ends that lock and slide inside the corresponding aluminum extrusion cavity to allow freedom of movement and flexure in all directions including vertical displacement so as to accommodate multidirectional seismic movement without causing stress to Joint components.

o) The materials used for Expansion Joints (other than air seal & metazeal type joint) shall have following properties.

Item Description	Given Specification	Indian Equivalent	Parameters to be Checked	Acceptable Values

Aluminium Extrusions. / Sheets & Plates	Alloy 6063-T5	IS 63400	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 15.00 21.00 8.00
Steel Shapes	ASTM – A36	IS: 2062	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 36.00 58.00 20.00
Stainless Steel	ASTM – A 479 Gr. 304	IS 6529 Gr. 0.4C Ni10	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 30.00 75.00 30.00
Neoprene Compression Seals	ASTM – D 2628	IRC – 83 (Part II) & MORT&H Specifications	Hardness (Shore "A") Elongation (%) [Min.] Tensile Strength (MPa) [Min.] Compression Set (%) [Max.]	55 +/- 5 250.00 13.80 28.00

20.3 JOINTS FOR NORMAL LOCATIONS

The Contractor shall provide all necessary accessories, related parts, devices, anchors etc. required for completing the installation of expansion joints in following locations.

a) Floor to Floor Joints at all internal locations
b) Roof to Roof Joints
c) Floor to Wall Joints at internal locations
d) Roof to Wall Joints
e) Wall to Wall Joints in exterior locations
f) Wall to Wall Joints & Slab to Slab Joints in case of underground trenches
g) Wall-to-Wall Joints & Slab to Slab Joints in case of underground tunnel subjected to ground water pressure from outside & water pressure from inside
h) Tunnel & Wall junction in case of underground structures.

20.4 JOINTS FOR CRITICAL LOCATIONS / HYDROSTATIC CONDITION APPLICATION

In case of underground structures which are susceptible for leakage due to ground water & hydraulic structures the expansion joint shall be provided with Airseal / Aladin type of expansion joint and/or Metazil type of expansion joint of M/S Sanfield / M/s BASF/ M/s Kanta Flex or any other equivalent with approval of Engineer. These joints are to be provided on the water face or both the faces depending on the wall thickness, severity of leakage & functional requirements as specified in the drawing or as directed by Engineer. These materials shall be qualified based on water hold test to the specified pressure and shall meet the following specifications.

20.4.1 AIR SEAL/ALADIN TYPE JOINT

The work shall consist supply and installation of Expansion Joint System model Airseal/Aladin of M/s Sanfield /M/s BASF or equivalent in accordance with the approved drawings and shall meet the following specifications.

The joints shall be designed utilizing neoprene profile, air pressurization and bonding in place with a specially formulated epoxy adhesive as per specifications.

The material shall be preformed, watertight, ozone and UV resistant, resilient and flexible neoprene profile with ribs on side faces for proper adhesion and bonding with the surface. The Joint shall be installed by air – pressurization technique only. Complete adhesion of the Epoxy to the neoprene seal profile and Joint Gap walls shall be achieved by air inflation during the installation. The relaxed (uncompressed) width of the seal shall be equal to the Joint Gap value and the Seal shall be always installed in uncompressed position so as to allow maximum expansion & contraction movements. The Joint system should be able to sustain water pressures upto 2 Bars minimum.

The structural sealing joint profile shall be preformed and manufactured from an extruded neoprene compound exhibiting the physical properties listed in the table below.

TABLE 20.1
PHYSICAL PROPERTIES NEOPRENE COMPOUNDS

SL. NO.	*PHYSICAL PROPERTIES*	TEST METHOD	REQUIREMENT
1	Tensile Strength, Min.	ASTM D 412	2000 PSI
2	Elongation @ break, Min.	ASTM D 412	250 % Min.
3	Hardness, Type A Durometer	ASTM D 2240	65 + / - 5 Points
4	Oven Aging 70 hrs. @ 212 ^{o}F	ASTM D 573	
4.a	Tensile Strength	ASTM D 412	20 % loss Max.
4.b	Elongation	ASTM D 412	20 % loss Max.
4.c	Hardness	ASTM D 2240	0 to + 10 Points
5	Ozone Resistance @ 20 % Strain	ASTM D 1149	No Cracks

The adhesive used to fix the Airseal/ Aladin type joint with concrete/ steel surface shall be resistant to most common organic and inorganic acids in diluted form, also resistant to alkalis, water, oils, grease, etc. It shall have following properties.

SL. NO.	*PHYSICAL PROPERTIES*	TEST METHOD	REQUIREMENT
1	Tensile Strength, Min.	BS 6319	10 MPa @ 7days
2	Compressive Srength, Min. @ 25deg cen.	ASTM C 580	40 MPa at 1 day 60 MPa at 7 days
3	Flexural Strength	ASTM C 580	20 MPa at 7 days
4	Pot Life	ASTM C603-90	50 min at 25 deg cen. min at 40deg cen
5	Bond Strength, Min	ASTM D 4541	2 MPa.
6	Slant Bond Strength		13 MPa

7	Setting Time	ASTM D 5895	1 day Initial Cure 5 Days Final Cure

20.4.2 META ZEALTYPEJOINT

The work shall consist supply and installation of Expansion Joint System model Metazil of M/s Sanfield / M/s Z-tech or equivalent as approved by Engineer in accordance with the approved drawings and shall meet the following specifications.

The joints shall be designed utilizing a low density, closed cell, expanded polyethylene joint material and specially formulated epoxy adhesive for Bonding purpose as per specifications.

The material shall be a preformed, waterproof, ozone and UV resistant, resilient and flexible expansion Joint material. No Halocarbon gases or volatile hydrocarbons shall be used in the manufacturing of the product. The product should have a working movement range of 60% compression and 30% tension. The Joint system should be able to sustain water pressures up to 2 Bars minimum. The same shall be demonstrated conducting water hold tests simulating site conditions. The product should be suitable for Potable water applications and should have ADA Compliance. The material shall exhibit the properties listed below.

PROPERTY	TEST	REQUIREMENTS
Density, Min.	ASTM D 3575	2.5 to 3.5 lb./cf
Tensile Strength, Min.	ASTM D 3575	70 psi
Water Absorption, Max.	ASTM D 3575	1.0 %
Compression Set, 22 hrs. @ 50 %	ASTM D 1056	
24 hrs. Recovery	(Residual Set, Max.)	8 %
Elongation @ break, Min.	ASTM D 3575	175 %
Tear Strength, Min.	ASTM D 624	13 psi

NOTE: For critical Joint locations, where the thickness of structural member (wall / slab) is exceeding 230 mm. Double layer Treatment comprising of Airseal on the critical / outer exposed face i. e. the face in contact with water / earth soil and Metazeal on the inner face is to be applied.

20.5 FABRICATION

20.5.1 Aluminum sections shall have factory-drilled holes spaced as per manufacturer's recommendation. Extrusions shall be miter cut at the site to suit directional changes.

20.5.2 Extrusions shall be supplied to site in their original packing in lengths as fabricated to suit the building dimensions.

20.5.3 Steel shapes shall be supplied in lengths as fabricated to suit the building dimensions.

20.5.4 Aluminum sections shall have mill finish unless otherwise specified.

20.5.5 Steel sections shall be blast cleaned and suitably treated against corrosion prior to their dispatch to the site. The cleaned metal surfaces which come in contact with the seal shall be protected against water logging / rusting till the seal and the adhesive are placed against the metal surface.

20.5.6 The Details of the finished colours offered by the manufacturer for Stainless Steel and Elastomeric components shall be furnished to the Engineer to enable him to exercise his choice.

20.6 EXECUTION

The expansion joint system shall be installed strictly as per the manufacturer's instructions and as directed by the Engineer. The work shall be carried out by the manufacturer or through an experienced manufacturer approved applicator, with the prior approval of the Engineer. In case, the work is carried out by the manufacturer-approved applicator, the manufacturer will have to provide the guarantee for the successful performance of total system including material & workmanship.

20.7 QUALIFICATION OF MATERIALS

For qualification of material at site contractor shall supply the Test Certificates for the material confirming the properties given in above-mentioned tables. In addition to above one sample (3 specimens) from each batch supplied at site, shall also be tested at independent approved laboratory for all the desired properties listed above, in case of Neoprene compression seals & Airseal.

20.8 EXPANDED POLYSTYRENE BOARDS FOR EXPANSION AND ISOLATION JOINTS

20.8.1 GENERAL

Expansion and isolation joints in concrete structures shall be provided with expanded polystyrene boards of specified thickness and form expansion joints shall be provided with 500 micron thick polyethylene sheets as per the relevant drawings.

20.8.2 SCOPE

The scope of work covered under this specification is as follows:

- Supply and use of approved quality polystyrene boards wrapped in 250 micron thick polyethylene sheet at various expansion and isolation joints in all main plant buildings.

- Supply and use of 500 micron thick polyethylene sheets as form separation joint, wherever required.

20.8.3 MATERIAL

- High density polystyrene boards conforming to IS: 4671 of density 35 kg/m^3.
- Polyethylene sheets conforming ton IS: 5210 of 250 micron & 500 micron thickness.

20.8.4 DESCRIPTION

Heavy duty expanded polystyrene boards of specified thickness and sizes shall be wrapped all round with 250 micron thick polyethylene sheet. These boards shall be placed in the locations (both in vertical and horizontal) as specified in the relevant drawings. Polyethylene sheet shall be properly secured and tied in position with expanded polystyrene boards.

Wherever specified, 500 micron thick polyethylene sheet as form separation layer.

20.9 WATERSTOPS

20.9.1 GENERAL

Water stops made of polyvinyl chloride (PVC) or galvanised MS sheet shall be provided in construction joints as indicted in the relevant drawing and specifications for all main plant buildings including underground structures and tunnels.

20.9.2 SCOPE

The work under this specification comprises of

- Supply, delivery, install in position water stops in accordance with the requirements of specifications
- Polyvinyl chloride water stops
- PVC fix cap.
- Galvanised MS sheet water stop of 3.15 mm thick. Installation including necessary site connection by furing/welding.
- Testing of joints and DPT for 100% of the weld length.

20.9.3 MATERIALS

PVC water stops : Material shall conform to the following Standards of the American Society for Testing Materials (ASTM)

D412-66 Tentative method of Tension Testing of Vulcanized Rubber

D624-54 Standard method of Test for Tear Resistance of Vulcanized Rubber

D2240-64-TTentative method of Test for Indentation Hardness of Rubber by means of a Durometer

PVC fixocap type 38 or equivalent conforming to IS 4461

Metal water stops of 3.15 mm thick conforming to IS 2062 galvanised for dry film thickness of 60-100 microns.

20.9.4 **DESCRIPTION**

Generally water stops shall be provided in construction joints as indicated in the drawing, water stops may be PVC of different width (with or without centre bulb), fixco cap of standardtype GI water stopper of 3.15 mm thick plate made to different width. Generally, Fixo-cap shall be provided in expansion joints of underground tunnels and PVC water stops shall be provided in water retaining structures unless specified otherwise by the Enginner .. The shear key shall be provided wherever specified and the water stops are generally located in the centre of wall at the construction joints or near to the edges in case of earth retaining walls and half of width shall be embedded into concrete. Necessary holding arrangement shall be made to ensure that water stops does not displace during concreting. It should be noted that, there shall not be any through supporting arrangement in order to prevent leakages. Continuity of the water stops shall be established by fusing or welding as the case may be. PVC water stops shall be joined together by fusing and metal water stops shall be 75 mm overlapped and welded on both sides. 100% dye penetrant test shall be carried on all joints. As far as possible care shall be taken to minimise the number of joints and also in-situ fusing/ welding.

21 Aluminium Lineal False Ceiling

Aluminium lineal suspended ceiling work shall be executed in flat, tapered, curved or circular form, both in plan and in section together with coves, etc. as required as per design.

21.1 General

Aluminium lineal ceiling shall be of Hunter Douglas as manufactured by Luxalon Building Products or approved equivalent together with all accessories and fittings such as carrier and clip, carrier splice, edge cover profile and corner splices, cross "T" connection near to the wall, etc.

21.2 Materials

21.2.1 Panels

The panels shall be 84C or 84R as per Luxalon's catalogue or approved equivalent and either plain or micro perforated. The length of the panel shall be 6m approximately. The panels shall be of any colours as approved by the Engineer, according to manufacturer's colour chart.

21.2.2 Panel carriers

Panel carriers shall be 4mm dia enamelled aluminium of satin black colour as per Luxalon's catalogue. The edges shall be provided with edge cover profile with a gap of specified width from the wall.

21.2.3 Suspension

The panel shall be suspended from the suspension system as mentioned in the relevant clause by means of adjustable turn buckle / level adjuster etc. In addition to the suspension system, the panel carriers shall be suspended by means of adjustable suspension steel rods of 4mm diameter with threaded rods and nuts for micro levelling, fixed to the slab/ beam by expansion fasteners. The expansion fasteners shall be fixed with epoxy/polyester resin. Seismic anchoring and isolation shall be provided as directed by the Engineer. Bracing shall be provided as specified for Gypboard ceilings.

21.2.4 Acoustic Pads

Acoustic pads shall be laid on top of perforated panels. Acoustic pads shall be of the approved manufacturer and shall consist of an insulation of 25mm thick glass wool pad having a density of 32 kg/cum wrapped in glass cloth. The provision of these acoustic pads for perforated ceiling is deemed to be part of the quoted rate and noting extra shall be payable for the same.

21.3 **SHOP DRAWINGS**

Shop drawings shall be prepared for all suspended ceiling work by the Contractor. The shop drawings shall show the entire installation system, including framing around light fixtures, ducts, grilles, access panels, etc. Shop drawings shall be submitted to the Engineer for approval. It will be the responsibility of the Contractor to co-ordinate with all the service Contractor’s doing work in ceilings, to incorporate appropriate suspension systems free of ducts, pipes, cable trays etc.

21.4 **APPROVALS**

The Contractor shall submit catalogues, samples of all items to be used in the ceiling and samples of workmanship, for approval of the Engineer.

22 GLASS AND GLAZING

22.1 **Scope**

The work in general shall consist of supplying and fixing all glass and glazing including all clips putty, mastic cement, etc., wherever required as shown on drawings and specifications.

In general, wherever applicable and unless otherwise noted, the work shall conform to IS 1081. Fixing and Glazing of metal (Steel and Aluminium) Doors, Windows, and Ventilators.

22.2 Installation

22.2.1 General

The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions, unless otherwise stated in the drawing or schedule. All glass shall be of superior quality from approved manufacturer like Modiguard or equivalent, having uniform refractive index and free from flaws, streaks, laminations and bubbles. The glass should be free from “wavy and rainbow formation”. Float glass for glazing and framing purposes shall conform to IS : 1761 . The glass shall be brought to site in the original packing from the manufacturer and cut to size at site. The cut edges shall be straight and free from chips, spalls or any other damages. Wherever clear glass is specified, it shall be flat drawn float glass and shall be at least 6mm thick. Where wire glass is mentioned, it shall be thick rolled glass with centrally embedded wire mesh of Georgian type. Where obscure glass is mentioned, it shall have a cast surface on one side. Heat absorbent and glare reducing glass shall be 'Calorex' of Modiguard , having a thickness of 6 mm unless specified otherwise in the schedule of Quantity. The Contractor shall submit samples of glasses for prior approval of the Engineer.

22.3 Putty

In general, the putty shall conform to IS:419. The putty shall be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing. Quick setting putty shall be used for windows and sashes except when glare reducing glass is used.

Neoprene gaskets with snap-fit glazing beads shall be fixed as per manufacturer’s instruction and shall sit snugly against glass to give a leak proof installation.

22.4 Glazing, Setting and finishing

All glazing clips, bolts, nuts, putty, mastic cement, etc. as required shall be supplied by the Contractor.

All glass shall be thoroughly cleaned before putting in position. Each glass pane shall be held in place by special glazing clips of approved type. As specified in relevant IS Codes, four glazing clips shall be provided per glass pane, except for large panes where six or more clips shall be used as per the Engineer's instructions. All holes that may be necessary for holding the clips and for all other attachments, shall be drilled by the Contractor at his own cost.

Glass panels shall be set without springing, and shall be bedded in putty and back puttied, except where moldings are specified. Putty, mastic cement, etc. shall be

smoothly finished to a true even line. Obscure and figured glass shall be set with smooth side out.

Necessary glazing clips, putty mastic cement etc., shall be supplied by the Contractor. The Contractor shall be responsible for damage of glass supplied by NPCIL during handling, transportation, fixing etc. and shall replace the same at his own cost.

After completion of glazing work, the Contractor shall remove all dirt, stains, excess putty, etc. clean the glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at Contractor's own cost.

22.5 **Float glass for Doors**

Float glass for vision panels in door shall have a minimum thickness of 4.0 mm unless otherwise specified or shown on drawings.

22.6 **Acceptance Criteria**

a) All installation shall be free from cracked, broken or damaged glass. Edge of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipping cracked or ungrounded edges.

b) Glazing shall be carefully done to avoid direct contact with metal frames.

c) All glass shall be embedded in mastic or fixed by neoprene gaskets to give a leak proof installation.

d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer.

22.7 **Drawings**

The contractor has to submit the drawings based on the above specification while quoting for these items.

23 ROOFING INSULATION, WATER PROOFING ETC.

23.1 SCOPE

The work under this specification shall cover all insulation and waterproofing necessary for the roofing work as shown in the drawings.

23.2 INSPECTION OF SURFACES

Prior to start of the work, the surfaces on which waterproofing /insulation is to be applied shall be inspected by the contractor and any visible/ noticeable defects found in the surfaces shall be rectified. The water ponding test shall be conducted by

ponding water on the roof slab and maintaining minimum 50 mm head of water on it for a period of 3 days. Any noticeable leakage/ seepage shall be corrected by the contractor at no extra cost to NPCIL. The surface then shall be made clean and dry before laying screed concrete/ starting roof insulation / waterproofing work.

23.3 SCREED CONCRETE

The grading shall be provided by an under bed using M-15 grade concrete (with max 10 mm aggregate) prepared properly to the satisfaction of the Engineer Unless otherwise specified, the grading shall be done in such a way so as to ensure a run-off gradient of not less than 1 in 120. The minimum thickness at low points and/or valleys shall not fall below 25 mm. After curing the under bed for 7 days, insulation work shall be taken up with prior approval of the Engineer. The screed concrete shall be laid on the invert of gutters for maintaining slope in the gutter.

Fillets at junction of roofs and vertical walls/ pedestals etc. shall be provided along with the roof screed concrete. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

23.4 INSULATION

23.4.1 MATERIAL

In case of structure where thermal insulation requirements are specified in the drawings or as decided by the Engineer, the concrete surface shall be applied with polyurethane foam (PUF) insulation. The PUF should be a 75 mm thick layer of two components high density spray applied polyurethane resin foam. The spray PU foam is carried out by a smooth spraying or pouring (for small areas) action to obtain the fill. The spray application to be done using specially designed spraying machine. The product must comply to class B2 as per DIN 4102, part 1 and shall exhibit the following properties:

PROPERTY	**ACCEPTANCE VALUE**	**TEST METHOD**
Core Density	40 Kg/m^3	DIN EN ISO 845,
Thermal conductivity (λ),	< 0.024W/(m.K)	DIN 52612
R-Value of 50mm thick,	> 2.1	ECBC Code
Compressive Strength,	DIN 53423,	>175KPa
Flexural Strength,	DIN 53423,	> 250KPa
Closed Cells	ISO 4590	90%
Water Vapour Diffusion	DIN 52615	60
Water absorption,	DIN 52848	<2.25%

23.5 WATER PROOFING

23.5.1 FOR BUILDING ROOFS

After completion of the curing period of the roof slab/ screed concrete and insulation (wherever applicable), the top surface shall be waterproofed using a solvent free spray applied polyurethane membrane.

In case of concrete prior to application of PU membrane, the surface should be ensured to be sound, clean and free from grease, oil or loose particles, laitance free shall have at least 1.5N/mm2 surface strength and moisture content shall be less than 4%. The concrete can be considered sufficiently dry when the relative humidity at the surface falls to 75% or less when measured with a hygrometer conforming to BS 8201 Appendix A. The preferred surface pretreatment for concrete is grinding or scarifying as necessary for concrete or when the primer has become soiled or when the re-coating interval has been exceeded.

The scope of work shall cover supply and application of one coat of primer (DFT 75 micron) and polyurethane membrane of approved make for total dry film thickness of 2200 microns comprising 2000 Microns thick (DFT) base coat of aromatic/ aliphatic PU and 200 Microns thick (DFT) UV resistant Aliphatic PU top coat excluding primer on flat or curved roofs.

a) Priming shall be done when the temperature of the substrate is at least 3 degrees above the dew point with a two pack epoxy primer with outstanding resistance properties and shall contain a high level of penetrating pigment which renders superior performance when sprayed over concrete having the following properties:

PROPERTY	TEST METHOD	UNITS	ACCEPTANCE VALUE
Density	ASTM 4052	g/cc	1.09 + 0.05 at 25°C
Mixing Ratio, by weight	IS 104		As per manufacturer recommendations
Flexural Strength	ASTM C 580-02	MPa	>30 at 7 days
Tensile Strength	BS6319 Pt 7	MPa	>20 at 7 days
Compressive Strength	ASTM C 579	MPa	>65 at 1 Day >70 at 3 Days >75 at 7 Days
Adhesive Bond Strength	ASTM D 4541	MPa	>1.5 at 25°C

For acceptance of material listed in above table, Manufacturer Test Certificate (MTC) from manufacturer confirming to above specified properties except for Tensile, Compressive &Bond strength shall be acceptable. The Tensile, Compressive & Bond strength tests shall be conducted by the contractor as per QAP in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL at no extra cost to NPCIL.

On the tacky primer surface, sand shall be broadcasted using dried, graded silica sand (size 0.3 to 0.9 mm) on to applied Primer Coat prior to its hardening. The sand shall

be evenly spread over the entire primed surface at the rate of 0.8 to 1.0 Kg/m2. When the surface is sufficiently cured, the surface is vacuumed to remove any loose sand.

The waterproofing system base coat shall be solvent free, two-component, fast setting, seamless spray applied Aromatic / Aliphatic Polyurethane (PU) membrane installed over the roof on primed substrate (concrete screed) using a pneumatic machine as per the manufacturer's specifications. The machine for application shall have optional pressure monitor kit to assure on mixing ratio. The pressure gauge shall monitor the spray pressures on both sides and shall automatically shut down the sprayer in case of non-acceptable conditions, like running out of material, pump cavitation, packing failures, leaks in valves or fittings, or plugged filters. The two component spray applied PU membrane for base coat shall have a total average dry film thickness of 2000 microns (excluding primer and top coat, with no single value less than 1800 microns). It shall possess the following properties:

Sr No	**Property**	**Test Method**	**Values**
1	Solids Content	ASTM D2697	> 95%
2	Density	ASTM D1475	>1.0 g/cm3
3	Ready for Light Traffic	DIN 53213	Max. 60 seconds
4	Adhesion Strength	ASTM D4541	Minimum 3.5 N/mm^2
5	Tensile Strength	ASTM D 412	> 8 MPa
6	Impact Strength	ASTM G14	>190 N/sq mm
7	Elongation at break	ASTM D 412	>400%
8	Average Tear Propagation	DIN 53363	>35 N/mm
9	Tear strength	ASTM D624	>25 N/mm
10	Puncture Resistance	ASTM E 154	>300 N
11	Crack bridging	ASTM C 836	No crack till 5 mm crack width
12	Shore Hardness (Shore A)	ASTM D2240	>65
13	Taber Abrasion Resistance	ASTM D4060	< 70 mg
14	Water Vapor Transmission	ASTM E 96	0.11 g/m2/day
15	Root Resistance	DIN 4062	No penetration

For acceptance of material listed in above table, solid content, density, tensile strength, % elongation at break, crack bridging & shore A hardness shall be performed in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL for every individual batch. For all other tests, MTC from manufacturer conforming to above specified properties shall be acceptable. Pull off adhesion test shall be done at site as per relevant standards using a portable pull off adhesion tester. All the laboratory tests shall be conducted by the contractor as per QAP at no extra cost to NPCIL.

b) The solvent free, two-component, spray applied base Polyurethane membrane system shall be protected using a two-component polyurethane UV stable aliphatic top coat having average 200 microns thick DFT (with no single value lesser than 150 microns). The top coat material shall have following properties:

Sl No.	Property	Test Method	Values
1.	Elongation at break (14 days)	ASTM D 412	>150%
2.	Tensile Strength (14 days)	ASTM D 412	>10 Mpa
3.	Tear strength	DIN 53515	>60 N/mm
4.	Density (Mixed)	At 20ºC	1.2 g/cm^3
5.	Viscosity (Mixed)	ASTM D2393	2000-4000 CPS at 23 degree C
6	Accelerated UV resistance	ASTM G 154	>1000 hours i.e No cracking, blistering or flaking
7	Shore A Hardness	ASTM D 2240	89

For acceptance of material listed in above table density, tensile strength, % elongation at break & shore "A" hardness as applicable shall be performed in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL for every individual batch. For all other tests, MTC from manufacturer confirming to above specified properties shall be acceptable. All the laboratory test shall be conducted by the contractor as per QAP at no extra cost to NPCIL.

23.6 PROTECTION SCREED CONCRETE

The water proofing done on roof other than OC dome shall be protected against damage due to working of other agencies on the roof top, wherever specified or decided by the Engineer. The membrane shall be overlaid with a layer of M-15 grade concrete (with max 10 mm aggregate) for a thickness of 50mm. The concrete shall be laid in panels of 2m x 2m, with an expansion groove 10 mm wide and 15 mm deep between the panels. The expansion groove shall be sealed with polyurethane sealant.

23.7 TESTING OF THE ROOF WATER PROOFING

The water proofing system on roof other than OC dome shall be tested by ponding water for a depth of 50 mm over the membrane layer, before laying the protective screed concrete. The water shall be retained for a period of 24 hrs and inspected for leakages if any. In case leakage/ seepage of water is observed, the contractor shall identify the leakage/ seepage spots and take corrective action as per manufacturer's recommendations at no extra cost to NPCIL. Repair procedure shall have the approval of the Engineer. The cost of testing the water proofing system is deemed to be included in the item rate for water proofing.

23.8 PROJECTING PIPES AND PEDESTALS ON ROOF TOP

The pedestals on the roof top and pipes passing through a roof on which water proofing treatment is to be laid, a cement concrete angle fillet shall be built around it. The spray PU water proofing treatment shall be taken over the fillet in the manner shown in drawings. Where pipe is passing through pipe sleeve embedded in concrete, a 20 mm Square groove shall be cut at top of concrete around pipe sleeve and the

same shall be filled with a hydro-swelling polymeric paste of 1.5kg/litre mix density. The paste shall be formulated to exhibit low premature swelling (less than 50% within 12 hours) and shall not release super absorbents during its service life. The re-swelling paste shall have low swelling pressure; not exceeding 0.25 MPa at full swelling capacity; confined between mortar & cement concrete angle fillet.

23.9 QUALITY ASSURANCE & SUPERVISION

A detailed work procedure in line with this specification and manufacturer's specification with resources deployment shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work. Contractor shall carry out testing of materials as per direction of Engineer and shall submit testing reports and manufacturer's test certificates to the Engineer. A strict check on coating thickness and consumption of coating material shall be exercised by Contractor's QA Engineer and necessary records in this regard shall be submitted to NPCIL. Contractor shall provide necessary assistance to NPCIL in supervision of roof insulation and water proofing work and checking of PU coating thickness.

During the entire process of work under this specification, the Contractor shall arrange at his own cost the supervision of the work on insulation, water proofing and flashing by the manufacturer's representative to ensure that the work is being executed as per manufacturer's specifications and instructions.

23.10 GUARANTEE

The Contractor shall be responsible for maintaining the roof top insulation for a period of 10 years from the date of acceptance of the water proofing work by the Engineer. The Contractor shall make periodical inspection especially before start of the rainy season and repair the waterproofing for any apparent defects to ensure effectiveness of water proofing during the guarantee period.

The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for 10% of the cost of roof insulation and water proofing works carried out. The bank Guarantee shall be valid for a period of five years from the date of acceptance of the water proofing work by NPCIL.

24 SURFACE DRAINS, UNDERGROUND TUNNELS, TRENCHES, SEWAGE CONVEYING SYSTEM ETC.

24.1 SCOPE

This specification covers furnishing all materials, plant, labour, equipment tools and services for the complete and proper construction of storm water, surface drainage, pitching using fly ash bricks and culverts as specified herein and shown in the drawings including all surveying and setting out necessary for the same and clean up of working areas.

24.2 GENERAL

All drains and culverts shall be constructed at the locations shown in the drawings or as directed by the Engineer. Care shall be taken to avoid clogging of the drains during progress of the work and should any drain become clogged or obstructed from any cause until final acceptance of the work, it shall be cleaned in a manner as approved by the Engineer or replaced by the contractor at no extra cost to NPCIL.

24.3 EXCAVATION

Excavation for storm water/ surface/ cut off drain and for culverts/ for laying RCC hume pipes shall be carried out as per the requirements covered in the technical specification for 'Excavation, Dewatering and Backfilling'

The excavated material shall be removed from the excavated/ adjoining area and disposed of at location(s) as directed by the Engineer.

24.4 STORM WATER/ SURFACE DRAINAGE

Where shown in the drawings, storm water/ surface drainage shall be constructed consisting of RCC trenches. Storm water/ surface drains shall be placed to prevent ground water from flowing directly into the structures and shall be constructed to a line and grade to allow proper drainage over the area of the site to the nearest natural drainage and in turn to the nearest natural water body. The contractor shall construct the storm water/ surface drainage system as per the details shown in the drawings.

24.5 PITCHING

Fly ash bricks of nominal size of 230x110x70 mm having compressive strength of minimum 75 Kg/sq cm shall be used in the work. Bricks shall be laid over sloped/ flat surfaces of the drain over well prepared and compacted bed of insitu soil. The joints between the bricks shall be filled with 1:6 cement mortar. Provision of weep holes with filter media etc. shall be provided in the pitching.

24.6 CUT OFF DRAINAGE

Where shown in the drawings, deep cut off drains shall be constructed at the various elevations to a line and grade to allow lowering of ground water levels and to arrest seepage water and surface runoff and direct the same to the nearest natural drainage for further flow to the nearby water body. The cut off drains shall consist of deep trenches, with concrete lining finished smooth of the bottom and the side facing as given in the drawing.

24.7 CULVERTS

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per drawings and as directed by the Engineer after clearing the site etc. as per specifications of Earthwork. The construction of culverts shall be done true to

line and levels as shown in drawings. The specification for masonry and/or plain and reinforced concrete shall be followed as applicable**.**

24.8 REINFORCED CONCRETE SPUN PIPES

24.8.1 GENERAL

The drainage pipes unless otherwise shown in the drawings or instructed by the Engineer shall be made of R.C.C. and shall be of class NP3.

Pipe culverts shall also be made of reinforced concrete pipe and shall be of class NP3. All pipes materials shall meet the requirements of IS: 458-Latest edition and shall be procured from approved manufacturers with collars as per manufacturers standard specifications.

24.8.2 APPLICABLE CODES

The manufacture, testing, supplying, jointing and testing of pipes at worksite shall comply with the code of practices, latest revisions, as given below:

IS: 456 Code of practice for plain and reinforced concrete

IS: 458 Specification for concrete pipes (with and without reinforcement)

IS: 783 Code of practice for laying of concrete pipes

IS: 3597 Method of tests for concrete pipes

24.8.3 CARTING AND HANDLING OF PIPES

Pipes and fittings shall be transported from factory to work sites by the Contractor and he shall be responsible for the safety of the pipes in transit and loading/unloading. Any pipe, which shows sufficient damage to preclude it from being used, shall be discarded. Dragging of pipes along concrete or similar pavements shall not be allowed.

24.8.4 STORAGE OF PIPES

Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom to keep the stack stable. The stack shall be in pyramid shape with height of pyramid not exceeding 1500 mm.

24.8.5 LAYING OF PIPES

a) Laying of concrete pipes shall correspond to IS: 783 – Latest edition – and specification given below. Safety requirements to be provided while laying of pipes shall conform to IS: 3764.

b) The foundation bed for pipe shall be excavated true to lines and grades shown in the drawings or as directed by the Engineer. When trenching is involved its width on either side of the pipe shall not be less than 150 mm not more than one-third the diameter of pipe unless otherwise instructed / permitted by the Engineer. The sides of the trench shall be as nearly vertical as possible. Side slope, shoring, bailing out water, etc. as required shall be done by the contractor without any extra cost. Side slope, if there be any, shall be removed by the contractor without any extra cost. Pipes shall be carefully lowered with the help of tripods with chain pulley blocks or any other mechanical means in the approved trenches. In no case pipe shall be dropped. Pipes damaged during lowering shall be rejected by the Engineer. After laying of the pipes are completed, back-filling of the trenches shall be done in 250 mm layers measured loose, clods and lumps broken, watered and compacted with iron rammers to the satisfaction of the Engineer. The surplus spoils shall be transported and filled in low-lying areas within the plant area, as instructed by the Engineer.

c) When bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock / boulders in the area shall be removed and space filled with approved earth free from stone of fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

d) Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

e) When two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

f) Laying of pipes shall start from the outlet and proceed towards inlet. Pipes are to be laid perfectly true both in alignment and to gradient specified. Pipes must be secured in place with approved backfill material tamped under it except at the collar. Precaution shall be taken to ensure that dirt do not enter jointing space. Pipes shall be laid such that the marking on pipes appears at the top of the pipes.

g) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS: 783 – Latest edition – having a projection ratio of not greater than 0.70, in which the pipe shall be carefully bedded on fine granular materials in an earth foundation, carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height, and in which the earth filling material shall be thoroughly rammed and tamped in layers not exceeding 15 cm in depth around the pipe for the remainder of the lower 30 percent of its height.

h) If the pipe is laid in trench, pipe bedding shall be first class bedding as per IS: 783.

i) When indicated on the drawings or directed by the Engineer, the pipe shall be bedded on a cradle constructed of concrete having a mix not leaner than N/20. The shape and dimension of the cradle shall be as indicated on the drawing or directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete has set.

j) The drop walls shall be made with first class brickwork or stone masonry in 1:4 cement mortar.

k) The pipe culverts shall be made with proper care regarding the invert of the pipe, gradient, if any, etc. as specified on drawings and / or instructed by the Engineer.

24.8.6 Where R.C.C. pipes are encased in concrete at road crossings or at other places the pipes shall be suitably supported avoiding reinforcements of concrete blocks, and joints properly done before concreting is taken up. Concreting of total height of the block may be done in one single operation or may be done up to some height for pipes to be properly laid in position and the remaining height of the block concreted subsequently.

24.8.7 The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part cement and 2 parts of clean sand with only enough water for workability. Procedure of jointing shall be as per IS: 783 – Latest edition.

24.9 ROOF DRAIN PIPING

24.9.1 Double walled corrugated pipe (For underground works)

Underground double walled corrugated pipe conforming to IS: 16098, Part 2, stiffness class SN 8 shall be provided for roof drains works. The scope of work includes supplying pipes including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes and any other fitting, fixtures, accessories required to complete the job etc. all complete as per manufacturer's specification and direction of the Engineer.

24.9.2 HDPE pipes for Roof drains works (Above ground)

HDPE pipes conforming to IS: 4984, grade PE 100, pressure rating PN 6 shall be used for elevated roof drain works. Scope of work includes supply of pipes including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. and any other fitting, fixtures, accessories required to complete the job etc. all complete as per manufacturer's specification.

24.9.3 RAIN WATER DOWN COMERS

24.9.3.1 GENERAL

Rain water down comers shall be ultra violet stabilized UPVC rain water pipes conforming to IS: 13592 Type-A and shall run along the exterior wall / column surface of all main plant buildings, unless specified otherwise.

24.9.3.2 SCOPE

The scope of work comprised in this specification are as follows:

- Supply, erection, fixing UPVC pipes at various elevations of main plant buildings including UPVC/ heavy cast iron roof drain and floor drain, all fittings and fixtures and including leak testing of the erected system.

- Supply, fixing necessary fittings inclusive of shoes, gratings, bends, sockets etc.

24.9.3.3 MATERIALS

- Ultra violet stabilized UPVC rain water pipes conforming to IS: 13592 Type-A and fittings conforming to IS 5382/ IS14735.

24.9.3.4 DESCRIPTION

Rain water down comers shall run along the exterior surface of walls/ columns and longitudinally over the roof and to be secured well to walls/ columns with strong clamps/ brackets as specified in the relevant drawings. Where desired by the Engineer these may have to be installed in chases cut in the structure. The brackets may be of galvanized iron/ anti-corrosive material clevis type, split ring or perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer shall be provided against the vertical surface. All bends and junctions shall be supplied with water-tight clean outs.

Roof drains at top shall be provided at locations as specified in the drawing and shall be provided with suitable MS gratings where ever specified.

25 QUALITY CONTROL, SURVEILLANCE AND ASSURANCE REQUIREMENTS

25.0 SCOPE

This chapter specifies requirements to be incorporated in the Contractor's quality assurance program for construction. The Contractor is responsible for planning and developing a program that assures that all his management, design and technical responsibilities for quality are incorporated and executed effectively. The program is aimed primarily at ensuring an efficient quality management in construction and taking corrective actions, when necessary.

Planning and detailed written procedures are essential for specifying how such activities as the following, which affect quality, are to be performed and controlled.

a) Design management whenever applicable

b) Procurement

c) Construction

d) Special processes

e) Measuring and testing equipment

f) Inspection and test

g) Handling, storing, preservation, packaging and shipping.

h) Item identification and traceability

i) Documentation and quality records.

j) Disposition of non conformances and corrective action.

25.1 APPLICABILITY

The requirements of this chapter apply to the construction activities when specified in a contract.

25.2 CONTRACTORS RESPONSIBILITIES

The Contractor's responsibilities

a) To develop and implement the controls and quality assurance procedures, specified herein, that will promptly detect and dispose of, or prevent, non-conformances to contractual requirements.

b) To comply with the NPCIL's requirements as specified in the contract.

c) To prepare a quality assurance manual which shall be submitted for the Purchaser's concurrence before the contract is awarded or at the latest before the work starts. This manual should cover activities of building design consultant, proof check consultant and building contractor and their subcontractors.

d) To prepare a quality plan which shall be submitted to the Purchaser before the work starts, as required in 25.3.3 (b).

e) To update and resubmit the quality assurance manual and quality plan to reflect current practices when significant changes occur in the Contractor's program or organization in order to improve its effectiveness or to prevent recurrence of non-conformances.

f) To initiate corrective measures promptly when the quality assurance representative notifies the Contractor of deviations from established requirements.

25.3 DEFINITIONS AND REQUIREMENTS

25.3.1 QUALITY ASSURANCE PROGRAM

The Contractor shall plan, establish, implement and maintain a quality assurance program that complies with the requirements of this chapter.

25.3.2 ORGANISATION

The Contractor shall :

a) Clearly define management policies, objectives and responsibilities for quality assurance, including the responsibility of each division within a multi-divisional organization. The responsibility and authority for quality of those managing and performing the work and of these auditing and verifying conformance to quality requirements shall be defined and their relationships shown on organization charts.

b) Provide for the review by management of the status and adequacy of the quality assurance program.

c) Appoint a representative who shall report regularly to management at a level that ensures that quality assurance requirements are not subordinated to design, manufacturing, construction or delivery and define his authority to resolve quality matters. Purchaser shall be notified of the appointment in writing.

d) Define the responsibility and authority of personnel who are primarily responsible for quality assurance and their organizational independence during audits and define the responsibility and authority of personnel who are primarily responsible for quality control and their organisational independence to :

- identify and record quality problems
- initiate or recommend or provide solutions through designated channels.
- verify the implementation of dispositions.
- control further processing, delivery or installation of a non-conforming item or service until the deficiency or unsatisfactory condition has been resolved.

Note that, generally, audit personnel shall not be within the pattern of daily activities.

e) Use competent persons for inspection, other than those performing or directly supervising the work being inspected, unless specifically designated otherwise in the quality plan. Such persons shall report to an adequate level of management,

excluding direct reports to supervisors responsible for producing the work being inspected.

Generally, inspectors shall verify the conformance to the specifications and drawings. In cases of problems or difficulties they shall request clarification from the design or other competent organisations and initiate appropriate measures.

If examinations, being a part of the whole inspections, are performed and documented by works personnel, the extent of the inspections by the independent personnel may be reduced, if such has been provided for by the quality plant.

25.3.3 **QUALITY ASSURANCE DOCUMENTS**

a) **QUALITY ASSURANCE MANUAL**

i) The Contractor shall :

- Prepare a quality assurance annual, approved and signed by a senior management official, and submit it for the Purchaser's concurrence before the contract is awarded or at the latest before the work starts. A quality assurance manual submitted under a previous contract or tender maybe referred to.

- Review and update the manual to reflect current quality assurance polices and procedures and resubmit the resulting manual.

- Implement the program according to the provisions specified in the manual.

ii) The quality assurance manual shall deal as appropriate with the following :

Organization - The manual shall define the organizational measures as specified 25.3.2.

Quality plan - The manual shall identify the group responsible for the quality plant specified in 25.3.3 (b) and define its main principles and features in adequate procedures.

Quality assurance procedures - Documented quality assurance procedures as specified in 25.3.3(c) shall be included or shall be outlined and cross- referenced. Referenced QA procedures shall be made available to the quality assurance representative.

Manual review - A statement shall be incorporated for reviewing and updating the manual as specified in 25.3.3. (a)(i).

b) QUALITY PLAN

i) The Contractor shall :

- Plan the inspection and test activities

- Identify in the quality plan the inspections and tests to be performed on the items listed in the contract, in compliance with contractual and/or technical requirements.

- Submit the plan for the Purchaser's concurrence following the award of the contract and before the work starts. Referenced inspection and test specifications and/or procedures shall be made available to the quality assurance representative during the implementation of the quality plan.

- Update the plan during the life of the contract to reflect current conditions of manufacturing, construction, inspecting and testing and resubmit the plan to the Purchaser.

b) ii) The quality plan may be of any format to suit the Contractor's system. The quality plan shall deal as appropriate with :

- Identification of the characteristics or items to be inspected and tested.

- Identification of required inspection, test and special process operations and their relative location in the construction cycle. The Contractor may include additional in-process inspection points for his own evaluation of quality which will not be subject to acceptance and witness by the quality assurance representative.

- Reference to inspection, test and special process procedures, standards, acceptance criteria and sampling plan, if any.

- Indication of hold points beyond which the activity shall not proceed until the required inspections or tests have shown satisfactory results and have been documented.

- Provisions for the Purchaser to insert witness points at which activities are to be observed. The activity may nevertheless proceed beyond a witness point should the Purchaser fail to attend in spite of due notification.

b) iii) The quality plans for subcontracted items, when concurred with by the Contractor, shall be submitted to the Purchaser as applicable, for concurrence & insertion of witness points.

c) <u>QUALITY ASSURANCE PROCEDURES</u>

The Contractor shall have procedures for the following specific requirements should they apply to the contract :

Document control	Cl.25.3.3
Design Control	Cl.25.3.5
Procurement	Cl.25.3.6
Measuring and testing equipment	Cl.25.3.7

Inspection and test	Cl.25.3.8
In-process inspection	Cl.25.3.9
Final inspection	Cl.25.3.10
Inspection status	Cl.25.3.11
Identification and traceability	Cl.25.3.12
Preservation, handling and storage	Cl.25.3.13
Construction	Cl.25.3.14
Special processes	Cl.25.3.15
Quality records	Cl.25.3.16
Non-conformances	Cl.25.3.17
Corrective actions	Cl.25.3.18

Each QA procedure shall define, as applicable, such things as: its purpose and scope; who is responsible for what; how all steps are to be performed; what materials, equipment and documentation are to be used; how it is all controlled.

Forms used shall be exhibited.

QA procedures shall be updated when necessary.

25.3.4 SPECIAL REQUIREMENTS

The Contractor shall

a) Establish measures to ensure that all essential quality related documents including but not limited to those listed below are reviewed for adequacy and approved for release by authorized personnel.:

i) Quality assurance manual required by 25.3.3 (a)

ii) Quality plan required by 25.3.3 (b)

iii) Quality assurance procedures required by 25.3.3(c)

iv) Design documents required as a consequence of 25.3.5

v) Procurement documents required by 25.3.6

vi) Calibration procedures required by 25.3.7

vii) Inspection and test procedures required by 25.3.8

viii) Manufacturing documents required by 25.3.13

ix) Special process procedures required by 25.3.15

b) Establish distribution lists for the above mentioned documents, update and maintain them in the current form to assure that the proper personnel are issued

with all the documents necessary to perform the work.

c) Make the applicable issues of these documents available at areas where these activities are performed.

d) Establish and update lists of applicable documents for construction and distribute them systematically. Controlled distribution is required for these lists only.

e) Ensure that changes to documents receive the authorizations by the same organizations as the initial documents unless other organizations are specifically designated. Maintain a record of changes as they are made. Written notes or documents are acceptable provided that they are made by authorized persons according to established procedures. Documents shall be revised and re-issued after a practical number of changes have been issued.

25.3.5 DESIGN CONTROL

a) General

The supplier shall establish and maintain documented procedures to control and verify the design of the product in order to ensure that the specified requirements are met.

b) Design and development planning

The supplier shall prepare plans for each design and development activity. The plans shall describe or reference these activities, and define responsibility for their implementation. The design and development activities shall be assigned to qualified personnel equipped with adequate resources. The plans shall be updated as the design evolves.

c) Organizational and technical interfaces

Organizational and technical interfaces between different groups which input into the design process shall be defined and the necessary information documented transmitted and regularly reviewed.

d) Design input.

Design input requirements relating to the product, including applicable statutory and regulatory requirements, shall be identified, documented and their selection reviewed by the supplier for adequacy. In complete, ambiguous or conflicting requirements shall be resolved with those responsible for imposing these requirements.

Design input shall take into consideration the results of any contract review activities.

e) Design output

Design output shall be documented and expressed in terms that can be validated against design input requirements.

Design output shall :

i) Meet the design input requirements.

ii) Contain or make reference to acceptance criteria;

iii) Identify those characteristics of the design that are crucial to the safe and proper functioning of the product (e.g. operating, storage, handling, maintenance and disposal requirements).

Design output documents shall be reviewed before release.

f) Design review

At appropriate stages of design, formal documented reviews of the design results shall be planned and conducted. Participants at each design review shall include representatives of all functions concerned with the design stage being reviewed, as well as other specialist personnel, as required. Records of such reviews shall be maintained .

g) Design verification

At appropriate stages of design, design verification shall be performed to ensure that the design stage output meets the design stage input requirements. The design verification measures shall be recorded.

NOTE : In addition to conducting design reviews, design verification may include activities such as

- performing alternative calculations.
- Comparing the new design with a similar proven design,, if available.
- Undertaking tests and demonstrations, and
- Reviewing the design stage documents before release.

h) Design validation

Design validation shall be performed to ensure that product conforms to defined used needs and / or requirements.

NOTES:

11. Design validation follows successful design verification .

12. Validation is normally performed under defined operating conditions.

13. Validation is normally performed on the final product, but may be necessary in earlier stages prior to product completion.

14. Multiple validations may be performed if there are different intended uses.

i) Design changes

All design changes and modifications shall be identified, documented, reviewed and approved by authorized personal before their implementation.

25.3.6 PROCUREMENT

a) Selection of Subcontractors

The Contractor shall identify items to be procured. He shall undertake the following :

i) Determine for these subcontracted items the applicable Quality Management Requirements. Classification of these Quality Management Requirements shall be in such a y that the overall quality is not impaired. The classification list shall be submitted to the Purchaser for acceptance.

ii) Evaluate and select subcontractors in accordance with of the applicable Quality Management Requirements with regard to their ability to meet subcontract and quality requirements.

iii) When `off the shelf' items are to be procured, evaluation of subcontractor may not necessarily be required. The Contractor shall nominate to the quality assurance representative those materials, parts and components that belong to this category.

b) SUBCONTRACT REQUIREMENTS

The Contractor shall include in subcontracts the following, as applicable:

i) A clear description of the items or services to be procured including technical data and inspection and test requirements by reference to standards, technical specifications, drawings, etc.

ii) A designation of the applicable Quality Management Requirements to be applied to the items and exceptions, if any.

iii) A designation of the Contractor's QA procedures to be implemented by the subcontractor, if applicable.

iv) Instructions for the submission, retention and disposition of quality records.

v) Requirements for packaging and shipping, where applicable.

vi) A statement related to the right of access to the subcontractor's premises and records for audit and/or surveillance by the Contractor or the Purchaser.

vii) Instructions for notification of witness points.

viii) Requirements for the subcontractor to report non-conformances.

ix) Applicable requirements to be extended to lower tier subcontractors, if any.

Subcontract documents shall be reviewed and approved in accordance with 25.4.4 (a).

All unpriced subcontracts and associated reference data shall made available on request for review by the quality assurance representative.

c) **Amendments to Subcontracts**

The Contractor shall process amendments to sub- contracts in the same way as the initial subcontract and reference the initial subcontract number in the amendments.

d) Verification of the Quality Management System Implemented by the Sub-contractor Refer applicable Quality Management Requirements.

e) **Receiving Inspection**

To the extent that is practical, receiving inspection shall be specified in the quality plan.

The Contractor shall:

i) Identify and inspect items on receipt to ascertain that they comply with contractual requirements. In determining the amount or nature of receiving inspection, consideration shall be given to the surveillance exercised at source and documented evidence of quality conformance. Receiving inspection shall cover as a minimum: verification of deterioration or damage during transport, identification control, review of required documentation.

ii) Initiate corrective action with sub-contractors when non-conforming items are received, as required by the nature and frequency of non-conformances.

iii) Hold incoming items until the required inspection and/or test have been completed or the necessary inspection and/or test reports have been received and verified except when items are released under positive recall.

25.3.7 MEASURING AND TESTING EQUIPMENT

All measuring and testing equipment and devices used to verify characteristics that can affect item quality shall be controlled and maintained. At prescribed intervals, or prior to use, they shall be calibrated and adjusted against certified equipment having a known valid relationship to nationally recognized standards. Where no national standards exist, the basis employed for calibration shall be documented.

No special calibration and control measures are necessary on rulers, tape measures, levels and other such devices, if normal commercial practices provide for adequate accuracy and/or if large tolerances are allowed for the corresponding measurements.

The Contractor shall:

a) Include in calibration procedures; equipment type, frequency of checks, description of check method, acceptance criteria and action to be taken when results are unsatisfactory. Exception will be allowed for measuring and testing equipment for which calibration is simple and does not require a specific detailed procedure. The Contractor shall identify those types of measuring equipment for which he has not provided calibration procedures.

b) Identify measuring and testing equipment with a tag, sticker, or other suitable indicator to show the calibration status.

c) Maintain calibration records for measuring and testing equipment.

d) Assess and document the validity of previous inspection and test results when measuring and testing equipment are found to be out of calibration.

For concreting and earthwork activities :

e) The above mentioned requirements are mandatorily applicable only to the following equipment and instruments :
- laboratory scale
- concrete batching plant
- compression test machine
- tensile test machine
- prestressing pressure gauge
- soil-cement batching plant
- gauge for mechanical splicing
- grout batching machine

For all other equipment and instruments, the requirements are non-mandatory but they may be used as a guide.

25.3.8 INSPECTION AND TEST

a) The Contractor shall provide for the performance of inspections and tests as specified in the quality plan. These inspections and tests shall be carried out in accordance with written procedures that define the method, the materials, instruments or equipment to be used and acceptance/rejection criteria.

The Contractor shall amend the selected inspection methods in cases where their unsuitability is demonstrated.

b) Inspections and tests shall be documented on inspection and test reports that identify as a minimum the item inspected or tested, applicable drawings, specifications or procedures, the date of inspection or test, the inspector, tester or data recorder, the type of observation, the results, the acceptability and the action taken in connection with any deficiencies identified.

25.3.9 **IN-PROCESS INSPECTION**

The Contractor shall:

a) Identify, inspect and/or test items as required by the quality plan.

b) Monitor process methods, where inspection is not feasible.

c) Hold items until the required inspections and/or tests have been completed or necessary reports have been received and verified except when items are released under positive recall. Release under positive recall shall not preclude (a) above.

For concreting activities :

i) The Contractor shall establish adequate measures for preconcreting, in-process and post-concreting inspections to be performed as applicable.

ii) A part of these inspections and the documentation thereof may be delegated to the works personnel. In such cases, the independent inspections can be reduced to an extent to be defined in the quality plan or in the inspection procedures.

This applies particularly to the case where a specialist is incorporated into the work staff for difficult or sophisticated tasks such as reinforcement placing, prestressing, etc.

iii) Such measures do not preclude complete independent inspections to be performed on a programd basis or as a consequence of results obtained.

25.3.10 **FINAL INSPECTION**

The Contractor shall :

a) Identify, inspect and/or test the completed item as required by the quality plan.

b) Verify that the item has been inspected at all points shown in the quality plan and that the records are adequate and complete.

25.3.11 **INSPECTION STATUS**

The Contractor shall :

a) Provide means for assuring that required inspections and tests are performed and that the acceptability of items with regard to inspections and tests performed is known throughout manufacturing and construction.

b) Establish and maintain a system for identifying the inspection/acceptance status by means of tags, stamped impressions, or other physical means to be affixed to the item or its container or by means of inspection records.

c) Show the identity of the Contractor and his inspector on any inspection marking used.

d) Provide for measures for controlling status indicators including the authority for application and removal of tags, stamps or other marking.

e) Identify non-conforming items.

25.3.12 **IDENTIFICATION AND TRACEABILITY**

The Contractor shall establish and maintain as adequate system to :

a) Identify each item (lot, component or part) to the applicable drawing, specification or other technical document, throughout the whole construction process.

b) Assign to each item a unique identification where specific traceability is required by the contract.

c) Record this identification on all process, inspection and test records, where traceability is specified.

d) List the items that do or do not require traceability concerning concrete activities.

25.3.13 **PRESERVATION, HANDLING AND STORAGE**

The Contractor shall :

a) Establish, maintain and document a system for the preservation, storage and handling of all items from the time of receipt through the entire construction process and subsequent storage to prevent abuse, misuse, damage, deterioration or loss.

b) Periodically inspect stored items for condition and shelf-life expiry.

c) Inspect and test-special handling tools and equipment at specific times to verify that the tools and equipment are adequately maintained and will not damage the items and will ensure safe and adequate handling.

d) Use specific written procedures for lifting of critical or high value items.

25.3.14 **CONSTRUCTION**

a) The Contractor shall clearly define the responsibilities for the documented preparation of works.

This written preparation shall consist of instructions or work assignments. It shall be established in accordance with the construction schedules and be available to the works and inspection personnel prior to commencement of work. This work instruction will document the following :

- Work methods
- sequence of operations
- workmanship criteria
- type of equipment needed
- special working environment, if any.

For concreting and other common civil work activities, these instructions may be included in drawings, specifications or other design documents.

b) The Contractor shall ensure that prior to release for construction all jigs, fixtures, tooling masters, templates, and patterns used for verifying quality are controlled. The extent and frequency of tool control shall be defined.

25.3.15 **SPECIAL PROCESSES**

The Contractor shall :

a) Identify those special processes subject to the requirements of this clause. Special processes shall include welding, heat treating and non- destructive examination, as applicable.

b) Establish documented procedures to assure that these processes are accomplished under controlled conditions by qualified personnel using qualified documented procedures and suitable equipment in accordance with applicable codes, standards, specifications, criteria and contractual requirements.

c) Maintain documentation for currently qualified personnel and processes according to the requirement of pertinent codes and standards.

d) Define the necessary qualifications of personnel and procedures for special processes not covered by existing codes or standards, or where item or service quality requirements exceed the requirements of established codes or standards.

e) Not consider concreting as a special process. However, the Contractor shall ensure that foremen and vibrator operators are properly selected from experienced or trained personnel prior to assignment of works and are given regular training by concrete placement experts as needed.

25.3.16 **QUALITY RECORDS**

The Contractor shall :

a) Maintain quality records as evidence that :

i) The quality assurance program meets the requirements of these Quality Management Requirements (manual, procedures, quality plan).

ii) The items or services meet contractual or other applicable technical requirements (specifications, drawings, calculations, manufacturing, inspection and test procedures).

iii) Personnel and procedures for special processes are qualified as required by 25.3.15.

iv) Measuring and testing equipment is calibrated as required by 25.3.7

v) The procurements meet the requirements of 25.3.6

vi) Corrective actions are being taken and are effective as required by 25.3.18

vii) Audits are performed as required by 25.3.19.

b) Maintain final performance quality records which include as appropriate :

i) as build records
ii) material test reports or certificates
iii) non-destructive examination records or certificates.
iv) inspection and test records.
v) non-conformance reports.
vi) concrete batch plant printout.

Items (iii) and (iv) apply to those operations performed after receipt of materials from the supplier.

c) Identify, index and file quality records for easy retrival.

d) Retain quality records for the time specified in the contract. If not specified, final performance quality records shall be retained for 10 years.

e) Provide a suitable environment for storing of records to minimize deterioration or damage and to prevent loss (the use of a double filing system is an acceptable

method).

25.3.17 **NON-CONFORMANCES**

The Contractor is responsible for the identification and disposition of all non-conforming items, including those of sub-contractors. Final acceptance of the Contractor's disposition of those items that violate contractual requirements is the prerogative of the Purchaser. The Contractor shall :

The Contractor shall :

a) Verify NPC certification.

b) Examine NPC supplied items on receipt for completeness and proper type and to detect transit damage. Further receiving inspection is not required unless the Contractor needs actual characteristics for subsequent work or unless specified in the contract. Examination may be deferred until further processing is scheduled if items are in sealed containers or have special preservation or packaging.

c) Control NPC supplied items from receipt onwards according to the requirements of this standard.

d) Report promptly in writing to the quality assurance representative, any NPC supplied items found damaged, lost, non-conforming, or otherwise unsuitable or unnecessary for use either on receipt or while in the Contractor’s custody.

25.3.18 **CORRECTIVE ACTION**

The Contractor shall :

a) Investigate the causes of significant or recurring non-conformances and take appropriate action to prevent repetition.

b) Document and have reported to appropriate levels of the Contractor's management causes of significant conditions that adversely affect quality and the corrective action taken.

25.3.19 **VERIFICATION OF QUALITY**

25.3.19.1 **INITIAL EVALUATION**

Quality Assurance Program, Facilities and Physical Resources :

Prior to the award of a contract, and to the performance of the activity, the Purchaser shall evaluate the Contractor's quality assurance program, manufacturing facilities and resources to determine whether the requirements of this section can be met.

In the event of the Contractor not fulfilling all applicable requirements, NPC may award the contract provided that he takes the responsibility for those QA requirements that will not be met by the Contractor. In such a case, the exceptions shall be clearly defined in the contract.

25.3.19.2 **QUALITY PLAN**

NPC shall evaluate the quality plan and all revisions thereto in order to determine its acceptability.

NPC shall indicate witness points on the accepted quality plan.

In addition, NPC shall perform surveillance according to the accepted quality plan.

25.3.19.3 **ACCESS**

The Contractor shall provide for reasonable access of the competent authorities and of NPC to his premises and records for audit and surveillance purposes.

LIST OF ANNEXURES

1. Annexure – 1: Typical details of Bore log data & Geotechnical Parameters of Natural Soil
2. Annexure – 1A: Geotechnical Parameters of Improved Soil
3. Annexure – 2: Procedure for preparation and approval of design documents
4. Annexure – 3: Digital value of Response spectra of SSE
5. Annexure – 4: Information to be Submitted Alongwith the Bid for the proposed agency for Civil Works
6. Annexure – 5: Details of Company
7. Annexure – 6: Proposed Deployment of Plant & Machinery
8. Annexure – 7: Technical Details to be Supplied along with Bid

LIST OF TENDER DRAWINGS

1. Drawing no. GHAVP- 1&2/10120/2001/DD- Borehole Location Layout
2. Drawing no. GHAVP- 1&2/10000/5001/GA- Main Plant Layout
3. Drawing no. GHAVP- 1&2/24200/ 2011 TO 2018/ GA - Control Building GA drawings
4. Drawing no. GHAVP-1&2-29700-2001-SK- Terminal Point of Turbine Island Package
5. Drawing no. GHAVP-1&2/29700/5002/GA - Outdoor Tunnel & Trenches Layout
6. Drawing no. GHAVP1&2/16000/2003 and 2004/DD – Excavation Drawings
7. Drawing no. GHAVP1&2/15300/5001/GA – Surface Drain Layout
8. Drawing no. GHAVP1&2/15200/5101/GA – Plant Water Drainage Layout
9. Drawing no. GHAVP1&2/15200/5001 and 5002/GA – Roof Drain Layout
10. Drawing no. GHAVP1&2/15200/5201/SK – Sanitary Sewer Layout
11. Drawing No.-.GHAVP1&2/15600/5001/SK- Typical Cross section of Road
12. Copy of drawings showing various Architectural Joints

LIST OF ATTACHMENTS

1. Report on Field Mock-Up for Ground Improvement by Replacement of Liquefiable Strata by Compacted Soil / Soil-Cement Mix (with addendum)
2. PC-E-00034-Scope of work for fabrication and erection of Critical and Important Embedded Parts (EPs) for 700 MWe Main Plant Civil Works
3. PC-E-160-Technical Specification for Manufacture of Embedded Parts
4. PP-E-2273-Technical Specification for Electrostatic Conductive Floors for KAIGA – 3&4 and RAPP- 5&6
5. PP-M-400-R1 – Technical Specification for two part Polysulphide Sealing Compounds for Containment Building
6. PP-M-1219 – Specification for Epoxy Coating for Reactor Building Internal Structure and Equipment

in Appendix-A irrespective of whether or not loose material is evident on visual inspection.

Galvanized and copper pipes and fittings if properly stored should not require any cleaning. However if storage or handling resulted in contamination, the Engineer-in-Charge will decide on suitable cleaning depending on the nature of the contamination. In any case all the pipes and fittings should be cleaned by oil free compressed air prior to fabrication and installation.

All pipes and fittings being assembled for pre-fabrication and or installation shall be in clean conditions as specified. In addition, at fabrication stage sub-assemblies shall be cleaned of weld spatter, slag, oxide films (such as occurring in brazing) and any other foreign matter.

Just prior to field erection of fabricated sub-assembly, its inside surface shall be subjected to wire brushing and oil free compressed air cleaning.

In cases where the carbon steel / alloy steel pipes are rusted / pitted, the metal brush cleaning may not be sufficient, in such cases the pipes shall be cleaned by pickling additionally with the concurrence of Engineer-in-charge.

PVC / CPVC pipes may be cleaned by using nylon brush followed by flushing with compressed air. Subsequently, the pipe & pipe fittings shall be washed / rinsed in water and dried.

5.0 DETERGENT WASHING OF CS/LAS/ SS PIPE & FITTINGS

The purpose of washing the pipes and fittings with detergent is to remove dirt grease, foreign matter and halides contamination and the extent of requirement is tabulated in Appendix-A. DM water rinse is mandatory on all systems containing heavy water or cover gas and for other systems clear, filtered water can be used.

The following equipment accessories will be required for washing operations:

a) **Enclosure and handling equipments**

This shall be adequate to accommodate all cleaning equipment. It shall be properly illuminated, be equipped with drainage facilities, and must be of the type which when closed would protect the equipment being cleaned from dust in the atmosphere. Handling facilities, monorails or other shall be as required.

b) **Tanks**

At least four tanks will be required as follows:

Wash tank for carbon steel materials

Wash tank for stainless steel materials

Each wash tank to have its corresponding rinse tank

Adequate working area must be available around each tank, and the tanks shall be suitably designed.

Minimum inside dimensions of the tanks shall be 7.8 to 9 meter long, 1 meter deep and 1.4 meter wide. Tanks for washing carbon steel can be of carbon steel material but tanks for washing stainless steel must have at least lining of stainless steel. The design of tanks shall be subjected to approval of Engineer-in-Charge.

c) **Heaters**

All tanks shall be equipped with heaters capable to maintain the temperature as required for detergent wash. The water in the rinse tanks shall be in continuous overflow or with feed and bleed, system the set rate of which will depend upon size of the equipment.

d) **Brushes**

Nylon brushes shall be used to ensure adequate cleaning of the surfaces and to speed up the cleaning operations. Flat brushes can be used on the flat surfaces or on the small components, circular brushes mounted on the rod shall be used for scrubbing inner surface of pipes. Similarly as in the case of metal brush cleaning described in Section 4, a slightly over size brush shall be used for a particular pipe diameter. Brushes will be classified in sets, all are to be suitably tagged to provide instant identification with respect to pipe / fitting material being used i.e. carbon steel, stainless steel, copper, etc. They shall be continuously in good condition and shall be examined before during and after the cleaning operations. Brushes showing any signs of disintegration shall be replaced. If any damage is noticed, the disintegrated part/s of the brush shall be removed from the pipe.

e) **Detergent**

Any suitable detergent complying with the following specifications can be used.

1) 25 ppm maximum free halogen expressed as Chlorine in solution at strength for use.

2) 25 ppm maximum sulphur in solution at strength for use.

However, selected detergent shall be submitted for the approval of the Engineer-in-Charge as follows:

I) The supplier of the selected detergent must clearly indicate in writing the Halogen and sulphur contents of his product and that it is free of any other contamination and does not contain secret additives and is exactly that represented by its chemical formula.

II) Subject to satisfactory certification by the supplier, the Engineer-in-Charge may request a sample of each batch of the detergent for chemical examination. The approval, if granted shall be restricted to this batch.

f) **De-mineralized Water**

Filters and Ion exchange equipment shall be supplied & erected for the production of clean de-mineralized water. The DM water shall be piped to the cleaning area in plastic, stainless steel, or aluminium piping. This pipe shall feed the tanks as and when required. A spare connection shall be provided for rinsing purposes.

De-mineralized water shall comply with the following specifications.

1) Specific resistance – Min. 500,000 ohms-cm.

2) pH value shall be between 6.5 to 8.

3) The suspended solids in the treated water shall be less than 0.2 ppm when retained on a +0.45 micron filter.

g) **Oil Free Compressed Air**

A compressor having graphite or Teflon ring, receiver, separator, dryer, filter etc. shall be supplied for the production of oil free compressed air. The air pipe to the cleaning area shall be plastic, aluminum, stainless steel or galvanized iron materials.

h) **Washing**

The preparation of washing solutions as regards concentration and temperature will be as recommended by the Supplier of the detergent and there will be no addition of any other chemical or ingredients.

An item to be washed shall be immersed in the solution, allowed to soak in the solution for 5 – 10 minutes, then its surfaces shall be brushed inch by inch. When lifted from the solution the item will be allowed to be completely drained. It will then be retained in a position, just on the outside of the wash tank where it will be adequately rinsed with de-mineralized water.

Subsequently, the item will be placed to soak in the rinse tank in which de-mineralized water is continuously overflowing. When lifted from the rinse

tank it shall receive from the hose a final rinse with excessive amount of de-mineralized water. It will then be allowed to drain and will be dried with oil free compressed air.

When inspected and approved, the open ends will be closed with the protective devices of the type shown in Appendix – B before the item leaves the washing area. NPCIL, QS shall be available at all time in the area when cleaning operations are in progress.

Any piece of equipment, pipe or fitting shall not be moved into the installation area without prior approval from the NPCIL, QS that a particular item has passed cleanliness inspection and is adequately protected from further contamination.

The "metal brushing" and "washing" operations should not develop into voluminous production for stock piling reasons and must be planned as required. Detergent and de-mineralized water bath shall be drained and fresh bath shall be prepared when they fail to do the cleaning function intended or the bath are dirty / have been kept for a long duration as and when directed by Engineer-in-Charge. The Contractor is responsible for final cleaning of the installed system prior to handing over to Engineer-in-Charge. The internal surfaces shall be cleaned with oil free compressed air and the external surfaces shall be cleaned of any dirt, paint marks, etc by thorough mopping with de-mineralized water.

i) **Blind Flanges and Caps**

Upon completion of cleaning operation, blind flanges or caps shall be installed on pipes or equipment approved specimens of these are shown in Appendix–B

6.0 CLEANING OF SPECIAL COMPONENTS, VALVES AND FLANGES

Special Components, Valves and Flanges will require cleaning by solvent or detergent wash including in presence of protective coating / compound, grease which is normally applied for transit protection purposes. Any solvent used and the procedure for such pre-cleaning shall be approved by the Engineer-in-Charge. This pre-cleaning shall be followed by adequate rinse with water except for the system containing heavy water or cover gas where washing with detergent followed by de-mineralized water rinse is mandatory. All these items after washing shall be dried by oil free compressed air.

All flanges and other machined surfaces shall not be brushed on gasket seat / sealing faces.

Suitable Ultra Sound cleaning methods may be employed with the concurrence of Engineer–in- charge.

7.0 DEGALVANIZING OF G.I. PIPE ENDS

Where Removal of Zinc coating from G.I. Pipe ends is required (e.g. for welding of G.I. pipes) the procedure for de-galvanizing which is to be adopted is described in Appendix – D of this specification.

8.0 CLEANING IN WORK AREA

All areas of installations shall be kept dust the free condition and the dust removal will be done by means of vacuum cleaners and wet mops. The cleaning operations may create dusty conditions / atmosphere in a particular area. The contractor shall identify such areas in advance and coordinate to take appropriate actions. For the duration of such operations pipe fitting shall not be permitted in that area. All installed piping and equipment shall be regularly cleaned by means of vacuum cleaner and wet mopping so as to be free of dust. The equipment and pipe lines (whether washed or cleaned by other methods) shall be closed at all times with the devices of the type shown in Appendix – B except during the actual performance of the work on the joint in question.

9.0 PREVENTION OF WET SURFACE PERIODS

All the materials/equipment taken-up for cleaning shall be processed in expeditious manner and at no stage these components be subjected to idle periods with wet surface.

10.0 HALIDE AND SULPHUR CONTAMINATION

The contamination of austenitic stainless steel, zirconium and high nickel alloys with halides and sulphur may affect their corrosion resistance and mechanical properties. Therefore, the specification as a rule prohibits the use of solvents, cleaning agents tapes, paints etc. containing free halides and sulphur in any other piping / equipment of the project. This is required to eliminate the possibility of their inadvertent use on stainless steel, zirconium and high nickel materials or materials which may come in contact with them.

Further more, where approved tapes/soap solution/lubricants are used for testing etc. in the project, these along with residue must be completely removed by washing because of possibility of breakdown of residue under radiation and formation of organic acids.

11.0 IRON AND CHLORIDE CONTAMINATION ON S.S. MATERIAL

All piping inside Calandria Vault shall be checked for these Contaminations. SS pipes to be used outside the vault for moderator and other system will be checked for these Contaminations on sample basis as and when asked by the Engineer-in-Charge. Contamination test may be carried out as per Appendix-E or any other suitable methods approved by the Engineer-in-Charge.

APPENDIX – A

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
OPRD PIPINGS	31280	SS	HELIUM	NA	A	
REACTIVITY DEVICES	32700	SS	D_2O/HELIUM	NA	A	
PROCESS SYSTEMS	39000	SS	H_2O/HELIUM	NA	A	
MODERATOR SYSTEM	32000	SS	D_2O/HELIUM	NA	A	
	32110	SS	D_2O/HELIUM	NA	A	
	32210	SS	D_2O/HELIUM	NA	A	
	32310	SS	HELIUM	NA	A	
	32400	SS	D_2O/HELIUM	NA	A	
	32510	SS	D_2O/HELIUM	NA	A	
	34510	SS	D_2O	NA	A	
	34520	SS	D_2O/HELIUM	NA	A	
	34540	SS	D_2O/HELIUM	NA	A	
	34810	SS	D_2O	NA	A	
	34910	SS	D_2O	NA	A	
	34920	SS CS	D_2O	NA A	A NA	
	34940	SS	D_2O	NA	A	
	34960	SS	D_2O/HELIUM	NA	A	
	34980	SS	D_2O/AIR	NA	A	
	34990	SS CS	D_2O/AIR	NA A	A NA	
D2O UPGRADING PLANT	34930	SS CS	D_2O	NA A	A NA	
PRIMARY HEAT TRANSPORT SYSTEM	33110	CS	D_2O	A	NA	
	33116	CS	D_2O	A	NA	SURFACE OF SS MATERIAL & FEEDER PIPES & FITTINGS UNDER 33116 TO BE WASHED
	33210	CS	D_2O	A	NA	
	33230	CS SS	D_2O	A NA	NA A	
	33310	CS	D_2O	A	NA	

APPENDIX – A - CONTD...

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
PRIMARY HEAT TRANSPORT SYSTEM - CONTD...	33320	CS SS	D_2O	A NA	NA A	
	33330	SS	D_2O	NA	A	
	33340	CS SS	D_2O/AIR	A NA	NA A	
	33350	CS SS	D_2O/H_2O	A NA	NA A	
	33360	CS SS	D_2O/H_2O	A NA	NA A	
	33370	CS SS	D_2O	A NA	NA A	
	33410	CS	D_2O	A	NA	
	33510	SS	N_2/H_2	NA	A	
	33610	CS SS	D_2O	A NA	NA A	
	33710	SS	D_2O	NA	A	
	33720	CS SS	D_2O	A NA	NA A	
	33820	SS	D_2O/H_2O	NA	A	
	33830	SS	D_2O/AIR	NA	A	
	33840	SS	D_2O/H_2O	NA	A	
	34330	SS	D_2O/H_2O	NA	A	
	36110	CS	H_2O	A	NA	
	36710	CS	H_2O	A	NA	
	36730	CS	H_2O	A	NA	
	36600	SS	H_2O	NA	A	
REACTOR AUXILIARY SYSTEM	34110	CS SS	DM WATER	A NA	NA A	
	34160	SS	DM WATER	NA	A	
	34200	CS SS	DM WATER	A NA	NA A	
	71810	CS SS	H_2O	A NA	NA A	
	34410	SS	DM WATER	NA	A	
	34710	SS	CO_2	NA	A	
	71310	CS	DM WATER	A	NA	
	71720	CS SS	D_2O/H_2O	A NA	NA A	
	73120	SS	D_2O	NA	A	

APPENDIX – A - CONTD...

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
SECONDARY SYSTEM	36110	CS SS	STEAM	A NA	NA A	
	36120	CS	STEAM	A	NA	
	36310	CS/LAS SS	H_2O	A NA	NA A	
	36510	CS	H_2O	A	NA	
	36600	CS	STEAM/ H_2O	A	NA	
	41120	CS	H_2O	A	NA	
	41130	CS	H_2O	A	NA	
	43110	CS/LAS	STEAM	A	NA	
	43130	CS/LAS	H_2O	A	NA	
	43140	CS/LAS	STEAM	A	NA	
	43210	CS/LAS	H_2O	A	NA	
	43310	CS/LAS	H_2O	A	NA	
	45110	SS	STEAM/ H_2O	NA	A	
	45210	CS/LAS SS	H_2O	A NA	NA A	
COMMON SERVICE INSIDE REACTOR BUILDING AND RAB	71120	CS	H_2O	NA	NA	Brush &Air cleaning
	71130	CPVC /PVC	H_2O	NA	NA	-DO-
	71200	CS	H_2O	NA	NA	-DO-
	71350	CS	DM WATER	NA	NA	-DO-
	71400	CS	H_2O	NA	NA	-DO-
	71710	CS	H_2O	NA	NA	-DO-
	71850	CS	H_2O	NA	NA	-DO-
	71500	CS	H_2O	NA	NA	-DO-
	71600	SS	DM WATER	NA	NA	-DO-
	71900	CS	H_2O	NA	NA	-DO-
	75100 75110 75120	CS SS	AIR	A NA	NA A	
	75130	SS	AIR	NA	A	
DG FUEL OIL SYSTEM	53530	CS	DG FUEL OIL	A	NA	

APPENDIX – A - CONTD...

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
FUEL HANDLING PROCESS SYSTEM	35216	SS	D_2O/H_2O/ OIL/ AIR	NA	A	
	35217	SS	-DO-	NA	A	
	35218	SS	-DO-	NA	A	
	35226	SS	-DO-	NA	A	
	35227	SS	-DO-	NA	A	
	35228	SS	-DO-	NA	A	
	35234	SS	-DO-	NA	A	
	62136	SS	-DO-	NA	A	
	62137	SS	-DO-	NA	A	
WASTE MANAGEME NT SYSTEM	79210	CS	H_2O	A	NA	
	79210	SS	H_2O	NA	A	
	79220	CS	H_2O	A	NA	
	79220	SS	D_2O/H_2O/ Resins	NA	A	

NOTES :

1) CS : Carbon Steel
PVC : Polyvinylchloride
CPVC : Chlorinated Polyvinylchloride
GI : Galvanized Iron
SS : Stainless Steel
DM : De-mineralized
LAS : Low Alloy Steel
A : Applicable
NA : Not applicable

2) If the entire process of pickling is completed by adequate rinse with DM water, further washing with detergent is not required.

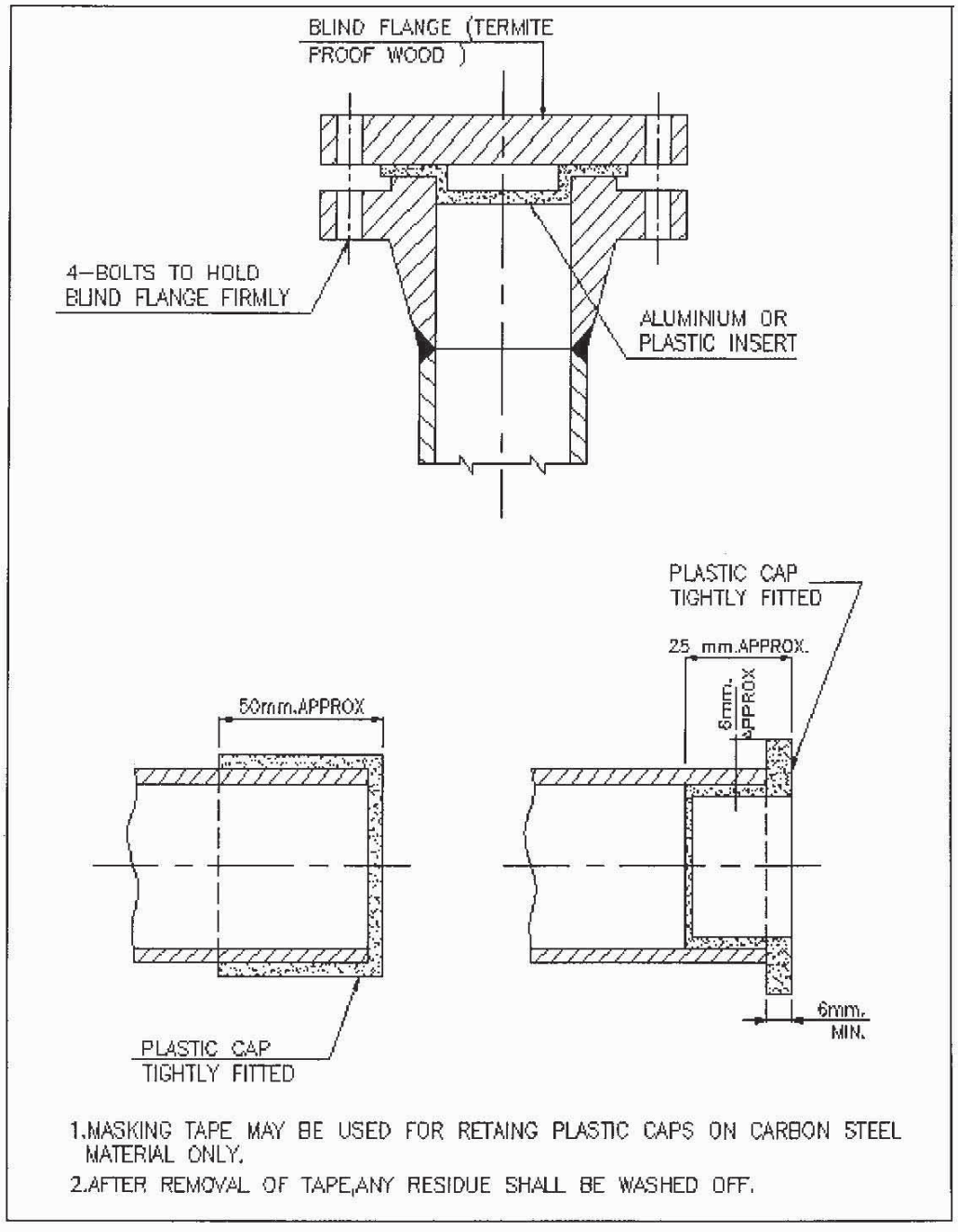
3) Feeder pipe and fittings under USI 33116 are bought in pickled condition. Normal degreasing method indicated at para 5 is considered adequate. However, depending on the surface condition, degreasing using step 1 to 4 and 10 of Appendix-C at the discretion of the Engineer-in-Charge will be used.

4) All CS Pipes and Fittings except as mentioned in (3) are bought in un-pickled condition.

5) For cleaning of GI and Copper materials refer para 4 of this specification.

6) In any case all the pipes and fittings should be cleaned by oil free compressed air prior to fabrication and installation.

APPENDIX – B : BLIND FLANGE AND CAPS



APPENDIX – C

GUIDE TO PICKLING OF CARBON STEEL PIPES

Pickling of Carbon Steel Pipes will be done in water solution of H_2SO_4. The concentration of acid will be approximately 15% by weight of H_2SO_4 and 0.1% inhibitor Corobit 1001. With the temperature of pickling at 50^0C to 55^0C by means of electric heaters, and depending on surface conditions of the pipe, the removal of mill scale should be achieved within 10 to 15 minutes. Brushing or air agitation will assist the process. When concentration of solids, i.e. iron sulphate in the pickling bath is excessive (i.e. approx. 12 to 15%) the solution will be changed. The pickling will follow the steps outlined:

1) Select batches of pipes with similar surface conditions, i.e. mill scale or rust.

2) Brush pipes to remove loosely adhering scale or dirt.

3) Degrease and clean in a bath of cold solution of 8% Caustic soda. Depending on contamination, the soaking time will be 5 to 10 minutes assisted by brushing or air agitation. Acid, NaOH and D.M. Water rinsing baths shall be changed when they fail to degrease / pickle / neutralize / rinse effectively as and when directed by Engineer-in-Charge.

4) Rinse with water and allow to drain.

5) Pickle in approx. 15% H_2SO_4 plus 0.1% of Corobit 1001 at 50^0C to 55^0C

6) The bath shall be changed when iron concentration in the bath reaches to13% by weight.

7) After pickling, place pipes in a tank with water and brush the pipes to remove any loosely adhering matter.

8) Rinse with fresh water from a hose and transfer into neutralizing tank.

9) Neutralize with 2% Caustic Solution. Pipes are to be soaked for 5 to 10 minutes in this solution which is to be agitated with compressed air.

10) Remove from neutralizing bath and rinse adequately with water. DM water should be used for rinsing pipes for D_2O and cover gas system.

11) Litmus paper shall be used to check for complete removal of acid / alkali.

12) Allow to drain, dry with oil free compressed air and cap it as required.

APPENDIX – C - CONTD...

GUIDE TO PICKLING OF CARBON STEEL PIPES

13) The bright shined surface shall indicate the appropriateness of the pickling process employed. The surface should not appear dull/ rough which is indicative of under pickling /over pickling respectively .

14) After cleaning, the overall thickness of pipe (in finally installed condition) shall not be less than permitted by applicable standard for pipes i.e. 90% of nominal wall thickness welded pipes (as per IS 1239) and 87.5% nominal wall thickness for seamless pipes.

The following laboratory checks shall be made:

a) Acid Concentration
b) Iron Sulphate concentration
c) Percentage loss of weight of a pipe sample for each batch.

NOTES:

i) The pickling procedure shall be subject to the approval of the Engineer-in-Charge before the pickling operation.

ii) Piping sub-assembly shall be pickled at such a stage that its interior is completely accessible for brushing and inspection.

iii) The Contractor shall provide all necessary tanks, electric heater and chemicals for the above cleaning.

APPENDIX – D

DEGALVANIZING OF GI PIPE ENDS

The pickling of GI pipe ends will be done in water solution of H_2SO_4. The concentration of acid should be approx. 8% by weight of H_2SO_4, and 0.10% of inhibitor Corobit 1001. The ends of pipes (recommended length from where zinc is to be removed for welding = 80 mm) shall be dipped in the acid bath for about 45-50 minutes or for just sufficient time to remove the zinc coating. The level of the acid shall be maintained in such a way that removal of coating takes place on required length of pipe from ends. Clearance shall be keep so as to maintain the same chemical conditions for outside and inside surface of the pipes.

The pipes being de-galvanized should be held vertically throughout the operation so as to avoid non-uniformity of the surface and attach of acid / NaOH on the area which is not be de-galvanized.

After de-galvanizing the ends of the pipes shall be adequately rinsed in clean over flowing water. After washing the pipe ends, they shall be dipped in neutralizing bath containing 2%. NaOH for enough time (recommended time 5 – 10 minutes). After neutralizing the pipe ends shall be adequately rinsed in clean over flowing water, followed by draining, drying with oil free compressed air and proper capping. Litmus paper shall be used to check for the complete removal of acid / NaOH. After washing, the ends shall be dried by blast of air which shall be followed by proper capping.

Tests :

The following tests shall be made after getting the approval of test procedure from Engineer-in-Charge :

1) Acid Concentration

2) NaOH concentration

3) The difference in pipe thickness before and after pickling.

APPENDIX – D - CONTD...

DEGALVANIZING OF GI PIPE ENDS

NOTES :

1) After cleaning, overall thickness of pipe (in finally installed condition) shall not be less than permitted by applicable standard for pipes i.e. 90% of nominal wall thickness for welded pipes (as per IS 1239) and 87.5% nominal wall thickness for seamless pipes.

2) The de-galvanizing procedure shall be subject to the approval of the Engineer-in-Charge before the de-galvanizing operation.

3) Acid and NaOH baths shall be changed everyday or when they fail to remove the zinc coating and complete neutralization respectively, which ever is earlier. Acid bath should be completely neutralized before draining.

4) All the pipes shall be visually inspected after de-galvanization and cleared by Engineer-in-Charge. Some of the de-galvanized pipes will be checked by using $CuSO_4$ solution for complete removal of Zinc.

5) Line numbers shall be marked on all the pipes before de-galvanizing.

APPENDIX – E

CHECK FOR CHLORIDE CONTAMINATION

The Spot-check for Chloride Contamination of SS surfaces shall consist of

1) Dropping 5 ml of 10% HNO_3 into a clean surgical swab.

2) Scouring a 100 cm^2 area of the surface to be tested with the acid-laden swab.

3) Reabsorbing the free liquid with the swab and dropping it into a glass test tube containing 5 ml. of de-mineralized water.

4) Preparing a control specimen – a clean acid laden swab dropped into a 5 ml. of de-mineralized water as per (3) above.

5) Picking out each swab and draining it back into its test tube.

6) Adding two drop of 1N $AgNO_3$ solution to each test tube.

7) Comparing the turbidity of the spot-check test solution with that of the control sample solution.

If the turbidity of the spot-check test solution visibly exceeds that of the control solution, the surface shall be deemed contaminated. In such event the surrounding contaminated areas shall be checked to establish the extent of the contaminated areas. These shall be cleaned by repeated swabbing with 10% HNO_3 and rinsing with warm demineralised water and re-checked to ensure effective removal of contamination.

APPENDIX – E - CONTD...

CHECK FOR CHLORIDE CONTAMINATION

Note :

Care shall be taken to prevent spurious indications through prior contamination of test tube, solutions and swabs. These shall be handled with rubber gloves and/or suitable tweezers.

CHECK FOR IRON CONTAMINATION

The check for this shall consist of

1) The surface to be inspected shall be Scoured with clean surgical swab using $CuSO_4$ solution (4g $CuSO_4$, 1 ml H_2SO_4, sp Gr 1.84) in 250 ml DM water.

2) The surface shall be kept wet with solution for 6 minutes min.

3) The surface shall be rinsed and dried.
4) Any copper deposit on the surface shall indicate presence of free iron and deemed to be contaminated.
5) In such event the surrounding areas shall be checked to establish the extent of contaminated areas.

6) The affected area should be cleaned by repeated swabbing with 10% HNO_3 solution and rinsing with warm de-mineralized water. In case the iron particles are found to be deeply embedded, the surface may be ground. In such case care shall be taken for the minimum thickness of the pipe.

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GHAVP-1&2/40000/PROCUREMENT SPECIFICATION/MS-1

REVISION No. – R0, AUGUST-2018

VOLUME-II –
Section-C
PART-2

C-2: SPECIFIC TECHNICAL REQUIREMENTS

C-2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

NUCLEAR POWER CORPORATION OF INDIA LIMITED

(A Government of India Enterprises)

PROCUREMENT SPECIFICATION NUMBER : GHAVP- 1&2/40000/ PROCUREMENT SPECIFICATION/ MS-1
PROCUREMENT SPECIFICATION
FOR
TURBINE ISLAND PACKAGE

SECTION C -2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

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	(Name & Designation)	(Signature)	(Date)

REVISION CONTROL SHEET

PROCUREMENT SPECIFICATION NUMBER : GHAVP- 1&2/40000/ PROCUREMENT SPECIFICATION/ MS-1

PROCUREMENT SPECIFICATION FOR TURBINE ISLAND

SECTION C -2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

REV. NO. / DATE	DESCRIPTION	PREPARED BY	CHECKED BY	REVIEWED BY	APPROVED BY

1. GENERAL

1.0.1 PROJECT

The proposed project of GHAVP-1&2 consists of two units of 700 MWe PHWR type Nuclear Reactors.

1.0.2 LOCATION

The site is situated on the left bank of the Fatehabad Branch of Bhakra canal, near running distance (RD) of 48159 m (158000 ft.), in Fatehabad District of Haryana State. The nearest village to the site is Gorakhpur.

1.0.3 ACCESSIBILITY

Chandigarh, the State capital is about 218 km away from the site by road. The site can be accessed by following ways:

By Road

National Highway No. 10 passes about 6 km away from site. The project site can be approached from NH-10 by turning-off at village Kharakheri, via. the Kharakheri-Gorakhpur road. From Delhi the road to site via NH-10 passes through Rohtak, Hansi and Hisar. The entire route from Delhi to Hissar and further upto Kharakheri is a black-topped national highway.

By Rail

The nearest rail head is Adampur at a distance of 22 km south-western of the site. Adampur station is on the Hisar-Sirsa Borad-Gauge section of Northern Railway. Jakhal Junction is located on the Delhi-Bhatinda sections of the Northern Railway. The road from Adampur station to the site is a good road. Narwana or Jakhal junction / railway station can be used by personnel coming from places like Mumbai, by train.

By Air

The nearest major airport is at Delhi (about 208 kms from project site).

1.1 GEOLOGY OF THE SITE

The site area lies on the western part of Indogangetic alluvial plain on the Punjab side, adjoining the Rajasthan shelf, separated underneath by the alluvium, by the NW-SE trending Lahore-Saharsa Ridge. The site is located on alluvial soil made up of both older and newer alluvium with a thickness estimated to be of the order of about 320 m, below which hard rock formation of the Lahore-Sahara Ridge is reported to occur.

Preliminary investigations at site indicate that the substrata consist of alternate layers of sandy silt/silty sand and silty clay/sandy clay (each layer being of approx. 4m thickness) upto approximate 110 M depth from EGL.

The water table is varying between 0-3 m below the existing ground level. It is likely that the water table may rise to a higher level during rainy seasons. Ground water variation is reported to be quite minimal thereby causing water saturation and water logging in the region during monsoon times.

The existing ground level of the site in the area around TI package is varying from RL 213.5 m to 215.0 m.

1.2 METEOROLOGICAL DATA

The maximum and mean wind speed observed at Hisar during the period 1969-2013 was 48km/hr and 3.6 km/hr respectively.

The other meteorological parameters at Hisar are as follows:

		Max.	Min.
1.	Air temperature (1969-2013)	48.8	-1.5
2.	Average annual Wet Bulb Temperature ^{o}C (1969-2013)	21.4	17.3

The annual average rainfall is about 450 mm with maximum of 793.6 mm (1976) and minimum of 145.2 mm (2000). Relative humidity of maximum 100 % & minimum 5 % has been observed.

Occasionally dust storms are experienced during summer months and hail storms during Feb-April. Fog and dew prevail generally during Dec-Jan. Thunder storm also occurs during post monsoon season and summer months.

1.3 SEISMOLOGY

The site falls under zone III as per the seismic zoning map of India (IS: 1893-Part-1).

1.4 SITE INSPECTION

Intending bidders should visit the site to familiarize themselves thoroughly with the site conditions before submitting their tender. Non-familiarity with site conditions will not be considered a reason either for extra claims or for not carrying out the work in strict conformity with the drawings, time schedule and specifications. For any information on site visit, the bidders may contact NPCIL site office, Village-Gorakhpur, District-Fatehabad, Haryana.

1.5 SITE CONDITIONS

The bore hole location drawing (Drawing No. GHAVP-1&2/10120/2001/DD) is enclosed along with the tender document. Typical details of a relevant Bore log data are given at the end of this section in Annexure-1 for general guidance to the Bidders. Seven Boreholes BH103, RBH-104,RBH-109, BH-110, RBH-111, BH-115 and BH-116 were drilled covering Turbine Building-1. Seven Boreholes BH105, RBH-112,BH-113, BH-106, RBH-114, BH-117 and RBH-118 were drilled covering Turbine Building-2. The bore hole no RBH107 & RBH108 covers the transformer yard area of unit 1 & 2 respectively.

The bidders are advised to study the bore log data for information. The details of other bore log data in balance area of plant is available in the office of the Engineer for reference of the bidders, if needed.

The finished grade level of EL 99.7m corresponds to RL 219.300m.

For detailed geology around Turbine Building & other structures, para 2.1.1 may be referred.

1.6 BUILDING DESCRIPTION

Description of Main structures covered in the scope of this tender are as follows:

1.6.1 TURBINE BUILDING :

The Turbine buildings are located to the East of Control building. The Structure of the Turbine building shall be of reinforced concrete and shall be supported on Raft Foundation. Wherever required, piles shall also be provided under the raft foundation. For wall/cladding , Concrete Block Masonry is to be provided unless approved otherwise by the engineer. The roof shall be made without any internal support, in order to avoid any interference in work being carried below the roof. The roof shall be provided with water proofing with thermal insulation as per specifications. All the fire rating & other technical requirements shall be considered while selection of material & sizing of the members. Each turbine building shall be accommodated within the allocated maximum plan size as shown in the main plant layout drawing. The location of buildings in the main plant lay out is shown in Drg No. GHAVP 1&2/10000/5001/GA enclosed along with the tender. A portion below condenser shall be lowered appropriately for cooling water inlet and outlet pipes.

The turbine building shall have floors and mezzanine floors at various elevations, housing the turbo generator and other components like HP Turbine, LP Turbine, Generator, Moisture Separator & Reheater, Deaerator, HP and LP feed water heaters, Condensate Extraction Pumps, Boiler Feed Pumps, Storage tanks, Vacuum pumps, Generator Circuit Breaker, Bus Ducts etc. The description given above is brief only . For detailed description relevant chapters of the tender may be followed.

For industrial & fire safety requirements relevant AERB & other statutory guidelines

as applicable shall be strictly adhered.(Refer C-1-3)

The Turbine Generator(TG) shall be supported on a separate RCC pedestal and Reinforcing Concrete Raft foundation. Wherever required, piles shall also be provided below TG raft. The TG foundation shall be isolated from the main turbine building, so as to avoid transmission of vibrations or any other kind of forces to the main building.

Inside the building, EOT cranes with suitable crane girders shall be provided, to handle the heaviest load within the building for maintenance & erection of Turbo Generator & other equipments except Turbo Generator Stator. During maintenance provision to facilitate the removal of Turbo Generator Stator , proper removable leak-tight opening shall be made in the roof of Turbine Building. The building shall have necessary cable & Pipe trenches / tunnels, racks, pipes, hangers & anchor supports. The lifts as well as stair cases shall be provided to access from one floor to another floor of the building.

The access to Turbine building from Control Building at various floors shall also be provided through proper connecting walkways, landing, Staircase etc. Floor levels & entry location from control building are enclosed in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, along with this tender. ***The connecting structure (Access Bridge) shall be planned & designed in such a way that it does not transfer any load to control building as the same is not considered in the design of control building.***

In addition to above, condensate storage area & ventilation buildings, are to be provided by the side of Turbine buildings as indicated in the Drawing No. GHAVP 1&2/10000/5001/GA enclosed along-with the tender.

Annex Buildings are located by the side of both the Turbine Buildings. One of the Annex Building houses the Workshop alongwith other facilities, whereas other Annex Building houses the Laboratory with other facilities. For details of various facilities in the Annex Buildings Chapter C-1-3 of the Tender may be referred. The Annex building may be designed by the bidder as standalone structure or could be a part of the Turbine Building.

The construction of a local Control center inside turbine building with noise barrier/acoustic insulation as specified is also included in the scope of bidder, The detailed requirements of same which are indicated C&I specifications in chapter C-2-4 are also to be met .

1.6.2 **Pipe Cable Bridge (PCB):**

The Pipe and Cable Bridge (PCB) connecting Control building to Turbine Building shall have RCC Structure with suitable foundation and the same is included in the scope of this tender . The intermediate floors & roof of PCB shall be of RCC. The roof shall be provided with water proofing with insulation as per specifications.. ***The structure of PCB shall be planned in such a manner that it does not interfere with***

the vehicular and equipment movement on 10 m wide (7m carriage bay and 1.5m wide shoulder on either side of road) road , as well as tunnels & trenches laid under the road. The tunnel & trenches in this area are indicated in drawing no GHAVP-1&2-29700-5002-GA.The PCB foundations should not transfer any load on tunnels & trenches.

The floor elevations of Turbine Building shall preferably match with Control building floor levels. (Floor levels of control building are enclosed in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, along with this tender). The width of PCB shall match with the PCB opening at control building end as shown in above mentioned drawings ,however the length of PCB will depend on the size of Turbine building as finalized by the bidder and approved by the purchaser. ***The PCB structure shall be planned & designed in such a way that it does not transfer any load to control building.***

1.6.3 **Electrical Bays:**

The electrical bays shall be provided adjoining to main turbine buildings. The electrical bay houses switchgears and Motor Control Centers. The size , layout & equipment arrangement of electrical bay shall be as specified in section C-2-3 of the Tender. The Structure of the Electrical bay shall be of RCC with raft foundation. Piles shall also be provided, wherever required. The roof shall be provided with water proofing with thermal insulation as per specifications. All the fire rating & other technical requirements shall be considered while selection of material & sizing of the members. ***The engineering of the Electrical Bay shall be carried out on the basis of equipment layout and other input as finalized by the Purchaser & given in the electrical specifications in section C-2-3.***

The present layout of Electrical bays is finalized based on the structural configuration and sizing of various columns, beams etc. as per drawings attached in section C-2-3. It is expected that bidder shall maintain the same while design of Electrical Bay Buildings . In case, it is found to be essential to change the given dimension and same is approved by Engineer, the Purchaser may modify the equipment layout, opening arrangement etc, to meet the design, construction and maintenance requirements. In such situation, Bidder shall carry out the necessary design changes based on modified layout by the purchaser without any extra cost to Purchaser.

1.6.4 **Access Bridge:**

The Access bridge for both the units needs to be provided to connect the turbine building from control building from each floor of Control building. This structure shall have landing at each floor of Turbine Building connected to nearest available Control building floor. It shall also have provision of lift, to access the Turbine Building & control building. The floor elevations of Control building at which turbine building to be connected with control building are given in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, attached with this tender. The Access Bridge structure shall be RCC. The roof shall be provided with water proofing with insulation as per specifications. Lift shall open at all floor levels of CB & TB.

1.6.5 **CCW Inlet & Outlet Pipes / Conduit**

The detailed requirement for CCW Inlet & Outlet Pipes/ Conduits given in Section C-2-5 shall be met. Suitable arrangement viz. culvert etc. shall be made to ensure that no loads are transferred by other Structures & Systems under this package on CCW Pipes/ Conduits.

1.6.6 **Transformer Yard:**

All the civil works for transformer yard (adjoining to turbine buildings & electrical bay) to accommodate SUT, UT, GT, Oil Separation Pit, Bus Duct, Rail Track (including rails) for maintenance upto Turbine building, spare GT area, fire barrier walls etc. are included in the scope of the bidder as shown in the relevant tender drawing. **The supply and erection of rail on road towards western side of grid X-2 is also included in the scope of bidder**. For detailed scope Section C-2-3 shall be referred. The transformer yard is open to sky. An area reserved for Transformer Yard is shown in main plant layout drawing attached with the tender. ***The engineering of this area shall be done on the basis of input data and equipment layout provided by the Purchaser as given in the electrical specifications in Section C-2-3.The foundation for all the equipment & structures shall be Raft or Pile- Raft foundation, unless approved otherwise by the Purchaser. The founding level for SUTs, UTs, GTs, Burnt Oil Pit and Fire wall etc. shall be kept at EL 95.4m or lower as required (unless specifically approved by the engineer).*** The equipment foundations shall be structurally isolated from the grade slab to avoid any transfer of load.

1.6.7 **Tunnels & Trenches around Turbine Building & Transformer Yard (Other than CCW Pipes/conduits) & other area:**

The engineering & construction of all the tunnel trenches within the road edges between grid (8&9), Grid (26-27), grid (r2- q2) & grid (x2-y2)is included in the scope of bidder. The terminal points are specified in Sketch No.GHAVP-1&2/29700/2001/SK. The end of the RCC tunnels shall be provided with proper construction joint & dowels of adequate length which can be used by other agency for further construction. (The load being transferred, if any, at terminal point and is to be accounted for during design by TI package contractor to be specified.) The tunnels / trenches shall be aligned & engineered properly considering the road crossing etc, if any as per overall layout of the plant. The Tunnel trenches included in the scope are:

- PTL 26, 33(upto terminal point),53,96,97
- PTR 26A , 26B & 68
- CTR 72,74, 74A,75, 77,78,79, 80
- CTL 73, 73A(upto terminal point), 73B, 94 (upto terminal point), 95, 95A
- ASW tunnels upto terminal points in East & West direction.
- Any additional tunnel / trenches / pipes required within the terminal points as given in above para. are also included in the scope of bidder. The portion of the tunnels/

trenches which is excluded from the scope of this package are specifically mentioned in the Sketch No . GHAVP-1&2/29700/2001/SK given with the tender.

- Tentative layout of Surface drain is given in Drawing No GHAVP-1&2/15300/5001/GA. Design and construction of down comer pipes & additional internal drains connecting to the Surface drains shown in above drawing is in the scope of bidder. Construction of Surface drains between nodes A26 to A29, A29 to A30, A30 to A45, A39 to A45, B2 to B5, B5 to B6 and B1to B6 are in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant.
- Tentative layout of Plant drain is given in Drawing No. GHAVP-1&2/15200/5101/GA. Design and construction of additional internal plant drains connecting to the nearest available plant drains shown in above drawing is in the scope of bidder. Design & Construction of plant drains from building to the terminal point (PDC-22, PDC-23, PDC-30, PDC-31, PDC-32, PDC-33 and PDC-34) are in the scope of the bidder. Construction of Plant drains between M62 to M67, PDC-31 to M67, M43 to M46 and PDC-33 to M46 is in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the boundary limit.
- Tentative layout of Roof drain is given in Drawing No. GHAVP-1&2/15200/5001/GA and Drawing No. GHAVP-1&2/15200/5002/GA. Design & Construction of roof down comers to the terminal points (RWE-16 to RWE-23, RM-18 and RM-19) are in the scope of the bidder. Construction of Roof drains between RWE-16 to RWE-23 and RM-18 to RM-19 is in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the battery limit.
- The tentative layout of sewer lines is given in Drawing No GHAVP-1&2/15200/5201/SK. Design & construction of sewer line from building to the nearest manhole is in the scope of bidder. The construction of Manhole no MH 338 to MH 340 and connecting sewer lines to these manhole as shown in the above drawing is in the scope of the bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the boundary limit.
- The construction of 10 m wide road between grid 17- 18 within terminal point is excluded from the scope of the bidder. However the bidder shall fill the area up to subgrade i.e. EL 98.0m , with soil cement mix as per the specification. The typical cross section to be followed for the road is given in Sketch No. GHAVP

1&2/15600/5001/SK attached with the tender .

1.6.8 The Hard Stand "C" is excluded from the scope of this tender. However, the area below the Hard stand within terminal point shall be graded upto EL 98.00 with soil cement mix as per detailed technical specifications.

1.6.9 **Area grading within the terminal points:**

The area grading within the terminal point within the road edges between grid (8-9), Grid (26-27), grid (r2- q2) & grid (x2-y2) , upto EL 99.7M (RL 219.3M) is within the scope of bidder. For area grading backfilling upto EL 98.7M shall be done using soil cement mix as per the specifications, unless specified in the approved drawing otherwise . The portion above EL 98.7M shall be backfilled using compacted soil as per technical specifications provided.

1.7 SCOPE OF CIVIL WORK

1.7.1 **General:**

The works proposed to be performed under this contract are for Engineering, procurement, fabrication, construction, commissioning and handover of two 700 MWe units of Gorakhpur Haryana Anu Vidhyut Pariyojana - 1&2 (GHAVP- 1&2) and shall include all the facilities required for power production utilizing the steam produced in secondary cycle. ***The facilities shall be established within the allocated area satisfying all the statutory, technical and performance requirements specified in the tender.*** The work shall generally include but not limited to following:

Finalization of equipment layout, general arrangement, loading, analysis , design , drawings, procurement, fabrication, construction & commissioning of :

- Turbine Building including BFP, CEP and Vaccum Pumps.
- Turbo Generator Foundations
- Foundation of all other equipments
- Annex Building ,Turbine Oil storage tank
- Condensate storage tank and its storage area
- Pipe and Cable Bridge (PCB) structure connecting Control building to Turbine Building
- Electrical bay (The engineering of the building is to be carried out on the basis of equipment layout and other input finalized by the Purchaser or his consultant as given in the Electrical Specification.).
- All other Tunnels , Trenches & pipes within the terminal points except those are specifically mentioned as excluded in the sketch No. GHAVP-1&2/29700/2001/SK.
- Transformer yard accommodating SUT, UT, GT, Oil Separation Pit, Bus Duct, Rail yard for maintenance upto Turbine building including rails in transformer yard to & within the turbine building unloading bay, spare GT area . The supply and erection of rail on road towards western side of grid X-2 is also included in the scope of bidder.
- Embedded parts / Penetrations,
- Access bridge to connect the turbine building from control building from each floor

of Control building (The floor elevations of Control building at which turbine building to be connected with control building are given in drawing Nos GHAVP 1&2/24200/ 2011 TO 2018/ GA, attached with this tender) .

- Surface drains, Plant drains, Roof drains and Sewer lines (Based on the engineering input provided by the purchaser)within the terminal point as specified in Para 1.6.7.
- Internal & External Finishes, cladding , plastering , flooring & painting etc.
- Fabrication & erection of all structural steel works like trusses , crane girders etc.
- Area Grading & temporary access roads within the terminal point
- All the civil, structural & architectural works as necessary for completion of the system.

1.7.2 **Detailed:**

The scope of work shall include engineering, procurement, supply & construction necessary for functional requirements. The work shall generally include but not limited to the following :

(a) Based on the geotechnical study carried out at site, the soil is found to be susceptible to liquefaction in varying depth. In order to mitigate the possibility of liquefaction the soil is to be treated up to a depth susceptible for liquefaction, by mixing the soil (at OMC) with 5% cement (by weight of dry soil) and compacting the same in a specific manner. The area within the battery limits of TI package shall be treated by the Purchaser up to the various levels specified in the attached Drawing GHAVP-1&2/16000/2003 &2004/DD. However, as per the layout and structural arrangement opted by the bidder or system requirements , if the founding levels are fixed at a higher elevation than the levels indicated in Drawing no GHAVP-1&2/16000/2003&2004/DD, the area shall be raised by treating it using soil cement mix (cement content 5% by weight of dry soil) by the bidder at his own cost, as specified in the relevant part of technical specifications. The area may also be raised by filling PCC, only if approved by the Engineer . ***It is preferred to take up the foundation of various structures from the level up to which Ground Improvement is carried out by the Purchaser and as indicated in the Drawing No*** GHAVP-1&2/16000/2003& 2004/DD**.** Wherever, the founding levels are lower than the levels specified in above drawing the ground shall be lowered by bidder at his own cost using appropriate cutting tool like chisel etc. which does not disturb and damage the improved soil below founding level. The damaged improved ground, if any, shall be made good by the bidder at his own cost. Additional excavation or backfilling, wherever required shall be carried out by bidder on priority avoiding any adverse effect on the existing works or the works being executed by other contractors in adjoining areas. Schedule of the additional excavation and backfilling shall be finalized in consultation with PURCHASER. Bidder must schedule his excavation and other activities considering the status of construction & schedule of construction of adjoining structure.

(b) Analysis ,Design and Detailed Engineering of all the structures i.e. covered in the scope of this tender and as detailed above.

(c) Preparation of Design Basis Reports (DBR), Static and dynamic analysis reports and other design reports as applicable and suggested by the engineer.

(d) Preparation of general arrangement, loading, Architectural , concrete forming, EP location, EP fabrication and Reinforcement drawings etc. The reinforcement detailing has to be as per Indian Standards/ ACI/ AERB code as directed by the engineer

(e) Complete analysis , design, procurement ,fabrication and erection of structural /Miscellaneous Steel works & EP including preparation of all necessary drawings within the terminal points &within the scope of this tender.

(f) Preparation of composite drawings including details of Civil, Electrical, Mechanical, Instrumentation etc.

(g) Preparation of Bar bending schedule and Bill of materials.

(h) Design , fabrication and erection of formwork and supporting system required for concreting of the various elements of the structure.

(i) All Reinforced concrete work in pile, raft, isolated footings, columns, equipment foundations, slabs, beams, underground tunnels/trenches, sumps, basement structures, ducts, precast covers and allied structures etc

(j) All RCC work required for equipment machinery, tanks, tunnels , trenches etc, supply & installation of EPs.

(k) Supplying and Fixing water stops, expansion joint.

(l) Supplying & Construction of brick, concrete block walls along with plastering , glazed walls, Metal sheet cladding & roofing as per the drawings .

(m) Providing & fixing the Metal Doors/ Fire proof doors, Windows, Ventilators & Louvers with glass & glazing along with all the necessary fixtures wherever required or as specified by the Purchaser. Wherever required, suitable sound insulation measures shall be provided.

(n) Providing and laying of plant drain, storm water drains, sewer lines, roof drains, UPVC pipe down comers and different pipes and other plumbing and sanitary works and connecting the sewer lines to nearest manhole outside the area within this contract or as required.

(o) F3 & U3 finishes to the concrete.

(p) Hardonate flooring by vacuum de-watering method and other types of flooring as specified in the specifications, including specific requirements given in other sections of the tender.

(q) Painting over concrete , structural steel , wall, ceiling, Doors , Windows & Ventilators etc. wherever required as specified in the tender or else as directed by

Purchaser.

(r) Water proofing work in basement, sump, wall and roof etc as specified in the tender specifications or approved by the Purchaser.

(s) Providing facilities throughout the contract period for sampling and testing of various construction materials as specified and as directed by Purchaser.

(t) Providing proper storage facilities for construction materials such as cement, steel, aggregate, admixture, Structural Steel, water stop, paints etc.

(u) Construction of temporary Access Roads & storm water drains within the terminal points .

(v) General area grading and drainage within the terminal points upto EL 99.7M unless specified otherwise, with proper retaining walls / sheet piles (wherever required) .

(w)Finishing works for above mentioned structures, partition walls. plastering, flooring, painting, false ceiling wherever specified & approved in the drawings, erection of doors, windows & rolling shutters, P.H. Works, waterproofing, construction joints, fire proofing, painting of equipment, structures and piping etc.

(x) Preparation of quality assurance plan, quality assurance manual, testing methodologies Inspection and testing plan, and acceptance criteria for material qualification.

(y) Preparation of construction methodology, safety manual, job hazard analysis, work procedures, etc.

(z) Submission & obtaining the purchaser approval on Construction Completion Certificate & system transfer docket containing necessary documents like Test Certificates, Pour Cards, As Built Drawings & Inspection reports etc.

(aa) Attending meetings with purchaser, AERB, wherever & whenever required, at own cost.

1.8 MATERIAL AND SERVICES BY NPC

Land, water and power etc. will be given by NPCIL on chargeable basis on conditions mentioned elsewhere in the relevant documents.

The supply of all the materials , required to execute the work covered under this contract, is in the scope of contractor.

1.9 DRAWINGS

Drawings being issued with bid are for ***guidance*** only. All the construction/ as-built drawings are to be prepared by bidder on suitable integrated engineering environment or AutoCAD (latest version) as per relevant standards and as specified by purchaser .

Drawings in Compatible AutoCAD version shall also be provided to the purchaser. Contractor should have adequate knowledge of prevailing codes and practices for reinforcement detailing .

3 number of prints (full scale) of each drawing shall be submitted to Purchaser for every revision/correction. Drawings /Documents preparation, checking and Approval of drawings shall be done by the EPC contractor as well as design consultant (if appointed) and same shall also be approved by Proof consultant. Before submission to Purchaser all documents should bear the signatures and names of persons preparing, checking and approving the documents/drawings as well as of Proof consultant .After the approval from Proof consultant the Drawings /Documents shall be submitted for final acceptance of Purchaser. Purchaser comments if any shall be incorporated in the relevant final drawings/ documents prior to execution.

Supporting design calculations (wherever applicable) shall also be submitted by EPC contractor prior to submission of related drawings. Two copies of the approved prints and one set soft copy shall be submitted to the Purchaser. The final soft copy of all the documents and drawings will be registered in Purchaser's document management system (PLM) in the format attached with the tender, progressively with the work progress. Execution shall be done only after proper registration of the documents/ drawings.

Submission of DVD/ CDs (2 copies) of all approved drawings, DBR, Mathematical model, software input and output files, post processors , static and dynamic analysis reports, Design Manual etc , along with soft copy of executable file of programme, excel sheets used in the process of analysis and design are also included in the scope of bidder.

The documents/drawings furnished by Purchaser and/or generated by the EPC contractor shall not be used by the contractor anywhere else without prior written approval of the purchaser. All the generated documents/ drawings will be property of the purchaser.

The bidder has to prepare the following drawings:

(a) General arrangement, loading, Architectural , Concrete forming, EP location, EP fabrication, Reinforcement drawings etc for all the structure covered in the scope of this contract. The reinforcement detailing has to be carried out as per Indian Standards/ ACI code as directed by the purchaser .

(b) Design of Joints, preparation & issue of fabrication drawings for Structural Steel works& other Miscellaneous Steel Structures.

(c) Preparation of Bar bending schedule and Bill of materials (BOQ).

(d) Preparation of composite drawings including details of Civil, Electrical, Mechanical, Instrumentation etc.

(e) Preparation of EP list

The bidder has to prepare all the drawings/ Report as per the approved format of the Purchaser. A period of minimum 15 working days shall be considered for obtaining the Purchaser's comments after submission of drawing / Document by the Contractor.

1.10 SPECIFICATIONS

The specifications given in this document cover the general description, quality and workmanship of materials and finished work. They are not intended to cover minute details. The work shall be executed in accordance with best modern practices.

For all the Civil works these specifications shall have precedence in case anything contrary to this is stated anywhere in the contract document, unless specifically mentioned in this document or approved by the engineer. The Purchaser's decision shall be final, on any issue arising out of such discrepancies.

1.11 PARTICULARS OF THE MATERIALS TO BE USED BY THE BIDDER:

The bidder has to use the following materials for civil construction unless otherwise specified /approved by the Engineer in writing

- **Backfilling:**

A) AREA GRADING:

i) Upto EL 98.70m : Using soil (at OMC) with 5% cement (by weight of dry soil) and compacting the same as per relevant specifications for Backfilling /ground improvement unless approved otherwise. PCC may be used , only if specifically approved by the engineer without financial implication.

ii) Above EL 98.70m: Soil suitable for land escaping/ Soil Cement mix as approved by the Engineer.

B) Within Foot Print of structure/ equipment Foundation:

PCC shall be used, unless specifically approved by the Engineer. The properties of the back fill material used shall be suitably accounted in the design.

- **CONCRETE : M 35 Grade**

- **PCC: M15 Grade**

- **STRUCTURE-**

Foundation Type : RCC Raft or RCC Raft with Piles

Structure above Raft: Reinforced Cement Concrete (RCC), unless approved otherwise by the Purchaser. *RCC slabs and roofs shall be constructed using Galvanized deck sheets as left in shuttering,* unless specifically approved otherwise.

- **WALLS :**All external walls shall be of Concrete Block Masonry, unless approved otherwise by the Engineer . Wherever required, proper glass partitions shall also be provided.

- **ROOFING :**

  The roof of Turbine buildings shall be cast in situ RCC (with water proofing and required thermal insulation as per specifications) over Steel Deck Span Sheets, unless specifically approved by the Engineer. The roof of Turbine Buildings shall be laid over steel roof trusses and purlins. The roof shall be made without any internal support from slab below in order to avoid any interference in work being carried below the roof.

  The floors & roofs for Electrical Bay, Annex Portion of Turbine Building, PCB and AB shall be cast in situ RCC (with water proofing and required thermal insulation on roofs) .

- **PLASTERING : On masonry works**

  A)EXTERNAL: 20 mm thick rough cast plaster / sand faced plaster wherever masonry is used for cladding and as approved by purchaser.
  B) INTERNAL: 15 mm thick cement mortar

- **FLOORING :**

  40 mm thick Hardonate flooring in cement concrete 1: 1.5: 3 or alternative flooring or as functionally required & approved by the purchaser.

  The areas used for handling the chemicals and battery rooms shall be provided with acid & alkali resistant lining .

  In case, if specific flooring requirements are specified in other sections of the tender the same shall be followed unless otherwise agreed by the engineer.

- **WATER STOP :**

  PVC type as required & approved by the purchaser.

- **WATER PROOFING:**

  FOR ROOF :

  Spray Applied 2 component Polyurethene Membrane as per specifications on all RCC roofs . Wherever required, proper thermal insulation shall also be provided .

  FOR BASMENT / TUNNELS/ TRENCHES /SUMPS:.

PVC Membrane as per the technical specifications. PVC membrane shall also be provided all around CEP foundation external surfaces.

❖ **PAINTING**

A) INSIDE SURFACE :
On masanory walls upto 2 m height 250 micron thick epoxy paint & for balance height acrylic emulsion paint of shade to be approved by purchaser.

B) OUTSIDE SURFACE:
Anti-Carbonation, Anti-Corrosive and Waterproof Coating on plastered/ concrete surface of shade as approved by the purchaser.

C) STEEL STRUCTURE:
Epoxy paint as specified in clause 19.18.5.5, unless specified otherwise.

D) FLOOR :
1200micron thick Self-Leveling Epoxy coating on Turbine operating floor. On all other floors except for Turbine operating floor, 500 micron thick epoxy paint shall be used.

In areas where any other specific type of flooring like Acid Alkali Resistant Lining etc (other than Hardonate flooring) is specified, epoxy coating need not be provided.

E) FIRE PROOFING OF STEEL STRUCTURE:
Using Intumescent Paint for desired fire rating or encasing in concrete as specified in the drawing and approved by the Engineer.

❖ **DOORS/ WINDOWS :**

Anodised aluminum doors / steel rolling shutters and anodised aluminum windows as approved by the purchaser .Wherever required, fireproof doors shall also be provided of adequate fire rating.

❖ The false ceiling shall be provided, wherever specified in the tender (inclusive of other sections).

1.12 GENERAL & ARCHITECTURAL REQUIREMENTS

1.12.1 *Grade of concrete*

All the cement concrete works involved in the Turbine Building& other associated structures shall meet the requirements for relevant IS standards.

Grade of concrete shall be M35 for sub-structure and for super-structure. The RCPT value of the concrete used for the construction shall not be more than 2000 columbs at 56 days.

1.12.2 *Types of cement*

The cement shall be OPC 43 grade confirming to IS 8112 or OPC 53grade confirming to IS 12269 as well as the additional requirements of technical specifications . To meet the durability requirement, mineral admixture like flyash may be used with proper mix proportioning . The quality of fly ash shall meet the relevant technical specifications.

1.12.3 *Reinforcement*

The reinforcement shall be HYSD TMT bars of grade Fe 500 as well as the additional requirements of relevant technical specifications shall be used.

1.12.4 *General Architectural Requirements*

Powder coated aluminum panel of minimum 0.5mm thick lined ceiling (closed type pattern) fixed to R.C. beams shall be provided for all air-conditioned areas. The illumination and duct grills in these areas shall match the overall aesthetics.

All the buildings shall be provided with minimum 1.0m wide concrete paving all round as plinth protection. Paving shall be slopped outward to provide a rapid run off rainwater away from building.

Doors, windows and rolling shutters on external walls of buildings shall be provided with sunshade with side projections .Sunshade from walls shall be minimum 750 mm over windows & doors and 1500 mm over rolling shutters.

All stairs shall have a maximum riser height of 175mm and a minimum thread width of 250mm with Aluminum nosing. Minimum width of stairs of in all building shall be 1200mm.

Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 3.0m and number of riser shall not exceed 12 for a single flight.

Hand railing minimum 1100mm high shall be provided around all floors/roof openings, projections, balconies, walkways, platforms, etc. ***All hand rails, toe guard, balustrades, vertical posts& horizontal rails of RCC staircases connecting the floors& railings around openings in RCC floors shall be of Stainless steel*** . Other hand rails shall be 32mm nominal bores MS medium quality pipes and shall be coated with 2 coats of high build epoxy paints with suitable primer. Vertical spacing of landings shall not exceed 1.5m center to center. Minimum 2 numbers 32NB GI pipe shall be provided for horizontal rails and toe guard shall be provided. All rungs for ladder shall also be coated with 2 coats of high build epoxy paints with suitable primer as per specifications.

All steel platforms above grade shall be constructed with 150 wide kick plates at edge of platform to prevent tools or materials from falling off platform.

Doors shall be provided at appropriate location to prevent dust ingress from outside.

Rolling shutter size and its operating system shall be decided based on the equipment handling for erection and maintenance with a side clearance.

All windows/louvers shall be of anodized aluminum .

External cage ladder shall be provided for access to Turbine building roof. Internal cage ladder 2 nos. shall be provided to access crane walkway .

All the edge protection angles shall be coated with 2 coats of high build epoxy paints with suitable primer.

1.12.5 *Glazing*

Glazing partition wall shall be provided in areas wherever required and as approved by the Engineer.

Glazing shall be in double toughened glass with glass of minimum 6mm thickness for effective thermal insulation. Vision panel shall be minimum 4mm thick.

Windows & ventilators located on external walls above operating floors levels and those located in fire prone areas shall be provided with wired glass of minimum 6mm thickness. Windows in other areas shall be finished with 6mm thick clear glass.

1.12.6 *Flooring*

The nominal total thickness of floor finish shall be 40mm. The areas used for handing of chemicals shall be provided with Acid & Alkali resistant Lining. Wherever, special type of flooring is required due to functional requirements or mentioned in other sections, the same shall be provided.

Skirting shall match with floor finish.

1.12.7 *Roof Drainage System*

A system shall be provided for removal of water from roof surface to avoid damage to the roof structure of all buildings and shall consist of the following:

Roof Drain Heads
Rainwater down comers
Fixtures

IS:1742 code of practice for buildings drainage shall be followed for this purpose.

Multiple drains (min.2nos.) shall be provided for all roof areas. System will be designed to handle rainfall at a rate of 125mm per hour and in accordance with

stipulations of IS:1742

Roof drains will be connected to main roof drain arrangement as given in Drawing No. GHAVP-1&2/15200/5001/GA and Drawing No. GHAVP-1&2/15200/5002/GA.

1.12.8 ***Plant Drain, Surface Drain & Sewer Line:***

Construction shall be done as per the system engineered by Purchaser as specified in clause 1.6.7 above . Wherever additional lines are to be laid to connect the system engineered by Purchaser, shall be designed and constructed by Bidder.

1.12.9 ***External Painting***

The building shall be provided with paint on external surface matching with the plant aesthetics as specified in clause 1.11 above.

1.13 LAYOUT

Only two main centre lines and one permanent bench mark would be furnished and all other lay out, fixing levels etc. shall be done by the Contractor at his own cost. The Contractor shall protect and maintain, during the course of execution of the work, the main centre lines and bench marks, so that they are left undisturbed even after completion of his work.

1.14 ACTIVITY SCHEDULE

The successful bidder has to prepare the detailed schedule and construction procedures for all major activities and submit the same for approval before commencement of work.

The work shall commence and completed in accordance with the Construction Schedule specified elsewhere. The various phases of work shall be completed within the periods as specified in the approved construction schedule, to be submitted by the bidder. The total completion period for this contract will be as given in the tender notice attached with this tender document.

2. DESIGN SPECIFICATIONS

2.1 PROJECT SITE FEATURES

2.1.1. LOCAL GEOLOGY

Seven Boreholes BH103, RBH-104,RBH-109, BH-110, RBH-111, BH-115 and BH-116 were drilled covering Turbine Building-1.

Seven Boreholes BH105, RBH-112, BH-113, BH-106, RBH-114, BH-117 and RBH-118 were drilled covering Turbine Building-2.

Boreholes RBH-107 & RBH -108 covers Transformer Yard of both the units.

The soil samples from these boreholes have been tested . The location of bore holes & relevant data are enclosed in Annexure-1.

Subsurface profile at Turbine building -1 & 2 areas generally consists of alluvial deposits for full depth of exploration. Alluvium soils, consisting mostly of clayey silt and silty sand, were encountered from the ground surface in the boreholes. Based on Standard Penetration Tests (SPT) conducted in this layer, consistencies of the cohesive soil (clayey silt) ranged between medium stiff to hard Clay Silt, while relative densities of the granular soil (silty sand) derived from SPT values, ranged between Medium dense to Dense silty sand. Boreholes were terminated in this layer at depths between 51.6m and 54.0m below existing ground surface and details are given in the Annexure - 1.Groundwater level was observed at depths between 2.3 m and 3.0 m below existing ground surface in the boreholes.

2.1.2. SITE GRADING

The site selected for general layout of Turbine Building and other associated structure are located in a relatively flat terrain. This area will be excavated and ground improvement will be carried out by the Purchaser up to the levels as indicated in drawing No GHAVP 1&2-/16000/2003 &2004 /DD. However, on completion of construction, this area will have to be graded to Finished Grade Level of RL 219.3 m. i.e. EL 99.7 M and the same is included within the scope of this tender.

The finished floor level of all the structures is fixed at EL 100 000 i.e RL 219.6 M . The site will be graded to EL 99700.

2.1.3. SEISMIC, SAFETY, QUALITY & DESIGN CLASSIFICATION

The site lies in Zone-III, as per the zoning map of India [IS-1893-2002, Part-1]. The structures within the scope of this tender are seismically classified category 3, safety class NINS (Not important from Nuclear Safety) & Design Class DC-4(Non Safety class structure.

2.1.4. METEOROLOGICAL CONDITIONS

Following meteorological data should be considered for design.

a) Annual average Rainfall: 450 mm
Maximum Intensity /Hr for 1 Hr duration: 125 mm/hr
(for design of roof drainage)

b) Wind pressures : Following wind speed shall be followed in the design.

Height	V_b	k_1 values for	Values of	3-sec averaged extreme wind

(m)	(m/s)	different return periods						speed for different return periods			
		50	100	1000	10000	k_2	k_3	50	100	1000	10000
10	47	1.00	1.07	1.35	1.63	0.99	1.00	46.5	49.8	62.8	75.8
20	47	1.00	1.07	1.35	1.63	1.06	1.00	49.8	53.3	67.3	81.2
30	47	1.00	1.07	1.35	1.63	1.09	1.00	51.2	54.8	69.2	83.5
40	47	1.00	1.07	1.35	1.63	1.12	1.00	52.6	56.3	71.1	85.8
50	47	1.00	1.07	1.35	1.63	1.14	1.00	53.6	57.3	72.3	87.3
60	47	1.00	1.07	1.35	1.63	1.15	1.00	54.1	57.8	73.0	88.1
70	47	1.00	1.07	1.35	1.63	1.16	1.00	54.5	58.3	73.6	88.9
80	47	1.00	1.07	1.35	1.63	1.18	1.00	55.5	59.3	74.9	90.4
90	47	1.00	1.07	1.35	1.63	1.19	1.00	55.9	59.8	75.5	91.2
100	47	1.00	1.07	1.35	1.63	1.20	1.00	56.4	60.3	76.1	91.9

Note: (i) Design wind speed obtained by multiplying basic wind speed by different factors of k_1, k_2 and k_3; and (ii) Values of k_2 at different heights are computed under assumption of terrain category 1, Class C

c) Max Dry Bulb Temp : 50.8 ^{0} C (1000 year return period)
d) minimum Dry Bulb temp : -6.9 ^{0} C (1000 year return period)
e) Relative Humidity
i) Max. during monsoon : 100%
ii) Min. during Dec to Jan : 5%

2.2 DESIGN

The design of the structures (unless specified otherwise) given in clause 1.6 &1.7 is in the scope of the Bidder. The design of the structures shall be done by the Bidder or his design consultant as approved by the purchaser .**The designer should have experience to design of similar structures i.e minimum one Turbine Building with Turbo generator Foundation of a power plant of minimum 500 MWe capacity of any Nuclear or Thermal Power Plant in soil sites**. ***The designer shall be acceptable & approved by the purchaser. The credentials of Designer shall also be provided along with technical bid.***

The bidder has to follow the procedure for preparation and approval of design documents given in flow chart as Annexure-2 of this tender.

2.2.1 PROOF CONSULTANT

The successful bidder shall appoint a proof consultant(s) with the approval of the purchaser for independent checking of the analysis, design and drawing works carried out by the bidder or his design consultant. The bidder shall provide the names of his prospective design consultants (if appointed) and proof consultants along with his bid.

It is preferred that proof checking consultants are from institutions like IIT's or

any other premier organizations / experienced professionals. The proof consultant shall have experience of analysis & design of machine foundation & framed structures. The proof consultant shall be acceptable & approved by the purchaser. The credentials of Consultant (if appointed) & Proof consultant shall also be provided along with technical bid.

All design related deliverables by bidder shall bear the certification by proof check consultant regarding conformance to codal provisions and technical specifications.

2.2.2 GUARANTEE FOR DESIGN

The bidder shall furnish guarantee against fault in the design (even though it might have been accepted by the Purchaser)of the structures covered under his scope of work. Further he shall also carry out at his cost all necessary rectification/improvements in the design of structures covered under the contract so as to make good any inadequacy arising out of above factors. The approval of Purchaser does not absolve the bidder from the overall responsibility of satisfactory performance of design & construction of the works within his scope.

2.3 DESIGN PARAMETERS AND METHODOLOGY

The following design parameters and methodology shall be followed for structural/civil engineering design of Turbine building and other structures within this contract. ***The fundamental principle controlling the design and construction of all the structures is to ensure that functional performance is maintained at all times upto earthquake level of zone III of IS 1893 and structural integrity against collapse is also to be maintained under the extreme loading including Safe Shutdown Earthquake condition*** to ensure safety of the adjacent safety related buildings viz. Control Building, SAB etc.
In principle this shall be achieved through a combination of using the best quality control standards for material and workmanship during construction and designing for all severe load combinations, whilst imparting a high level of redundancy within the structural system.

2.3.1 DESIGN PARAMETERS

2.3.1.1 SAFE BEARING CAPACITY, FOUNDING LEVEL & OTHER GEOTECHNICAL PARAMETERS:

The safe bearing capacity at founding level of any structure shall be computed based on standard codal approach/ practices considering the geotechnical parameters of the influence zone, based on dimension of structure and maximum intensity of pressure. For finalization of influence zone, the soil profile up to a depth, where net increase in vertical pressure becomes less than 10% of the initial overburden pressure from founding level of the structure shall be considered in the analysis.

The various geotechnical parameters to be considered for evaluation of engineering parameters are given in Annexure 1.

The geotechnical parameters given in Annexure-1, are evaluated based on bore hole data obtained on original ground prior to excavation. Subsequently, the ground improvement is carried out to mitigate liquefaction, in varying depth below the founding level using Soil Cement mix. Therefore the properties of the improved soil as given Annexure-1A shall be considered instead of soil properties for the relevant improved portion of ground.

The foundation of all major equipments of transformer yard (SUT, UT, GT etc.) & oil separation pit, CCW Inlet & hot water tunnel, PCB & Electrical bay, Turbine Building and Turbo-generator etc. shall be taken from EL 95.4 or below, unless required otherwise functionally or approved by the engineer. All other tunnel / trenches may be engineered & founded on PCC / Soil Cement mix, unless approved otherwise and as accepted by the Engineer.

2.3.1.2 MODULUS OF SUBGRADE REACTION :

The value of subgrade reaction for both static and dynamic analysis shall be worked out as per detailed soil structure analysis using ABAQUS or equivalent software. The detailed approach for the same is given in clause 2.4 below.

2.3.1.3 GROUND WATER

From the recording of ground water table observed in various bore holes during site investigation, it has been established that the bore holes and trial pit water level variation within the main plant area is quite erratic. The ground water table varies from 0m to 3m from the existing ground level. The Coefficient of permeability based on pump-out test is 1.2 x 10-5 m/sec. This value is recommended for the design of dewatering system in this area. The design, operation & maintinance of dewatering system for the TI package area is in the scope of NPCIL. The details of the same will be provided to the successful bidder. The bidder has to schedule his work plan in coordination with dewatering contractor engaged by NPCIL. However, if any water accumulates within the building same shall be dewatered by the bidder at his own cost.

As the foundations are below the ground water table, de-watering will be required during construction. Suitable de-watering system will be adopted during construction stage to maintain the water level 1 m below the founding level. All the foundations, retaining walls etc. will be designed taking into account worst conditions of ground water hydrostatic pressure. As per the current practice for design and stability check purpose, ground water level will be taken upto finished grade level/EL 95.4M as approved by the engineer. The structural integrity of the basement raft and walls shall be ensured by designing them for full hydrostatic head upto ground level/ EL 95.4M as approved by the engineer.

2.3.1.4 EARTHQUAKE INDUCED LIQUEFACTION

The phenomena of Landslides, Collapse, Subsidence and Liquefaction depend on the nature of ground and prevailing sub-soil water conditions. The soil is found to be susceptible for Liquefaction and same is being treated upto the expected founding level of structures as indicated in the Drawing No GHAVP-1&2/16000/2003 &2004/DD by the purchaser.

2.3.1.5 LOADS & LOAD COMBINATIONS

The following loads shall be considered in their worse combinations as appropriate for the design of the Turbine Buildings, Ventilation Buildings, Electrical Bay, Pipe & Cable Bridge , Transformer Yard area& CCW Tunnels etc

a) Dead Loads (D)

Dead loads comprise of the self-weight of all permanent construction, including walls, floors, roofs, ceilings, columns, stairways, cable shafts and fixed service equipments. While estimating dead loads for the purpose of design, the unit weight specified in IS: 875 Part-1 shall be used.

b) Equipment Loads (EL)

The buildings shall house a number of equipment on various floors. The loads from these equipments shall be specified as per vendor details.

c) Live Loads (L)

Live loads on floors shall be considered as per the following sub-sections:

d) Uniformly distributed loads

The uniformly distributed live loads assumed shall be the highest values likely to be produced. The uniformly distributed loads are static loads on the plan area and provide for normal effects of impact but do not take into consideration special concentrated loads, which are been dealt below.

e) Concentrated loads

Except for offices, toilet blocks etc. all floor slabs, secondary beams and girders etc. (other than the operating platforms near the equipments) shall be designed for a concentrated load of 10000 N acting simultaneously with the uniform live load as given in (i) to take care of any unforeseen exigent loads. This load shall be assumed to act at points so as to result in maximum moment and/or maximum shear. However, this load shall not be considered concurrently along with any actual concentrated load given to be carried over to the main beams, columns and foundations. For floor slabs, unless otherwise specified, this load shall be assumed to act as distributed uniformly over an area of 750mm square and shall be located so as to produce the maximum

stress condition in the floor slab.

f) Live load on roof (LR)

Live load on roof shall be considered, as the roof is provided with access. The following provisions as per BIS 875 Part-2 shall be followed. The minimum live load on roof that shall be considered for design is 1500 N/sq m. but not less than 3750N uniformly distributed over any span of one meter width of roof slab or 9000N uniformly distributed over the span in the case of beams or truss or wall.

g) Loads on purlins supporting the RCC roof

Every purlin shall be designed to carry the more severe of the two loads indicated below:

- The loads transmitted to the member RCC roof in accordance with (f) and
- An incidental concentrated load of 10000N placed at the most unfavorable position on the member.

h) Loading on handrails, parapets etc

Stairway railings, hand rails, parapets and balustrades, both exterior and interior shall be designed to resist horizontal thrust of 750 N/m applied at the top of the railing.

i) Loads due to impact and vibration

Structures carrying live loads, which induce impact or vibration, shall be designed for increased live load as follows:

Structures	**Min. Impact Factor**	**R e f e r e n c e**
a) For light machinery, shaft or motor units.	20%	BIS:875
b) For reciprocating machinery or power units.	50%	BIS:875
c)Transformer roller loads	10%	Assumed
d)Truck wheel load	30%	Assumed

Impact and vibration load for gantry girders, monorails etc

For crane gantry girders and supporting columns, the following allowances shall be deemed to cover all forces set up by vibration, shock from slipping of slings, kinetic action of acceleration and retardation and impact of wheel loads –

Type of load	Additional load
a) Vertical loads for electrical overhead crane (EOT)/monorails	25% of maximum static wheel loads.
b) Vertical loads for hand operated cranes/monorails (HOT)	10% of maximum wheel loads.
c) Horizontal forces transverse to the rails for electric overhead cranes.	5% of weight of the crab and the weight lifted on the crane.
d) Horizontal forces along the rails for EOT cranes.	5% of the static wheel loads.

The horizontal forces specified in (c) & (d) shall be considered as acting at the rail level.

For monorails no horizontal surge shall be considered.

j) Construction Live Load (CL)

These are the superimposed loads, which may come on a member during construction or after construction as erection loads.

k) Soil/Earth Pressure (Sp)

Turbine building with C.W. Pit basement walls shall be subjected to lateral earth pressure for the portion where sides of the wall are back-filled. The walls shall be subjected to earth pressure at rest derived as per standard formulae.

l) Hydrostatic Pressure (F2)

The basement walls shall be designed considering the subsurface water pressure rising up to finished grade level/ El 95.4m, as approved by the engineer , under normal and severe environmental load combinations including Earthquake. Computation shall be based on the buoyant unit weight of the soil plus full hydrostatic pressure. The value of δ shall be taken as half the value of δ for dry backfill. The full upward pressure of water below basement floors shall be taken over the entire area.

m) Rain Loads (RL)

Design maximum intensity of rainfall for the roof is 125 mm/hr. The flat roofs shall be designed to sustain the load of rainwater that could accumulate on it during any unlikely event of roof drain blockage. The maximum accumulated height of water shall be assumed as 300mm over roof drain and 150mm over roof slab. Rain load and live load on roof shall not be considered to act simultaneously and more critical of the two shall be adopted in the design.

n) Wind Loads (WC)

The design wind speed (Vz) shall be computed in accordance with BIS:875 (Part-3).

The relevant normal loadings to be considered in combination with wind load as stated above shall comprise of the full dead load and the reduced percentage of live loads as applicable, together with live loads on roof. For structural design 100 year return period of wind shall be considered.

o) Seismic Loads (EO/ES)

Since no safety related systems are located in turbine building and other associated structures, but due to provision of MSIV on PCB, the seismic classification has been kept as NINS and structure design is to be done as per codal provisions of IS 1893.However, the structural integrity against collapse is also to be maintained for all the structures under the extreme loading (SSE) condition to ensure safety of the adjacent safety related buildings viz. Control Building, SAB etc.

The elements of the structures shall be checked considering the SRSS values of responses due to all the three ground motions acting concurrently.

At GHAVP- 1&2 site, in SSE condition the digital value of Response spectra is given in Annexure-3 corresponds to the peak free field ground acceleration .

The relevant normal loadings to be considered in combination with seismic load (SSE) shall comprise of the full dead load and the following percentages of live loads:

Load Class	Percentage of Design Live Load
Staircase & balconies	25%
Uniformly distributed live loads 4000 N/sq.m. and above	50%

Under earthquake conditions the structure shall be assumed as loaded with the above-reduced percentages of live loads and the roof with no live load . Self wt. of EOT cranes shall be considered without any lift load.

Active earth pressure distribution due to submerged backfill on the basement walls during an earthquake shall be as per the provisions of BIS:1893. Also active pressure due to uniform surcharge over backfill behind basement walls shall be obtained as per BIS:1893. For saturated earthfill, the saturated unit weight of the backfilled soil shall be adopted. For submerged earthfill, the dynamic increment in active earth pressure during earthquakes shall be found using Mononobe-Okabe formulae which has been furnished in of BIS:1893and also recommended in ASCE 4-16.

p) Crane Load:

The maximum load while lifting the test load shall be considered . However this shall

not be considered during the seismic condition.

q) Surcharge:

A suitable surcharge (Minimum 2 T/SQM) shall be considered in the design on account of movement of equipment, traffic, stacking of material , crane etc on the ground adjacent to structures .

r) Internal Pressure (In case of Pressure Tunnels)

The internal water pressure in the tunnels including the surge & shut off condition shall be considered in the design appropriately as specified in Section C-2-5.

***s)* Any Other Load:**

As applicable the load due to temperature, creep, shrinkage etc shall be considered in the design following the relevant codal provisions.

t) Combination Of Loads

The turbine buildings and other structures shall be designed for worst combination of the loads specified above and any other loads as applicable. The suitability of the design shall be checked for load combinations to satisfy the Limit state of serviceability & Limit state of strength / Collapse as defined below:

i) Limit state of Serviceability :

Load combinations under this category are unfactored (or as given in Table-18 , BIS:456 for Limit State of Serviceability) and shall be used to ensure the requirements of limit state of serviceability of the structure. For CCW Tunnels relevant requirements specified in the AWWA standards and requirements specified in C-2-5 shall be met.

ii) Limit State of strength/ Collapse:

Load combinations for design under this category are factored and shall be used to ensure that no applicable limit state of failure is exceeded and stresses in the structure are well within its permissible limits . The structural elements to grouped into a number of groups and the basic loading combinations applicable to each of these groups shall be applied . The load factors applicable for the various load combinations shall be based on the combination philosophy of BIS:456, except for the Extreme Environmental load combination. No load factors of the extreme environmental load (SSE) combination has to be considered.

All loads with appropriate load combinations shall be considered to act with the corresponding load factor. The most unfavorable effect on the structural element shall be considered for design. In the load combinations, under Severe Environmental and

Extreme Environmental condition, the earthquake and the wind loads are considered not to act concurrently. Moving loads such as those of monorail hoists, EOT crane together with the loads lifted are considered only for normal load combinations. In other combinations their static load effects without the loads being lifted are to be considered. Loading effects due to truck or transformer movement are to be considered under normal load combination. Construction load shall be combined with dead load only.

For CCW Tunnels relevant requirements specified in the AWWA standards and requirements specified in C-2-5 shall be met.

2.4 Submission of design report

The analysis shall be carried out using NISA, ANSYS, ABAQUS, SAP which has been validated. The bidder shall make copies of all the analysis & design documents available to the owner in required numbers as desired by the purchaser.

2.5 ANALYSIS AND DESIGN METHODOLOGY

Prior to carrying out actual analysis, the structural analysis software needs to be validated by solving some benchmark problems.

2.5.1 Modeling of Soil Structure Interaction

2.5.1.1 Evaluation of Geotechnical Properties

Soil Structure Interaction shall be taken into account by providing suitable springs at the foundation nodes.

The following approach for soil springs calculation for raft foundation with/without pile shall be followed, unless approved otherwise by the engineer:

a. The soil profile in the site consists of two parts. The upper layer is known as improved soil consisting of soil-cement mix to mitigate the liquefaction potential. The layer below the improved layer is natural soil. The depth of excavation and soil improvement is shown in the Drawing No. GHAVP-1&2/16000/2003&2004/DD.

b. Design soil profile up to a depth where net increase in vertical pressure becomes less than 10% of the initial overburden pressure from founding level of the structure shall be considered in the analysis.
c. Geotechnical parameters of the Improved Soil and natural soil profile (below the improved soil) shall be considered are per its properties given in Annexure -1 &1A.
d. Wherever geotechnical data are not available up to required depth, worked out as per para (b) above, the geotechnical properties of the last available layer of soil shall be considered up to the required depth for which data are not available.

2.5.1.2 Evaluation of Soil Springs using above Geotechnical Properties

In case of structure supported on raft foundation or combined piled raft foundation (CPRF), evaluation of springs for soil/soil & pile shall be carried out as follows:

a. Detailed Soil –Structure-Interaction (SSI) analysis with appropriate simulation of soil-pile-structure interaction shall be carried out using ABAQUS or similar software to compute the stiffness of soil spring (i.e., for raft foundation system) and soil & pile spring (for CPRF) for both static and dynamic condition.
b. Validation report of the calculation of springs using above software shall be submitted.

Suggested approach for evaluation of static and dynamic spring by detailed Soil-Structure Interaction using ABAQUS or similar software:

I. Geometric modeling of layered soil strata shall be done, as 3D finite element of size 3LX3L where L is the longest dimension of raft/structure.
II. Boundary condition of soil layer element in lateral direction shall be considered as fixed and vertical direction free. And boundary condition of bottom elements of soil is fixed in all direction.
III. Geometric modelling of structure (including pile for CPRF) shall be carried out.
IV. Modelling of interface of soil – structure and soil-pile-structure shall be done, which requires computation of following interaction parameter:
    (a) Friction factor ($0.75\tan\phi$)
    (b) Critical/limiting shear stress $\{0.75x\ (Cu+ \sigma \tan\phi)\}$
    (c) Elastic slip

V. Perform static analysis with static modulus of elasticity, E_{static} values of soil profile under sustained load, which includes dead load, equipment load and live load. The modulus of subgrade reaction value (Kz_{static}) is estimated by dividing the induced contact pressure at typical i_{th} node of the raft with displacement of that node. The modulus of subgrade reaction thus obtained is multiplied by the contributory nodal area of that node to obtain the vertical stiffness of soil and pile spring at typical i_{th} node.
VI. Similarly dynamic analysis shall be performed using dynamic modulus of elasticity, $E_{dynamic}$ (using correction factor of $G/G_{max} = 0.4$, where G_{max} corresponds to low strain shear modulus) under sustained load plus Earthquake loading to obtain dynamic springs as $Kx_{dynamic}$, $Ky_{dynamic}$ and $Kz_{dynamic}$. The stiffness at typical i_{th} node in lateral directions is computed by dividing the induced contact shear stress in that

direction with the lateral displacement along that direction and further multiplied this value by the contributory nodal area of that node.

VII. To obtain static spring stiffness in lateral direction (x &y direction) at typical i_{th} node, following equations may be followed

$Kx_{static}=Kx_{dynamic}$ x $(Kz_{static}/Kz_{dynamic})$

$Ky_{static}=Ky_{dynamic}$ x $(Kz_{static}/Kz_{dynamic})$

2.4.1.3 Using spring values calculated by above approach further structural analysis shall be carried out using any standard Finite Element software like NISA, ANSYS, ABAQUS, and SAP etc.

2.5.2 F.E. Modelling & Design of Turbine Building, Electrical Bay, PCB, Access Bridge &Transformer Yard

The structures should be idealised as a 3D framed system. Raft, Pile(if applicable) Columns, beams and slabs should be modeled using suitable finite elements available in the structural analysis software to be used. Commercially available software for structural analysis like NISA, ANSYS, ABAQUS, SAP etc.

3D static analysis has to be done to obtain the member forces due to the static load conditions.

To obtain the member forces due to earthquake, response spectrum analysis with 3-D model of the structure has to be performed using the response spectra as per IS 1893. For collapse study under SSE , the response spectra given in Annexure -3 shall be used **.**

2.5.3 TG BLOCK

The TG block consists of top deck, columns, intermediate platforms and TG mat. Top deck supports the turbine, generator and the exciter. The columns of TG pedestal, independent columns supporting the platforms, some internal columns and pit walls are supported on the TG mat.

The design of TG block shall be based on working stress method. The permissible stresses in concrete and reinforcement shall be based on IS: 456 and IS: 2974 (part-3). In addition to functional requirement mentioned above codal requirements of IS: 2974 (Part-3) shall be satisfied. Some of the important requirements are listed below:

- The base mat shall be so dimensioned that the resultant force due to weight of the machine, the top deck, intermediate floors/platforms, columns supporting the TG deck, equipments and supporting structures resting on mat, basement walls resting on the mat etc., shall not have eccentricity with respect to the centre of gravity of the base area more than 3% of the base dimensions in the direction of the eccentricity.
- Adequate haunches shall be provided at intersections of the beams and the columns to avoid large concentration of stresses and to increase general rigidity of the frame.

- Fundamental natural frequency of the TG block in horizontal direction shall be separated by a minimum of 20% of the operating speed and fundamental natural frequency in vertical direction shall be separated by 50%.
- Minimum reinforcement for the deck beams shall be 0.25% of the sectional area at top and bottom and 0.1% of sectional area at sides.
- Allowable bearing pressure on soil/rock shall be 80% of allowable safe bearing pressure on soil
- For grouting of machine bed plates and pockets for anchor bolts, non-shrink grout shall be used.
- TG block should have adequate strength to withstand the worst combination of static, dynamic and seismic loads.
- Raft should be rigid enough to ensure fixed end conditions for the columns and prevent non-uniform settlement. If required , the Piles shall be provided under the raft.
- The natural frequency of the machine foundation system to be such as to avoid resonance at operating speed of the turbo-generator and the amplitude of displacements or any other specific criterion specified by the Turbine / Equipment Manufacturer.

2.5.4 Tunnel Trenches

The Tunnels are to be designed for the worst combination of loads considering Internal water pressure , wherever applicable (Considering Surge both positive & negative pressure & Shutoff Pressure), Earth Pressure (considering fully saturated soil conditions) , Surcharge, Seismic Loads, Loads from vehicular movement over tunnels and any other additional loads etc as applicable. The support for tunnel shall be properly modeled considering the springs or any other elements as the case may be. The suitability of design shall be checked for completely filled as well as in its empty condition etc also.

The tunnels are to be designed meeting requirements specified in IS 3370

2.5.5 SPECIFIC REQUIREMENTS

2.5.5.1 FIRE RATING & CORROSION

The Turbine building& other associated structures in the scope of this tender will have to cater the fire rating specified in Section C-1-3, unless approved otherwise. The following minimum dimensions and clear covers shall be provided.

Element	Parameter	Minimum Dimension (mm) for Resistance Period			
		1 hour	2 hour	3 hour	4 hour
Column	Side	200	300	400	450
	Cover	25	35	35	35
Load	Thickness	125	150	200	250

bearing wall	Cover	15	25	25	25
Slab	Thickness	100	125	150	175
	Cover	15	25	35	45
Beam	Width	125	200	250	275
	Cover	30	60	70	80

Note: Covers indicated relate to main reinforcing bars. Floor finishes shall be taken as part of clear cover for top reinforcement in beams and slabs . Fire rating requirements will not govern for secondary structural elements like lintels, transoms, mullions and canopies. Weld mesh shall be provided wherever cover is more than 40 mm.

2.5.5.2 EMBEDDED PARTS (EP)

These shall be designed for maximum forces arising out of Operating condition and Earthquake (codal) condition**.** It may be noted that the usage of Cinch anchors for anchoring any equipment is prohibited unless specifically permitted by the engineer. Therefore the bidder should provide adequate number of EPs for fixing the equipments and services. However, anchors less than 6 mm dia may be used to provide electrical fixtures etc.

3. CLEARING AND EARTHWORK

3.1 EARTHWORK EXCAVATION

3.1.1. GENERAL

SCOPE OF WORK :

The major excavation of site will be carried out by the Purchaser. The area after excavation up to a depth susceptible for liquefaction is improved using compacted soil- cement mix to a level as indicated in the drawing no. **GHAVP-1&2/16000/2003& 2004/DD.**

It is preferred to take up the foundation of various structures from the levels indicated in above mentioned drawing. However as per layout and structural arrangement opted by the bidder or system requirements , if the founding levels are lower than the levels specified in Drawing no GHAVP-1&2/16000/2003& 2004/DD, the ground shall be lowered by bidder using appropriate cutting tool like chisel etc which does not disturb and damage the improved soil below founding level. In case of damage the same shall be corrected by the contractor without any extra cost to Purchaser.

The above work of excavation shall be carried out as per relevant technical specifications. The contractor has also to make necessary arrangements for side protection to avoid any slippage of soil etc. at his own cost. No extra payment will be

made to remove any of slipped earth etc in the excavated area**.** The contractor is also requested to visit the site prior to quoting & satisfy himself with the actual site conditions. In case further excavation is required, the same shall be carried out as per following specifications:

A) This section covers all the excavation works to be performed under this contract which shall consist of clearing of site and excavation of all existing material of whatever nature, to the lines and grades shown on the construction drawing or as otherwise directed by the engineer. The work shall also include chiseling, loading, hauling and disposal of materials in designated spoil, stockpile areas or directly as construction materials.

B) The contractor shall also be responsible for excavation which is not specifically required for the construction of permanent structures, but incidental to the installation of temporary facilities such as site roads, approach ramps etc.

C) Slope protection and stabilization measures, which may be needed in conjunction with surface excavation work, shall be carried out as defined in other sections of these specifications by the contractor at his own cost.

D) The approval given by the Engineer during the course of execution, to the contractor's methods and equipment shall not relieve the contractor of his full responsibility for the proper and safe execution of excavations, or of liability for injuries to, or death of persons, or any other obligations under this contract. It shall also not relieve his responsibilities for the accuracy or adequacy of the plan for obtaining the desired results in the stipulated time schedule.

3.2 SUBMITTALS

A) The contractor will be required to submit along with the bid, a detailed method statement, drawings and work programme for the excavation. The method statement has to give the details on the plant and equipment proposed to be used by the contractor for excavation and haulage, blasting methods, drainage and safety precautions, disposal of material, procedures for installation of soil supporting and stabilization works, and for construction of temporary site facilities such as roads, temporary drainage lines etc.

B) After the award of work and at least 15 days prior to commencement of the actual excavation, the contractor shall submit to the Engineer an updated method statement and programme for the activities set out in (A) above giving refined and full details of the proposed excavation methods in improved ground and sequences including necessary plans for site drainage and safety precaution. Any and all variations from the corresponding data submitted with the tender will be explained and justified in the updated document to the satisfaction of the Engineer. The data shall include the following:

i) Method for excavation of improved ground
ii) Method of mucking & disposal of excavated material.

iii) Details of the equipment to be deployed with proper justification.

C) Within 7 days of receipt of the above updated excavation method statement and programme, the Engineer will advice the contractor in writing, of his acceptance of, or comments on the submitted documents. The Engineer reserves the right to reject the proposed plan, if, in his opinion, undesirable damage to improved ground or existing structures would result from the proposed excavation method. If acceptance is withheld, a new plan in whole or in part shall be submitted. Excavation shall only be carried out in areas for which the Engineer has accepted the plan.

D) At least 15 days prior to dumping and stock piling any excavation material, the contractor shall submit the layout of spoil or stock pile areas which will be within the areas designated on the tender drawings or as approved by the Engineer. All pertinent data of working methods and provisions for stability and temporary and permanent drainage of the areas shall be included. Details of volume proposed to be stored, material types, heights of storage and grades shall be provided.

E) The Contractor shall submit and agree with the Engineer a monitoring plan for the progress of the excavation as well as to observe potential or actual movement of the slopes of the excavated pit. This plan shall also give details of the procedure and equipment to be employed by the contractor to stabilize or to protect as quickly as possible any areas in which untoward movement or slope deformation is likely to occur or has occurred.

3.3 CLEARING THE SITE (IF APPLICABLE)

All the areas upon which the construction is to be carried out and over which excavation is to be done and areas which are required by the Contractor for his construction facilities are to be cleared of all rubbish, and any other objectionable matter. All spoils and unserviceable materials and rubbish shall be disposed of at locations away from the work site in a manner directed by the Engineer. Care shall be taken to see that unsuitable waste materials are disposed off in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction. Useful materials, saleable timber, firewood etc., shall be stacked properly at the work site in a manner directed by the Engineer and finally handed over to Purchaser.

3.4 LAYOUTS AND LEVELS

Under no circumstances shall the contractor remove or disturb any permanent benchmarks / reference pillars installed by Purchaser. The contractor shall carefully maintain and protect all benchmarks and reference pillars and shall layout all his works by accurate reference thereto. The layout and levels of all structures shall be made by the Contractor from the general grid of the plot and bench marks given by the Engineer. The Contractor shall make his own surveying arrangements for laying out and establishing the reduced levels based on two reference grid lines and one bench mark as furnished by the Engineer and shall be responsible for the accuracy of layout and levels.

The theodolite and leveling instruments to be used by the Contractor shall be of digital type (total station). He shall also render necessary assistance to the Engineer by way of surveying instruments, materials and men for checking the layout and levels.

The ground level shall generally be taken at spacing at a grid of 5m x 5m.Where local mounds or abrupt undulations are met with or when so directed by the Engineer, the grid spacing may be at closer interval not exceeding 2m. The ground levels shall be properly recorded and plotted on plans, which shall be signed by the Contractor and the Engineer before the earthwork actually commences.

3.5 EXTENT OF EXCAVATION, LINES AND GRADES

The contractor shall perform excavation in all types of soils, murrum, soft and hard improved cement-soil mix., etc. in foundation, over areas and in trenches to widths, lines, levels, grades and curves as shown in the drawing or to lesser widths, lines and levels as directed by the Engineer.

3.6 APPLICABLE CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

a) IS-3764 - Safety Code for Excavation Work.

b) IS:9758 - Guidelines for de-watering during construction.

c) IS:10379 - Code of practice for field control of moistures and compaction of soils

d) Indian Explosives Act 1940 (Latest Version)

e) IS-2720 - Part-II - Determination of water content.

Part-VII - Determination of water content. - Dry Density Relation Using Light Compaction.

Part-VIII - Determination of Moisture content - Dry Density Relation Using Heavy Compaction.

Part-XXVIII - Determination of Dry Density of Soils, In-place, by the Sand Replacement Method.

Part XXIX - Determination of Dry density of Soils, In place, by core cutter method.

f) IS-4081 - Safety Code for Blasting and Related Drilling Operation.

g) IS-1200 - Method of Measurement of Building Works.

3.7 EARTHWORK EXCAVATION -GENERAL

Excavation shall be done to lines and levels defined in the drawings or as directed by the Engineer. The earthwork shall also include, where required temporary sheet piling or sheeting, bracing and shoring, to maintain the excavated pits, without interruptions to service lines, cables, duct banks, etc., encountered within the area of excavation or within reasonable distance of excavation.

3.7.1 LIMITS OF EXCAVATION

All excavation shall be carried out very carefully using methods and techniques that will produce smooth and sound surfaces with minimum over-break beyond the lines and grades/ limit of excavation shown in the construction drawings and will preserve the structural integrity of the excavated area. The contractor shall take all precaution to preserve in the soundest possible and undisturbed condition all materials beyond the limits of excavation. Special care shall be exercised where vertical or near vertical faces are required. Any extra excavation beyond the specified limit shall be made good by the contractor at his own cost with the class of material proposed to be laid over it or any other material approved by the Engineer.

Soft pockets, if any, shall be removed even below the final level and extra excavation shall be filled up by material which is proposed to be laid over it or any other material approved by the Engineer.

3.7.2 CLASSIFICATION OF EARTH WORK

For purposes of work to be executed in accordance with this specification, the following classification shall apply.

A) All types of soils, murrum, loose boulders of size with volume up to 1 cum, intrusions and soft rock

The excavation work shall further be categorized in the following 3 categories:

A) Excavation in General Areas & grading work up to grade level.
B) Excavation for buildings /structures foundations below grade level.
C) Excavation for Tunnel & trenches etc., below grade level

3.7.3 EXCAVATION IN SOIL

This includes earth, murrum, top deposits of agricultural soil, reclaimed soil, clay, sand or any combination thereof, soft and hard murrum, shingle etc. which is loose enough to be removed with spades, shovel, pick axes, poclain & poclain mounted rippers.

When the bottom of the excavated pit as indicated in the construction drawing is disturbed or loosened by the excavation process, the contractor shall improve it at his

own cost with the class of material proposed to be laid over it or any other material approved by the Engineer.

3.7.4 EXCAVATION IN HARD CEMENT SOIL MIX:

This includes all improved soil other than materials mentioned above, , which shall be removed only by , chiseling and wedging etc. as approved by the engineer.

3.7.5 STRIPPING BLUFFS AND LOOSE SOIL

All loose soil, not directly in the excavation but close to the area to be excavated as to be liable, (in the opinion of the Engineer), to fall or otherwise endanger the workmen, equipment, or the work etc. shall be stripped off and removed away from the areas of excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion, which was originally sound and safe. Any materials not requiring removal as contemplated in the work, but which, in the opinion of the Engineer, is likely to later become loose or unstable shall also be promptly and satisfactorily removed as directed by the Engineer.

3.7.6 APPROACH RAMPS/ROADS

The contractor shall adopt method of mucking by clamshell, dragline or conveyors. However only under exceptional circumstances where ramps are unavoidable, the Contractor may provide the same with the prior approval of the Engineer. Berms, if required at intermediate levels may be provided beyond 6-m depth with the prior approval of the Engineer. Such ramps shall be excavated later and the excavation shall be finished to the lines and grades shown on the approved drawings and to the satisfaction of the Engineer. No extra payment shall be made for formation of such berms , ramps etc. The berms , ramps falling outside the line of excavation shall be made good after the completion of work as directed by the Engineer.

3.8 STABILITY OF EXCAVATION

The methods of excavation shall, in every case be subject to the approval of the Engineer. The Contractor shall ensure the stability and safety of the excavations, adjacent structures, services and the works. The Contractor shall ascertain himself the nature of materials to be excavated and difficulties likely to be encountered in executing the excavation. Coffer dams, sheeting and shoring, bracing and maintaining suitable slopes, draining etc. shall be provided and installed by the contractor. The contractor shall submit drawings to the Engineer showing the proposed arrangement with detailed design calculations and shall obtain written approval from the Engineer. Irrespective of the approval of the Engineer, the responsibility for adequacy of such measures shall rest fully with the contractor.

If any slip occurs, the Contractor shall remove all the slipped material from the excavated pit, at his own cost. Also, if any damage to the built up structure occurs because of the slip, the Contractor shall make good the same at his own cost & to the satisfaction of the Engineer.

3.8.1 TIMBER SHORING

Timber shoring shall be as specified in IS: 3764-Safety Code for Excavation Work. Wherever the shoring is required for deep excavations, the same shall be designed by the Contractor and got approved by the Engineer prior to its use in the work

Timber shoring shall be 'Close' or 'Open' type, depending on the nature of soil and the depth of pit or trench. The type of shoring shall be as approved by the Engineer.

3.8.2 OPEN TIMBERING

In the case of open timbering, the entire surfaces of the side of trench or pit are not required to be covered. The vertical boards of minimum 25 cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangements, sizes of the timber and the spacing shall be subject to the approval of the Engineer.

3.8.3 CLOSE TIMBERING

Wherever so directed by the Engineer the contractor shall provide close timbering

3.8.4 LEFT IN SHORING

If the Engineer directs any timbering to be left in for the safety of the structure or otherwise for reasons commensurate with the type of construction, necessitating such decision, the same shall be provided by the contractor.

3.8.5 REMOVAL OF SHORING

The removal of shoring timber shall be done very carefully to prevent the collapse of the pit or trench. It shall start at one end and proceed systematically to the other end. No part of the work should be damaged during the removal of the shoring. No claim shall be entertained for any shoring, which cannot be withdrawn and is lost and buried.

3.9 ACCEPTANCE OF EXCAVATED AREA

Excavated area shall be cleaned, trimmed to exact shape and size. All disturbed material and other debris shall be removed and the surface shall be thoroughly cleaned to the satisfaction of the Engineer. A joint survey of the excavated pit shall be carried out at various stages of excavation before acceptance of the excavated area. The joint survey report duly signed by NPCIL and the contractor. Before any further work with concrete or backfill is commenced, the Contractor shall inform the

Engineer and get the area approved by him.

3.10 DISPOSAL OF SURPLUS MATERIAL

All surplus materials shall be carried away from the site and disposed at dumping site/ stock piles, in separate heaps as per the utility of the material, as directed by the Engineer. The Engineer may ask the contractor to dump the excavated materials in low lying areas, regular heaps, bunds, blankets riprap with regular slopes and level so as to provide natural drainage. As a rule, all softer material shall be laid towards the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. All such works as mentioned above are deemed to have been taken into account while quoting .

All excavated material from the pits shall be the property of the Corporation and if the Contractor wants to use it, he shall have to obtain it from the Engineer at a rate fixed by the Purchaser, until unless specified otherwise.

In no case, the excavated soil shall be stacked within a distance of 1.5 m from the edge of the excavation or 1/3rd of the excavation depth, whichever is more.

3.11 PRECIOUS OBJECT, RELICS, OBJECTS OF ANTIQUITY ETC.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or on the site shall be the property of the Corporation and contractor shall duly preserve the same to the satisfaction of the Engineer and from time to time deliver the same to such person or persons as the Engineer may from time to time authorize or appoint to receive the same.

3.12 USE OF EXCAVATED MATERIAL:

The Contractor may note that useful material excavated from the structures shall be used for backfilling. All the material suitable for backfilling shall also be stacked suitably. The excavated material used for backfilling will be available free of charge, if required the contractor has to break the bigger sized available material to the suitable size as specified in the specification, for backfilling at his own cost .

4. BACKFILLING

4.0. GROUND IMPROVEMENT /BACKFILLING USING COMPACTED SOIL / SOIL-CEMENT MIX

4.1 OBJECTIVE

The objective of this document is to lay down the specifications for Ground improvement of GHAVP-1&2 site by replacement of in-situ soil from

existing/excavated level as per drawing by well compacted in-situ soil / in-situ soil cement mix.

The bidder shall study this specification along with the other documents and input data given by NPCIL and work out the detailed working methodology for the execution of the work.

4.2 SCOPE

As per the Liquefaction studies carried out at site, the soil is found to be susceptible for liquefaction in varying depth . Based on records of water table the ground upto EL 95.40M is only susceptible for Liquefaction. Based on Purchaser's experience from earlier projects and geotechnical studies , the Ground improvement upto the depth susceptible for Liquefaction, within the battery limits of this package is carried out by the Purchaser upto the top levels as indicated in Drawing No GHAVP-1&2/16000/2003 &2004/DD.

Any area which is to be raised (including after excavation) shall follow the requirements given in Clause 1.11. The specifications given below shall be followed for backfilling .

1. Improvement of soil characteristics by mixing cement in soil at Optimum Moisture Content (OMC) corresponding to modified Proctor density (Heavy compaction) test and application of suitable roller compaction to achieve the target maximum modified Proctor density at site.

2. Improvement of soil characteristics by suitable roller compaction of soil at OMC corresponding to modified Proctor density (Heavy compaction) to achieve the target maximum modified Proctor density at site, wherever specified or specifically approved by the Engineer.

This specification covers the following aspects:

(a) Study of trial report on Ground Improvements (Compacted soil/ soil- cement mix) and liquefaction analysis by USNRC guidelines.

(b) Collection of soil samples from site for carrying out laboratory tests.

(c) Conducting laboratory tests to arrive at optimum moisture content and modified proctor's density of soil and soil cement mix samples.

(d) Carrying out grain size analysis, moisture content (for soil) and unconfined compressive strength and stability for soil cement samples.

(e) Excavating and drying soil in drying beds, mixing/batching of soil/soil cement mix in suitable batching-mixing plant, laying and spreading of soil/ soil cement mix at OMC in layers and compacting each layer by suitable vibro rollers.

(f) Conducting field tests to find out moisture content, density & SPT values for compacted soil and soil - cement mix.

(g) Determining post improvement values of cohesion & angle of internal friction of soil.

(h) Carrying out liquefaction analysis as per USNRC guidelines using the above laboratory and field test values.

(i) Maintaining batching, mixing, compaction & testing records.

NOTE

Report on field mockup - report no. GHAVP-1&2/Civil-1/10120/Report/2017/02/R2 is provided for *broad information/ general understanding purpose*. The work shall be carried out in line with the recommendations of the trial mock up. Any modification suggested by the successful bidder for optimization purpose shall be demonstrated to yield desired results by conducting additional mock up by the bidder at his own cost.

4.3 REFERENCE CODES/ DOCUMENTS

- Trial mock up Report: Report no. GHAVP-1&2/Civil-1/10120/Report/2017/02/R1
- IS 2131: Method for Standard Penetration test of Soil.
- IS: 4332- Part-1: – Method of sampling and preparation of stabilized soils for testing.
- IS: 4332- Part-2: – Determination of moisture content of stabilized soil mixtures.
- IS: 4332- Part-3: – Test for determination of moisture content- dry density relation for stabilized soil mixtures.
- IS: 4332- Part-4: – Wetting and drying, and freezing and thawing tests for compacted soil-cement mixtures.
- IS: 4332- Part-5:– Determination of unconfined compressive strength of stabilized soils.
- IS: 4332- Part-7: – Determination of cement content of cement stabilized soils.
- IS: 2720- Part-4: – Methods of test for soils; Grain size analysis.
- IS: 2720- Part-5:– Method of test for soils; Determination of Liquid and Plastic limit.
- IS 2720- Part-7: Determination of Water Content-Dry Density relation using Light Compaction.
- IS 2720- Part-8: Determination of Water Content-Dry Density relation using Heavy Compaction.

- IS 2720- Part-28: Determination of dry density of Soils In-place, by the Sand Replacement Method.
- ASTM D5778-12: Standard Test method for electronic Friction Cone &Piezocone penetration testing of Soil.
- IS 12175: – Specification for rapid moisture meter for rapid determination of water content for soil.
- IS 3764: – Excavation work- Code of Safety.
- IS: 269: Specification for 'Ordinary Portland Cement'
- IS: 456: Specifications for 'Plain and Reinforced Concrete'
- IRC SP-89: Guidelines for Soil and Granular material stabilization using cement, lime and fly ash.
- Soil-Cement Inspector's Manual by Portland cement association.
- Specifications for road and bridge works, Indian roads congress, Ministry of shipping,
- road transport & highways.

4.4 MATERIALS

Following material shall be used for the work under this specification:

1. Soil excavated from Project area.
2. Ordinary Portland cement.
3. Water

4.5 INPUTS BY NPCIL

NPCIL will provide the following documents with regard to this work:

GHAVP-1&2/Civil-1/10120/Report/2017/02/R2: Report on Field Mock-up for Ground Improvement by Replacement of Liquefiable Strata by Compacted soil/Soil-Cement Mix.

4.6 DEWATERING: The dewatering for the area will be carried out by the Purchaser through some other agency. However, if any water accumulates within the building same shall be dewatered by the bidder at his own cost.

4.7 COLLECTION OF SOIL FROM PROJECT AREA

The excavated soil from the project area shall be used for preparation of soil/ soil-cement mix. Contractor shall prepare the drying beds for facilitating natural drying of the excavated soil. The excavated soil shall be spread in the drying beds for sufficient time before using the same for preparation of compacted soil/ soil-cement mix. Soil in

drying beds shall be protected against rains through provision of suitable sheds, bunds, cut-off trenches, diversion channels, etc. and also protected during subsequent stages, i.e. transportation to batching plant, transportation to site for placement and after placement & compaction. The size and number of such drying beds shall be planned so as to meet the overall construction schedule. All efforts shall be made to minimize dust pollution during handling/ transportation/ mixing of soil/ soil-cement in mixing/ batching plant etc.

4.8 PREPARATION OF COMPACTED SOIL/ SOIL-CEMENT MIX

The methods of ground improvement to be adopted for this work i.e.

1. Compacted soil-cement mix (with 5 % of cement) in consultation with the Engineer.
2. Compacted soil.

The dried soil shall be thoroughly pulverized and taken to batching-mixing plant for preparation of compacted soil/ soil-cement mix. Mixing of soil/ soil and cement with water, as the case may be, shall be done in a mechanical mixer/batching plant. The quantity of water to be added shall be such that optimum moisture content (OMC) is achieved at the time of compaction. The capacity of batching-mixing plant shall be commensurate with the construction schedule requirements.

Tolerance on water content shall be maintained within +0.5% & -2% of OMC. Layer displaying plastic behavior in the form of bumpiness during compaction shall not be accepted & removed.

4.9 MIXING, TRANSPORTATION, PLACEMENT & COMPACTION

Automated plant with weigh batching shall be used for mixing.

The mix shall be transported to site in tippers (covered, if necessary, depending on ambient atmospheric conditions) and placed in position by conveyor belt or other appropriate means. Transit time shall not be more than 30minutes for soil-cement mix. Suitable ramps shall be prepared for entry/exit to/from excavated pit. The mix shall be placed on dry sub-base and in no case pooling of water shall be allowed at any point of time. The compaction of soil/ soil-cement mix shall be done at OMC in layers of maximum compacted thickness of 200 mm each by adequate number of passes of suitable vibratory roller so as to achieve 95% of modified proctor's density for both soil and soil-cement mix. Moisture loss from soil cement shall be minimized by either laying of subsequent layer of soil cement or curing with damp burlap (in case of break in laying of subsequent layer). Interlayer gap for soil cement mix as adopted in mockup will be adhered to. For soil cement mock-up, compaction must be finished within the Initial Setting Time and next layer shall not be laid before the final setting time.

The work shall be carried out strictly as per the recommendations of the trial mock up. Any modification suggested by the successful bidder shall be demonstrated to yield desired results by conducting additional mock up by the bidder at his own cost, however the capacity, type of vibro-roller and number of passes in mutually perpendicular directions shall meet requirement of target dry density.

4.10 LABORATORY & FIELD TESTS ON SOIL SAMPLES

4.10.1 LABORATORY TEST

The following laboratory tests shall be conducted on the soil samples as per relevant IS.

1. Grain size analysis
2. Atterberg's Limits of Soil.
3. Bulk density and dry density of soil.
4. Natural moisture content.
5. Modified Proctor density to find out maximum dry density at OMC for soil/ soil cement mix.
6. Unconfined compressive strength, stability tests and cement content (through procedural means) on soil-cement samples.
7. Organic content of soil

4.10.2 FIELD TESTS

1. Measurement of ground water table.
2. Measurement of ground Levels.
3. Standard Penetration tests (SPT) on compacted soil and compacted soil-cement. After completion of SPTs the bore hole shall be grouted with cement sand in the proportion of 1:10.
4. Measurement of in-situ Moisture content.
5. In-situ density of the compacted backfill shall be determined by any of the following three methods:

- Nuclear Method
- Sand Cone method
- Rubber-Balloon method

The contractor shall develop laboratory facility at site to carry out day-to-day testing of soil and soil-cement mix. However, for any special/ non routine laboratory tests, testing may be carried out at NPCIL approved laboratory with prior permission of the Engineer.

4.11 INSPECTION AND TESTING PLAN

The following testing frequencies shall be adopted for the work:

The soil dried in the drying beds shall be tested for grain size analysis & moisture content before mixing. The testing frequency shall be 1 test per 1000 cum. & 200 cum. respectively.

All the cement supplied shall be accompanied by manufacturer's test certificate. The cement shall be tested for Normal consistency, Compressive strength (3 days and 7 days) & Initial and final setting time for every batch/week no. subject to minimum of 1 test per 250 MT.

Sample extracted from prepared mix, before compaction shall be tested at site for OMC requirement for every 200 cum.

The soil cement mix shall be tested at the age of 3 days & 7 days for unconfined compressive strength, at the rate of one sample (consisting of three specimens) from each layer for every 2500 sqm. For the purpose of this testing, the core/ specimen shall be extracted from the compacted soil cement layer with the help of sampler immediately after compaction i.e. in green condition and removing the core from the sampler with the help of plunger.

Both soil & soil-cement mixes shall be tested for in-situ density in each layer along with moisture content. The testing frequency shall be one test per 500 sqm of each layer.

After completion of compaction of all the layers of soil, SPT shall be conducted as per the given frequency: one test per 900 m2 area for the improved portion of soil. For soil-cement mix one SPT per 9000 m2 area shall be conducted. The SPT shall be done at 1.5 M interval throughout the depth of improvement for both soil and soil-cement mix.

In case of soil-cement mix owing to high resistance to penetration (as observed during mockup), the test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, efforts shall be made to extract the core for conducting Unconfined Compressive Strength.

After completion of SPTs the bore hole shall be grouted with cement sand in the proportion of 1:10.

The consolidated recommended ITP for various activities is summarized below:

Testing frequency for soil mix		
S.No.	Type of test	Frequency of test

1	Grain Size	1 Test per 1000 cum
2	SPT	1 Test per 900 sqm
3	Moisture Content (before mixing)	1 Test per 200 cum
4	Moisture Content (after mixing before compaction)	1 Test per 200 cum (*to be staggered with S.No.3 above)
5	In-situ dry density with moisture content	1 Test per 500 sqm per layer

Testing frequency for soil-cement mix		
S.No.	Type of test	Frequency of test
1	Grain Size and Modified Proctor's Density in case of both soil and soil cement	1 Test per 1000 cum
2	Cement content of soil-cement mix	1 Test per 500 cum(Through procedural checks on cement consumption)
3	Soil cement core compressive strength	1 Test per 2500 sqm per layer (3 & 7 days)
4	Cement- Normal consistency	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
5	Cement- Compressive strength (3 days & 7 days)	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
6	Cement- Initial & Final Setting time	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
7	Moisture Content (before mixing)	1 Test per 200 cum with minimum of 1 test on each day of ground improvement
7a.	Organic matter (before mixing)	1 Test per 50000 cum
8	Moisture Content (after mixing before compaction)	1 Test per 200 cum (to be staggered with S. No. 7 above)
9	In-situ dry density with moisture content	1 Test per 500 m2 per layer
10	SPT	1 Test per 9000 m2 *
11	Stability test of soil-cement mix	1 Test per 2 lakhs cum of GI considering the grain size distribution of soil covering different soil types.
12	Multichannel Analysis of Surface Wave Studies for confirmation of uniformity in improved ground.	Two profiles covering the entire area of improved ground for every 10000 m2 after laying all the layers.

* In case of high resistance to penetration (as observed during mockup), the test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, efforts will be made to extract the core for conducting Unconfined Compressive Strength.

4.12 RECORDS

Records shall be kept for procurement, production, compaction and post compaction and testing activities. The following records shall be maintained by contractor and submitted to NPCIL:

1. Test certificates of cement.
2. Testing records of soil & cement.
3. Batching/ mixing records.
4. Testing records on soil & soil-cement mix.
5. Field records on placement & compaction at site.
6. Testing records connected with post compaction testing

4.13 SUPERVISION & QUALITY ASSURANCE

During the entire process of works under this specification, independent qualified QA inspectors shall be deployed by the contractor. Contracting agency shall make all the arrangements for testing and inspection by NPCIL.

A detailed work procedure with resources deployment and cycle time calculations shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work.

4.14 ACCEPTANCE CRITERIA

The target minimum in-situ dry density of compacted soil/ soil-cement layers shall be 1.8 gm/cc as one of the acceptance criteria to be met during compaction. This is on the basis of densities achieved during the mockup.

For soil-cement method of ground improvement, 7 days UCS of samples casted at mixing plant shall be controlled. SPT will be conducted however, in case of high resistance to penetration, the SPT test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, the core shall be extracted for conducting Unconfined Compressive Strength as a quality control measure for variability

Contractor may optimize the type of equipment (roller type) and number of passes to achieve and demonstrate meeting the acceptance criteria as per ITP mentioned above by conducting mockup.

5. **DEWATERING :** The dewatering for the area will be carried out by the Purchaser through some other agency.

6. CONCRETE

6.1 SCOPE

a) This specification covers all the aspects of concrete production like procurement of ingredients, storing, proportioning, mixing, placing, vibrating and curing of plain, reinforced, pre-stressed and pre-cast concrete etc. This specification broadly covers: -

i) Requirements for source-qualification, procurement, batch qualification testing and storage of concrete ingredients.

ii) Requirements for proportioning of concrete mix, batching, mixing, Transportation, sampling, testing and acceptance of concrete of specified grades.

iii) Requirements for preparation and placement of concrete including chilling, conveying, depositing, compaction, curing, finishing, inspection, testing and preparation of construction joints and repairing, if needed.

b) Wherever information shown is in contradiction to the contents of this specification, all information pertaining to plain, reinforced, pre-stressed and pre-cast concrete shown and noted on the drawings shall be considered part of this specification and shall supersede this specification.

c) During concrete mix proportioning, it may be required, in consultation with the Engineer, to include pozzolanic material (fly ash, micro silica, GGBS etc.) either individually or in combination, to meet the specified requirement of strength and durability. Special provisions with regard to allowable limits of these pozzolanic materials, effect on properties of concrete, durability requirements of concrete have been highlighted. To achieve high level of mechanization in concrete production and placement, special requirements for batching plant, concrete pumping equipment, field practices etc. have also been highlighted.

6.2 QUALIFICATIONS AND APPROVAL OF SOURCES

All materials required for the manufacture of concrete and used for curing of concrete shall be procured only from approved sources. Such approvals shall be given by the Engineer only after due evaluation of tests and test certificates and also after further sampling and testing the materials as per relevant specifications by the contractor. It is the responsibility of the contractor to carry out investigations and evaluation of sources of material for pre-qualification. The contractor shall also ensure that at least two sources of each material are pre-qualified for ensuring uninterrupted supply of material. Bulk procurement of the ingredients of the concrete shall be made only after the contractor has completed the process of pre-qualification and the Engineer has

duly approved the sources/ products. The approval of the Engineer does not, however, absolve the contractor of his responsibility for the quality and consistent supply of the materials.

6.3 STANDARDS AND SPECIFICATIONS

The provisions of the latest revisions with amendments, if any, of the following Indian Standards and other relevant codes shall form part of this specification to the extent they are relevant. Where the provisions of these Standards/Codes are in conflict with the stipulations of this specification, the specification supersedes the respective Standard or Codes.

6.3.1 BUREAU OF INDIAN STANDARDS

IS – 383	Specification for coarse and fine Aggregates from natural sources for concrete.
IS – 456	Plain and reinforced concrete – code of practice
IS – 460	Specification for Test Sieves (Part I, II & III).
IS – 516	Methods of Tests for strength of concrete.
IS – 1199	Methods of sampling and Analysis of concrete.
IS – 1343	Pre-stressed Concrete - Code of practice
IS – 1727	Methods of test for pozzolanic materials.
IS – 1791	General requirements for batch type concrete mixers
IS – 2386	Methods of Test for Aggregates for concrete. (Part I to VIII)
IS – 2395 Part I & II	Painting of concrete, masonry and plaster surfaces - Code of practice.
IS – 2430	Methods of sampling of aggregates for concrete.
IS – 2505	Concrete vibrators – immersion type. - General requirements
IS – 2506	General requirements for concrete vibrators, screed board type.
IS – 2514	Specification for Concrete vibrating Tables.
IS – 2645	Integral Waterproofing Compounds for Cement Mortar and Concrete – Specification.
IS – 2722	Specification for portable swing weigh batchers for concrete. (Single & Double bucket type).
IS –3025	Methods of sampling and test (Physical and Chemical) for water and waste water (Part 1 to63)
IS – 3085	Method of test for permeability of cement mortar & concrete.
IS – 3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS-3812 (Part-I)	Pulverized Fuel Ash – Specification: For use as Pozzolana in Cement, Cement Mortar and Concrete.
IS – 4031	Methods of physical tests for hydraulic cement (Part 1

	to 15).
IS – 4032	Method of chemical analysis of hydraulic cement.
IS – 4082	Stacking and storage of construction materials and components at Site - Recommendations.

IS – 4634	Batch type concrete mixers - method of test performance of.
IS – 4845	Definitions and terminology relating to hydraulic cement.
IS – 4925	Concrete batching and mixing plant: specification
IS – 5816	Splitting Tensile Strength of Concrete – Method of Test.
IS – 5892	Concrete transit mixers - specification
IS – 6461	Glossary of terms relating to cement concrete (Part-1 to 12)
IS – 7320	Specification for Concrete slump test apparatus.
IS – 7325	Specification for Apparatus for determining constituents of fresh concrete.
IS – 7861	Code of practice for Extreme weather concreting (Part 1 & Part 2).
IS – 8112	Specification for 43-grade ordinary Portland cement.
IS – 8142	Method of test for determining setting time of concrete by penetration resistance.
IS - 9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS – 9103	Concrete Admixtures – Specification
IS – 10262	Concrete mix proportioning - Guidelines.
IS – 12089	Specification for granulated slag for manufacture of Portland slag cement.
IS – 12269	Ordinary Portland cement 53-grade - Specification.
IS – 12600	Portland cement low heat - Specification.
IS – 14687	Falsework for concrete structures – guidelines.
IS –14959 (Part-I)	Determination of Water Soluble and Acid Soluble Chlorides in Mortar and Concrete (Fresh mortar and concrete).
IS- 15388	Silica fume- Specification
SP-23	Handbook on Concrete Mixes.

6.3.2 ASTM STANDARDS

ASTM C-33	Standard Specification for Concrete Aggregates.
ASTM C-94	Standard Specification for Ready Mixed Concrete
ASTM C-295	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C-494	Standard Specification for chemical admixtures for concrete.
ASTM C–1202	Standard Test method for electrical indication of concrete's ability to resist chloride ion penetration.
ASTM C-1240	Standard Specification for silica fume used in cementitious mixtures.

ASTM C–1260	Standard test method for Potential Alkali Reactivity of Aggregates (Mortar - Bar Method)
ASTM D–75	Standard practice for Sampling Aggregates
ASTM D–1411	Standard Test methods for Water - Soluble chlorides present as admixtures in graded aggregate road mixes.

6.3.3 ACI / ASME CODES AND SPECIFICATIONS

ACI 211.1	Standard Practice for selecting proportions for normal, Heavy Weight and mass concrete.
ACI 304.1R.	Guide for the use of Preplaced Aggregate Concrete for Structural and Mass concrete Applications.
ACI 304.2R	Placing Concrete by Pumping Methods.
ACI 318	Building code requirements for structural concrete and commentary.
ACI 349	Code requirements for Nuclear safety - related concrete structures
ASME Sec-III Division-2	Code for Concrete Containments

6.3.4 OTHER STANDARDS

a) Railway Specifications – Tests for chloride and sulphate content of aggregates.

b) The European guidelines for Self-Compacting Concrete – Specification, Production and Use (EFNARC Publication).

c) DIN-1048 Specification for water permeability of concrete.

d) Concrete library of JSCE No. 36 – Recommendations for construction of concrete containing ash as a mineral admixture

e) JSCE Concrete engineering series 31- Recommendation for self-compacting concrete

f) BS6699- Specifications for Ground Granulated Blast Furnace Slag for use with Portland cement

6.4 STORAGE OF MATERIALS

a) The contractor shall make necessary arrangements, for safe storage and ensure prevention against deterioration of the materials. Cement, fly ash, GGBS, micro silica, super plasticizers, admixtures, retarders etc. shall, invariably, be stored in weather proof sheds of adequate capacity for storage of the material for at least 3 weeks' of work. However, the contractor shall ensure that sufficient quantities of all materials are available for uninterrupted progress of the work. Cement and other construction materials shall be stored as per recommendations of Indian Standards and as per manufacturer's recommendation. Storage silos shall be watertight. In the

storage area, proper access and lighting shall be provided for inspection, identification and drawl of material. The material shall be stored batch wise with proper identification tag, indicating the quantity received, batch number and the date of receipt and issue. The consignments shall be used in the order of receipt at site, unless otherwise directed. In case of large concrete pours, the material to be used shall be identified and procured well in advance, taking the quantity required for a particular concrete pour into consideration. The cement shall be used within three months from the date of manufacture. However, in exceptional circumstances, if approved by the Engineer, the above stipulation may be relaxed subject to the condition that the material shall be retested to ensure the conformity with the technical specifications. Normally, materials of different type or grade shall not be stored in the same godown. If materials of different type or different grade are stored in the same place, it shall be clearly demarcated and separated to avoid intermixing.

b) The contractor shall prepare an elaborate procedure for the periodic inspection and testing of the materials to detect any deterioration and also for segregation of the deteriorated material. The above procedure shall be approved by the Engineer and implemented by the contractor. It is the responsibility of the contractor to provide all samples and other facilities to the Engineer for carrying out inspection and testing of materials both at the source and at the site of work at his own cost. The rejected materials shall be removed from the site within 48 hours. If the contractor fails to remove the rejected material within 48 hours, the right to get the materials removed from the site rests with the Engineer and all the expenditure incurred by the Engineer for such removal shall be borne by the Contractor.

c) Coarse and fine aggregate (both normal and heavy) shall be stacked on concrete/masonry platforms separately in a manner to prevent their intermixing and to avoid contamination by foreign materials. Each size of aggregate shall be kept separately with wooden, steel, concrete or masonry bulkheads in such a way, to prevent intermixing. If necessary, rock ladders, reclamation tunnels etc. may be provided so that the grading of the material is not affected.

d) All storage arrangements, handling schemes shall be subject to the approval of the Engineer. If the storage arrangement is not to the satisfaction of the Engineer, he may direct the contractor to make such arrangements as he considers necessary and in the event of non-compliance, the Engineer reserves the right to make such arrangements as may be needed at the contractor's risk and cost.

e) A detailed record of receipt and issue of all materials with the associated test certificates shall be maintained by the contractor and shall at all times be available to the Engineer for his scrutiny.

6.5 CONCRETE INGREDIENTS

6.5.1 CEMENT

6.5.1.1 SOURCE QUALIFICATION

a) In no case, cement shall be purchased from agents/ distributors. A minimum of two cement plants shall be pre-qualified well before the start of the concreting works.

b) In general, Ordinary Portland cement (OPC) of 43 grade conforming to IS 8112 and 53 grade conforming to IS 12269 shall be used. In addition to the requirements specified in these standards, following additional requirements shall also be met with:

i) Chloride content shall not be more than 0.05% by mass of cement.
ii) C_3A content shall be between 5% and 8%.
iii) In case of alkali reactive aggregate, alkali content, as Na_2O equivalent shall not be more than 0.6% by mass of cement.

c) Any other special type of cements i.e. Portland Pozzolana Cement (IS 1489 – Part 1 and 2), Portland Slag Cement (IS 455), Sulphate Resisting Cement (IS 12330), Low Heat Portland Cement (IS 12600), Rapid Hardening Portland Cement (IS 8041) may be used in works only with the written permission of the Engineer and only if the design of structures demands the usage of the same.

6.5.1.2 PRE-DISPATCH TESTS

All the consignments of cement shall be accompanied by the manufacturer's test certificate for individual batches, ensuring that cement meets all the requirements of the specification.

6.5.1.3 TEST AT SITE (BATCH QUALIFICATION)

a) In addition to the manufacturer's test certificate, the Contractor shall arrange for testing of the cement either at site laboratory or at any other outside laboratory approved by the Engineer. Cement samples, for such tests, shall be drawn, in the presence of the Engineer or his authorized representative. A composite sample shall be collected representing 250 MT (or such smaller quantity as may be decided by the Engineer) of cement from each grade / brand with proper batch identification. At least 10 grab samples shall be taken representing the entire batch. When cement is supplied in bowser / bulker and directly fed to the silo, grab sample shall be taken from each bowser / bulker. Composite sample shall be prepared by thorough mixing of the grab samples to represent the entire batch.

b) The tests and their frequency shall be as given in Table 6.1.

TABLE 6.1

FREQUENCY OF TESTING OF CEMENT

Sl. .No	Description of Test	Frequency
1	Normal consistency	250 MT or lesser
2	Compressive strength 3 days, 7 days, 28 days	250 MT
3	Initial and final setting time	250 MT
4	Specific gravity	2000 MT

5	Soundness	
a	Le Chatelier's method	2000 MT
b	Auto clave method	2000 MT
6	Specific surface	2000 MT

c) All the chemical tests specified in the relevant standards shall be conducted at an independent laboratory for every 20000 MT of cement supplied or at every 6 months whichever is earlier for each brand/grade. All the chemical compounds shall be reported separately. Bogue's compounds shall also be calculated and furnished.

d) The Engineer shall be able to witness sampling, testing and inspection of cement at the site laboratory or at independent laboratory. Cement shall be released for use, only after ensuring that it meets the requirements of initial and final setting time as well as 3 days compressive strength results. If required, necessary co-relation shall be established between accelerated 1-day strength with 3, 7 and 28-day strengths. Based on this co-relation, cement may be inducted into the work with the prior approval of Engineer in exceptional cases only.

e) Cost of above testing shall be borne by the Contractor. Contractor shall ensure that the construction schedule is not affected because of testing of material at outside laboratory.

f) Test results either from the site laboratory or from an approved outside laboratory shall be taken as final for acceptance or rejection criteria.

6.5.2 FLY ASH

a) Fly Ash conforming to IS 3812 (Part 1) shall only be used. Bottom ash, Ash from Air pre-heater and pond ash shall not be used for mortar as well as for concrete production. Fly ash shall be collected in dry condition from the source with proper moisture proof packing arrangement. Fly ash can also be supplied in bulk containers. For source qualification, three samples from a particular source shall be collected and tested for physical and chemical properties. If all the three samples pass the requirements given in IS 3812 (Part-1) then the source shall be considered as acceptable. However, loss on ignition shall not be more than 2% and particles retained on 45-micron sieve shall not exceed 20%. This requirement is in variance with IS 3812 (Part-1). Bidder will have to meet the requirements given in the specification. In case the quality of fly ash collected from the source does not meet the requirements the contractor will have to use the processed flyash or install a classifier at his own cost.

b) All the physical and chemical tests specified in IS 3812 (Part-1) shall be conducted at every 2,000 MT of fly ash or at every 1-month intervals whichever is earlier. However for fineness only percentage retention on 45-micron sieve shall be the criteria for acceptance or rejection. The discretion to change this frequency rests with the Engineer depending upon the consistent performance of the previous batches. The fly ash, if stored for more than 3 months, it shall be re-qualified before its use.

c) The contractor shall get the test certificate for each batch of supply from the fly ash supplier. The contractor at his own cost shall undertake the following tests either at field laboratory or at outside approved laboratory for each batch of 100 T or part thereof:

i) Percentage retained on 45 micron sieve
ii) Loss on ignition
iii) Moisture content

6.5.3 MICRO SILICA

a) Though micro silica is available in three forms i.e. un-densified, densified and slurry form, only densified form of silica fume shall be used and shall conform to the requirements of IS: 15388.

b) Test requirements of micro silica for source qualification as well as batch qualification shall be as per Table 6.2. For batch qualification tests specified under serial No. 2, 3,5 and 6 of following table (Table 6.2) shall be conducted for every 100 Tons and all other tests shall be carried out at every 2000 Tons.

TABLE 6.2

TEST REQUIREMENTS OF MICRO SILICA

Sl. No.	Description of test	Test method	Requirements
1	SiO_2,(%), min	IS 1727	85.0
2	Maximum Moisture content (%)	See Note 1	3.0
3	Loss on ignition (%), max	IS 1727	4.0
4	Alkalies as Na_2O (%), max	See Note 2 and 3	1.5
5	Oversize percent retained on 45 micron IS sieve (%), Max	IS 1727	10.0
6	Compressive strength at 7 days as percent of control samples	IS 1727 See Note 3	85.0
7	Specific surface (m^2/g), min	IS 15388 Annexure A	15.0
8	Specific gravity*	IS 1727	-

NOTE:

1. For determination of moisture content, dry a weighed sample as received in an oven at 105^0C to 110^0C. Express the percentage loss in mass and record as moisture content.

2. For determination of alkalis, method of test used for determination of alkali in cement may be adopted.

3. In the test method for determination of compressive strength of silica fume cement

mortar in accordance with IS: 1727, the value of factor N may be taken as 1.

4. Specific surface test is optional.

5. Tests specified above shall be carried out by the contractor at his own cost.

(*) For batch qualification the specific gravity value shall not deviate by ±0.2 from the values obtained during mix qualification

6.5.4 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

a) The GGBS shall conform to BS 6699. The GGBS may be used with OPC (Ordinary Portland Cement) 43 grade conforming to IS: 8112 or 53 grade conforming to IS: 12269.

b) Test requirements of GGBS for source qualification as well as batch qualification shall be as per Table 6.3. Cost of testing shall be borne by the Contractor.

TABLE 6.3

TEST REQUIREMENTS OF GGBS AS PER BS 6699

Sl. No	Description of test	Test method	Requirements
1	Fineness (M^2/Kg)	EN-196-6	275 (minimum)
2	Soundness (Le Chatelier Expansion) in mm	EN-196-3	10.0 (maximum)
3	Loss on ignition (%), max	EN-196-2	3.0 %
4	Insoluble Residue (%)	EN-196-2	1.5 (max)
5	Initial Setting Time (IST)	EN-196-3	Not less than IST of OPC
6	Magnesia content (%)	EN-196-2	14.00 (max)
7	Sulphide Sulphur (%)	EN-196-2	2.00 (max)
8	Sulphite Content (%)	EN-196-2	2.50 (max)
9	Magnese Content (%)	EN-196-2	2.00 (max)
10	Chloride Content (%)	EN-196-21	0.10 (max)
11	Moisture Content (%)	BS 6699-APPN-E	1.00 (max)
12	Glass Content (%)	BS 6699-APPN-D	85 (min)
13	Compressive strength in (N/mm^2) After 7 days After 28 days	EN-196-1	 12.0 (min) 32.5 (min)
14 a b c	Chemical Moduli $CaO + MgO + SiO_2$ $CaO + MgO / SiO_2$ CaO / SiO_2	EN-196-2	66.66(Min) > 1.0 < 1.4

In case of use of Portland Slag Cement the cement shall meet all the requirements

given in IS 455.

c) All the physical and chemical tests shall be conducted at every 500 MT of GGBS or at every 6 months intervals whichever is earlier. The discretion to change this frequency rests with the Engineer depending upon the consistent performance of the previous batches. The contractor shall also get the test certificate for each batch of supply from the GGBS supplier.

6.5.5 AGGREGATE

a) The samples of coarse and fine aggregate shall be tested by the contractor at his own cost as per Table-6.4 while qualifying the source and thereafter at regular intervals as mentioned therein. The regular supply of coarse and fine aggregates shall commence only after approval of the source. The layout of the crushing, washing and batching plant shall be subject to the approval of the Engineer. The crushing plant shall include vertical shaft impactor in the system, so as to obtain cubical aggregate as well as crushed fine material for use as manufactured sand. ***Contractor shall note that crushing of aggregate at GHAVP site is prohibited.*** Direct purchasing of crushed aggregate from outside suppliers may be allowed subject to the condition that the material so procured meets this specification. The contractor, however, is advised to procure the boulder and crush the same at a place convenient to him. Alternatively, he may establish crushing machinery at the quarry and transport the crushed aggregates/ crushed sand. All efforts should be made by the contractor to contain the dust level to the minimum so as to meet environmental standards by incorporating suitable filters and/ or any such arrangements.

TABLE 6.4

AGGREGATE TESTING SCHEDULE AND REQUIREMENTS

Sl. No.	Activity/Test	Frequency	Applicable Code	Requirement
1(*)	Petrographic strained quartz analysis by weight	One sample for new source or change in source of aggregates	IS: 383 / ASTM C-295	<20%
2(*)	Alkali reactivity			
a)	Mortar bar method	One sample fornew source or change in source of aggregates.	ASTM C-1260	Expansion shall be less than 0.10% at 16days
b)	Chemical method	One sample for new source or change in source of aggregate and Subsequently once in 6 months during progress of work.	IS: 2386 / IS: 383	Shall fall in innocuous zone
3	Chloride content	-do-	IS 14959(P-I) / Railway Spec	0.04% by wt. max.
4	Sulphate	-do-	IS 3025(P-24)	0.40% by wt. max.

Sl. No.	Activity/Test	Frequency	Applicable Code	Requirement
	content		/Railway Spec.	
5	Iron content for heavy density aggregates	One sample for every 5000 MT for new source or change in source	NPC Spec.	Shall not be less than 60% 4.65 (for HA)
6	Specific gravity (SSD condition)	-do-	IS: 2386	2.6 (for C.A.) 2.55(for F.A.)
7	Deleterious material	-do-	IS: 2386 / IS: 383	Refer Table No.6 and 8
8	Size and Gradation	One sample for every 1000 Cum of concrete (minimum one sample per week)	IS: 2386 / IS: 383	Refer Table No. 5 and 7
9	Absorption/. Moisture content	One sample daily	IS: 2386	3% max.
109	Silt content (for natural sand only)	Once in a week	IS: 383	8% max. By volume
10	Organic impurity (for natural sand only)	Once in six months	IS: 2386 / IS: 383	No impurity
11	Flakiness and elongation index (for C.A. only)	Once in a month	IS: 2386	Individual-15% max.
12	Crushing value (for C.A. only)	Once in six months	IS: 2386	45%** max.
13.	Abrasion value (for C.A. only)	Once in six months	IS: 2386	
14.	Impact valve (for C.A. only)	Once in six months	IS: 2386	

(*) Based on the test results of Petrographic examination and /or alkali aggregate reaction test, if aggregate is found alkali reactive, remedial measures like restricting the alkali content of cement, admixture and/or addition of pozzolanic material shall be resorted to with the approval of the Engineer. As a normal rule, such aggregate shall not be used into work and efforts shall be made to obtain non-reactive aggregate.

(**) These limits shall be 30% (maximum) for aggregate to be used in road construction.

6.5.5.1 WASHING OF AGGREGATE

The impurity level in both coarse aggregate and fine aggregate shall be controlled. If impurities are beyond acceptable limits, the contractor shall at his own cost make necessary arrangements to wash the river sand/ aggregate before inducting the same into concrete. Silt content of sand shall be checked for each truckload and shall be brought within acceptable limits by washing. Both coarse aggregate and fine aggregate shall be washed thoroughly to remove all vegetation, perishable substances, and objectionable amounts of foreign matter, quarry dust, clay lumps, silt and such other deleterious materials. A suitable washing mechanism shall be provided as per scheme approved by the Engineer. The contractor shall prepare a detailed procedure for washing indicating the washing arrangement and get approval of the same from the Engineer. The washing arrangement shall be such as to remove the wastewater along with the unwanted materials and drain the same away from the site. It shall also not be directly let into the river/ nallah or such other existing water bodies.

6.5.5.2 FINE AGGREGATE

Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof. Fine aggregate having a specific gravity of less than 2.55 (saturated surface dry condition) shall not be used. Fine aggregate shall be graded within the limits specified in Table 6.5. The sand shall be of siliceous material, sharp, hard, strong and durable and shall be free from adherent coating, clay, dust, alkali, organic material, deleterious matter, lumps, etc. Sampling of fine aggregate shall be in accordance with IS: 2430. Fine aggregate shall be so graded that concrete of required workability, density and strength could be produced using the specified water binder ratio. The method of determination of gradation shall be as per IS: 2386.

TABLE 6.5

GRADING LIMITS FOR FINE AGGREGATES

IS Sieve designation	Percentage passing by weight		
	Zone-I	Zone-II	Zone-III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-75	55-90	95-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

NOTE :

1. For crushed sand, the permissible limit on 150 micron IS sieve shall not exceed 20%. This shall not affect 5% allowance permitted on clause 1.3 of IS – 383 applying to other sieve size.

2. Fine aggregate complying with the requirement of both grading Zone-I and II of Table–1.5 are only suitable for concrete production. However, in exceptional cases, with the specific permission of Engineer the Zone –III sand may also be used.

3. In addition to above, the fine aggregate shall be so graded that the concrete of the required workability, density and strength can be produced. The method of determining gradation by sieve analysis shall be in accordance with IS: 2386.

6.5.5.2.1 FOREIGN MATERIALS LIMITATIONS IN FINE AGGREGATE

The fine aggregate shall be free from injurious amounts of dust, clay lumps, pyrites, coal, lignite, soft, elongated or flaky particles, shale, alkali, organic matter, loam, mica and other deleterious substances. The percentage of deleterious substances in the fine aggregates, as delivered to the mixer, shall not exceed the values given in Table 6.6, when tested in accordance with IS: 2386.

TABLE 6.6

LIMIT OF DELETERIOUS MATERIALS IN FINE AGGREGATE

Description of test	% By weight	
	River sand	Crushed Sand
a) Material passing 75 micron	3.0 (max)	15.0 (max)
b) Shale	1.0 (max)	Nil
c) Coal and Lignite	1.0 (max)	Nil
d) Clay lumps	1.0 (max)	1.0 (max)
e) Total of other deleterious substances such as alkali, Mica coated grains, soft and flaky particles and loam	2.0 (max)	2.0 (max)
f) Total of all above substances	5.0 (max) *	2.0 (max) *

* Excluding (a)

6.5.5.2.2 ORGANIC IMPURITIES

Aggregate, when tested in accordance with IS: 2386 (Part-2), “The method of test for aggregate for concrete – Estimation of deleterious materials and organic impurities”, producing a colour darker than the standard shall be rejected. However, such sand, when tested for mortar-making properties and the mortar develops a compressive strength at 7 and 28 days of not less than 95% of that developed by a similar mortar made from another portion of same sample which has been washed in 3% solution of sodium hydroxide followed by thorough rinsing in water, then the Engineer may permit use of such sand on works.

For sand that is used after washing, the washed water from the sand shall be free from water-soluble chloride and sulphate content. The presence of chloride and sulphate

content can be checked with silver nitrate and barium chloride respectively. Prior approval of the Engineer shall be taken for bringing sand from new sand quarry or change in quarry.

6.5.5.2.3 USE OF CRUSHED SAND

If the contractor desires to replace sand partially or completely, with crushed sand, he may do so only if the quality of final product meets all the requirements of these specifications. It shall be noted that crushed sand shall be manufactured by specially crushing it from the aggregate by deploying proper machinery for the same. Crusher dust obtained while producing aggregate shall not be directly used for replacing sand unless it meets the technical specifications/ grading limits specified in Table Nos.6.4, 6.5 and 6.6.

6.5.5.2.4 FREQUENCY OF TESTING AND OTHER CHARACTERISTICS

The fine aggregate shall be tested for physical, chemical & mechanical properties and impurities content as per schedule given in Table Nos. 6.4, 6.5 and 6.6.

6.5.5.2.5 COARSE AGGREGATE

Coarse aggregate for normal concrete shall consist of hard, strong, durable particles of crushed stone and shall be free from thin elongated soft pieces, vegetation or other deleterious matter. It shall have no adherent coating. Coarse aggregate shall have an average specific gravity (saturated surface dry condition) 2.6 or more and no individual value shall be less than 2.55.

6.5.5.3.1 GRADING

The size of normal aggregate shall be selected from the standard sizes given in Table 6.7. The method of determining grading by sieve analysis shall be according to IS: 383. The stones required for making aggregates shall be transported to the crushing plant, preferably to be installed near the site of work and shall be crushed by the Contractor in primary and secondary crushers to yield the aggregates to the required sizes and specification as described under various items of schedule of quantities in Section-VIII of the document. In areas, where there is congestion of reinforcement and embedment, the Engineer may direct the contractor to use smaller size of aggregate without any additional cost for screening off the higher sizes.

TABLE 6.7

GRADING REQUIREMENTS OF COARSE AGGREGATES

Sl. No.	Nominal size	Amounts finer than each sieve (square openings) weight							
		50 mm	40 mm	20 mm	12.5 mm	10 mm	4.75 mm	2.36 mm	1.18 mm

1	40 to 4.75 mm	100	95 -0	30-70	-	10-35	0-5	-	-
2	20 to 4.75 mm	-	100	95-100	-	25-55	0-10	-	-
3	12.5 to 4.75 mm	-	-	100	90-100	40-85	0-10	-	-
4	10 to 2.36 mm	-	-	-	100	85-100	0-20	0-5	-
5	20 to 10 mm	-	100	85-100	-	0-20	0-5	-	-
6	40 to 20 mm	100	85-100	0-20	-	0-5	-	-	-

6.5.5.3.2 FOREIGN MATERIALS LIMITATION

The amount of deleterious substances in coarse aggregate shall not exceed the limits given in Table 6.8.

TABLE 6.8

LIMIT OF DELETERIOUS MATERIALS IN COARSE AGGREGATE

Sl. No.	Deleterious substances	Maximum percent by weight of total sample
1	Coal and Lignite	1.00
2	Shale	NIL
3	Clay Lumps	1.00
4	Soft fragments	NIL
5	Material finer than 75 micron	3.00
6	Sum of percentage of all Deleterious materials	5.00

6.5.6 WATER

a) Water used for both mixing of concrete and curing shall be clean and free from injurious amounts of oil, acids, alkalis, salt, sugar, organic materials or other substances that may be deleterious to the concrete or steel. Potable water is generally considered satisfactory for mixing and curing of concrete. The pH value of water shall generally be not less than 6. The sources of water shall have approval of the Engineer. The quality of water shall meet the provisions of IS: 3025 particularly Parts 22 and 23. The sample of water taken for testing shall represent the water proposed to be used for concreting, due attention being paid to seasonal variation. The quality of water shall be tested at every 6 months. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete or curing. The sample shall be stored in a clean container previously rinsed out with similar water. ***The exploitation of Ground Water for construction work is prohibited at GHAVP site .***

b) Permissible limits of solids, when tested in accordance with IS: 3025 are given in Table 6.9.

TABLE 6.9

PERMISSIBLE LIMIT FOR SOLIDS

Sl. No.	Description of test	Tested as per	Permissible limits (max.)
1	Organic	IS3025 (Part 18)	200 mg/l
2	Inorganic	IS3025 (Part 18)	3000 mg/l
3	Sulphates (as SO_3)	IS3025 (Part 24)	400 mg/l
4	Chlorides (as Cl)	IS3025 (Part 32)	2000 mg/l for concrete not containing embedded steel and 500 mg/l for reinforced concrete work
5	Suspended matter	IS3025 (Part 17)	2000 mg/l

c) In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests of concrete.

d) Average 28-day compressive strength of at least three 15 cm size concrete cubes, prepared with water proposed to be used, shall not be less than 90 percent of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with IS: 516.

e) The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes. The initial setting time shall also not differ by more than +30 minutes from the initial setting time of control test block prepared with the same cement and distilled water. The test blocks shall be prepared and tested in accordance with IS: 4031 (Part 5).

6.5.6.1 USE OF ICE AND CHILLED WATER

a) The Contractor shall study the placement temperature requirement, the ambient conditions and work out the refrigeration plant capacity to meet the construction schedule. It shall be noted that the temperature of the concrete indicated in the drawings/ specifications is at the placing point. The contractor shall submit his scheme of temperature control of concrete with detailed calculations before the actual commencement of work. The temperature control may be achieved either by mixing chilled water or by addition of ice flakes depending upon the ambient conditions and transportation time.

b) Mixing water shall be kept cool by storing it under cover. Storage tank shall always be kept clean. Water shall be transported to the mixing plant in such a way that there

is no rise in temperature. If chilled water or crushed ice is used as a part of mixing water to achieve the specified temperature of water, the Contractor shall install and maintain in good working condition a refrigeration plant to produce chilled water at temperature not exceeding 8^{o}C. The Contractor shall also build and maintain well-insulated adequate capacity storage tanks for cold water with insulated piping. To supplement this refrigeration facility, the Contractor may establish ice plant of suitable capacity. The full quantity of crushed ice shall be stored in cold storage 24 hours in advance of start of concreting. The temperature in the cold storage shall not be higher than (-2°C).

c) Ice, if used as replacement for a portion or all of the mixing water, shall be produced from water, which meets the requirements of this specification. Ice shall be in flaky condition and such ice flakes shall have thickness less than 3 mm. The ice plant should be capable of producing flaked ice. The Contractor shall make his own arrangement for storing adequate quantity of ice. Commercial ice shall not be used. In case of large pours, where the existing refrigeration capacity is not adequate, the contractor may use commercial ice, subject to the approval of the Engineer, after ensuring that the quality standards of this specification are met with.

6.5.7 CHEMICAL ADMIXTURES

a) The Contractor shall procure all chemical admixtures required in the specification. The Contractor shall ensure consistent behavior of proposed admixtures in concrete mixes and at all ambient temperatures likely to be experienced at project site throughout the year, and especially at the recommended placement temperatures. Contractor shall arrange for pre-qualification of such admixtures to fulfill the requirements specified in ASTM C-494 at his own cost. Qualification of chemical admixtures shall be carried out as per the guidelines given in ASTM C 494, using concrete with a cement content of 307 kg/m^3. Setting time of concrete with admixtures shall be decided by casting specimens and keeping the same in a temperature controlled room at a temperature of 23 (+/-) 2^{0}C. Base material of admixture shall be either sulphonated naphthalene formaldehyde based or poly carboxylic ether based only. High range water reducing and retarding admixture conforming to type G of ASTM C-494 shall be used.

b) Generically high range water reducing and retarding admixture shall be of either Sulphonated Naphthalene Formaldehyde condensate (SNF), Sulphonated Melamine Formaldehyde condensate (SMF) or Poly Carboxylate and conform to type G of ASTM C-494 depending on the fines content and limitation of chlorides, sulphates and other alkali contents.

c) The admixture to be used for Viscosity Modifying Agent (VMA) shall generically be either of Modified Cellulose or Poly-ethylene Glycol.

d) Admixture samples, when tested, shall meet the requirements given in Table 6.10.

TABLE 6.10

ADMIXTURE QUALIFICATION TEST

Sl. No	Description of Test	Acceptance values for Type G
1	Water Reduction as % of Control Mix	18 % minimum (*)
2	Air entrainment	± 1 % of control mix
3	Initial Setting Time Deviation from control At least Not more than	 1:00 hour later 3:30 hours later
4	Final Setting Time Deviation from control At least Not more than	 -- 3:30 hours later
5	Compressive strength As % of Control Mix 1 day 3 day 7 day 28 day	 125 % min 125 % min 115 % min 110 % min
6	Flexural Strength as % of Control Mix 3 day 7 day 28 day	 110 % min 100 % min 100 % min
7	Specific gravity at 25^0C	Within ±0.02 of the value stated by manufacturer
8	Solid content	With ± 3% of the value stated by the manufacturer
9	Ph	7-8
10	Chloride content	0.2 % max
11	Infrared Spectrograph	Identification of base material of the admixture

(*) This value is at variance with the ASTM C 494.

6.5.7.1 SAMPLING

a) The manufacturer's tests certificates shall accompany all individual batches of admixtures. Batches of admixture, not accompanied with correlating test certificates, shall not be inducted into the work till the tests are completed and the material found

meeting the standards. The batches/lots of admixture, accepted for testing, shall be identified with the unique sample number. Location of the product containers shall be distinctly identified and cordoned off to prevent mix-up with other products and brands and unacceptable materials.

b) Admixture shall be thoroughly agitated by using mechanical agitator, prior to sampling and a composite sample shall be collected representing 25.0 MT of admixture with proper batch identification. Grab sample shall be taken from each batch. Even if number of batches are less than 4, minimum 4 such grab samples shall be taken representing 25 MT of admixture and composite sample shall be prepared by thoroughly mixing the grab samples. Volume of each grab sample and composite sample shall be as decided by the Engineer.

c) It may also be noted that the admixture shall be thoroughly stirred before actual use. Mechanical stirring is mandatory and manual stirring shall not be permitted.

6.5.7.2 BATCH QUALIFICATION

Each batch of 25 MT (or lesser) of admixture shall be tested and qualified before use. All the tests, as given in Table-6.10, except 1-day compressive strength and flexural strength, shall be conducted. Admixture shall be released only after meeting the specified requirements. Infrared spectrograph of each batch shall be compared with the signature infrared spectrograph of that brand taken at the time of brand qualification to ensure consistent quality. In the event of tests failing to meet the specified requirements during batch qualification, the particular batch shall be rejected and removed from site.

Once accepted by the Engineer, one representative sample of 5 litres (approx.) shall be preserved from each batch upto 1 month from its expiry date. Such representative samples shall be identified, tagged and sealed indicating the sample identification number, brand name, batch number, date of manufacture, date of collection and expiry date.

6.5.7.3 STORAGE

The admixture shall be accompanied by manufacturer's certificate indicating the expiry date. The product shall not be used after this date. Admixture shall be used as per manufacturer's instruction and with the control specified by the Engineer.

Utilization and storage conditions shall conform to in the corresponding technical documentation given by the manufacturer.

Contractor shall make adequate arrangement for procurement of admixture at least 45 days prior to use, as testing time for batch qualification takes minimum 30 days. Adequate quantity of tested material shall be stored to meet the construction schedule.

6.5.7.4 OTHER TYPE OF ADMIXTURES

The Engineer may, at his discretion, instruct the contractor to use any other type of admixture in concrete i.e. admixture conforming to ASTM C-494 Type A to F, water proofing admixture conforming to IS 2645 etc. These admixtures, if used, shall be qualified, on the same lines before use.

6.5.7.5 VISCOSITY MODIFYING AGENT (VMA)

a) Viscosity modifying agent shall be used in self-compacting concrete (SCC) to increase the segregation resistance of concrete. VMA shall be added in SCC as per the recommendations of the manufacture and it shall be ensured through trials that it does not have any adverse effect on any of the properties of green and hardened concrete.

b) The VMA shall generically be of water-soluble polymers, Modified Cellulose or Poly-ethylene Glycol, which are adsorbed on to the surface of the cement granules causing changes in the viscosity and the rheological properties of the mix. It shall be chloride free and compatible with all cements envisaged by IS standards.

c) Sulphonated Naphthalene based superplasticizer SNF is avoided, as it is not compatible with VMA. Other type of VMA can also be used if it meets the desired parameters of SCC, and compatible with the superpasticizer. It may be noted that there is no specific testing for qualification of VMA, other than its meeting desired properties of SCC for each batch of material (VMA).

d) Super plasticizers containing VMA may also be used for the production of self-compacting concrete subject to meeting all the desired properties of SCC.

6.6 CONCRETE MIXING PLANT

A numbers of modern concrete batching and mixing plant capable of producing concrete of specified quality and at the required output rate shall be established by the Contractor at site. For mixing fly ash at site, Pan type mixer is preferred. A balanced complement of mixing, transporting, handling and placing equipment shall be deployed. Prior to use, the concrete mixing plants shall be completely installed and operated for a sufficient length of time to enable the Engineer to make the necessary physical tests (to assess the performance). Batching plants shall be fully automatic with computerized control along with the facility of automatic moisture correction.

Contractor shall provide, along with the tender proposal, full details of the batching plants to be deployed at site. After the award of the work, the layout of the plants, the full technical data and other details shall be submitted to the Engineer well before the actual setting of the plant.

6.6.1 TYPE OF PLANT

a) The type of plant to be deployed shall be automatic. The term ‘automatic’ is used to define a plant in which:

i) Batch weights are set on a mix selector manually,

ii) Mixes are batched in weigh hopper by operation of electric switch in one operation automatically,

iii) Ingredients are charged in the mixer, concrete is mixed and unloaded in a hopper in one operation by selecting mix number and operating a push button or through operation by computer.

b) Batching plant shall be capable of producing concrete according to the proportion set and controlled by the computer within the desired accuracy and tolerances specified for each of the ingredients, with different combinations of mixing sequences to produce concrete of different grades with the help of a single command. Plant software shall be capable of giving the batch weight records for each batch along with mixing cycle time in a format approved by the Engineer.

c) Each batching and mixing plant shall preferably comprise offour or five overhead storage bins for coarse and fine aggregate and cylindrical silos for cement, fly ash, GGBS and / or micro silica of adequate capacity, arrangement of adding water and admixture, to meet uninterrupted supply of concrete for placement in different pours. If cement is brought to the site in browsers / bulkers and directly loaded to the silos, then it is preferable to have minimum 3 silos for each batching plant for storage of cement. Alternatively, the silos can be kept connected to all the batching plants by providing interchangeable facility. Separate silos of adequate capacities are to be provided for fly ash, GGBS and micro silica, as the case may be, with suitable arrangement for direct loading and charging into the mixer. For loading fly ash, GGBS and micro silica, pneumatic conveyer shall be used, as screw type conveyers get choked frequently.

d) Storage bin of sufficient capacity for ice flakes shall be installed and fixed in such a way that water from melting ice shall not flow in the mixer through batcher but shall be collected in a conical vessel and drained outside.

e) The least count of weighing dials for 1 cu.m batch size plant shall be as per Table 6.11

TABLE 6.11

CAPACITY AND LEAST COUNT OF WEIGHING MECHANISM

Si.No.	Item	Capacity of dial (Kg.)	Least Count (Kg.)
1.	Cement	600	1
2.	Fly ash	600	1
3.	GGBS	600	1
4.	Microsilica	100	0.2
5.	Aggregate	2500	5
6.	Water	250	1

7.	Ice	250	1
8.	Admixture	25	0.1

f) If the batch size is different from 1 cu.m, then the capacity and least count of dials shall be modified accordingly. However, considering the demand rate of concrete, batching plant mixer of 2 cu.m. Capacity is preferred for all major concrete works.

g) Control room of the batching plant housing the instrumentation shall be free from vibrations and dust and shall be arranged as per the specification of the manufacturer. Indicators shall be fixed in such a way that operator is able to see batching of aggregate, mixing of concrete etc. directly and also all the dial indicators are clearly visible from one point.

h) All operations from charging the mixer to unloading of mix shall be interlocked so that unless mixer is empty, no new batch of ingredients is charged into the mixer.

6.6.2 WEIGHING AND BATCHING

6.6.2.1 WEIGHING UNITS

Every delivery point of aggregate, cement, fly ash, GGBS and/or micro silica into the mixer charging hopper shall have a weighing unit and each weighing unit shall include a visible, spring-less direct reading dial which shall indicate the scale load at all stages of the weighing operation from zero to full capacity. As far as practicable, the scale dials and the weighing equipment shall be in full view of the operator, so that he may conveniently observe the operation of the batcher gates and the discharge of the materials. Provision shall be made for adjustment and change in weights of materials being charged into the hopper.

Bins with adequate compartments shall be provided in the batching plant for fine aggregate and for each required size of coarse aggregate. Each bin compartment shall be designed and operated so as to discharge efficiently and freely into the weighing hopper with minimum segregation. Means of control shall be provided such that, when quantity desired in the weighing hopper is approached, the gate shall shut off with precision. Weighing hoppers shall be so constructed that it will eliminate accumulations of tare materials and material is discharged fully.

6.6.2.2 MEASURING WATER AND ICE

Water and Ice shall be measured by weight. The mechanism for measuring and delivering water to the mixers shall not permit leakage when the valves are closed. The filling and discharge valves for the water tank shall be so interlocked that the discharge valves cannot be opened before the filling valve is fully closed.

6.6.2.3 MOISTURE CORRECTION

The batching plant shall be provided with at least one moisture probe attached to the fine aggregate bin. This probe shall sense the moisture in the fine aggregate at the

time of batching and send the appropriate signal to the computer of batching plant so that adjustment in water quantity and fine aggregate quantity is made.

6.6.2.4 DISPENSER FOR ADMIXTURE

The concrete plant shall include dispensing device to accurately measure and deposit the full quantity of admixture into each mix at one time. The dispenser shall be interlocked with the batching and discharging controls of the water so that the batching and discharge of the admixtures will be automatic. The device shall be capable of ready adjustment to permit varying the quantity of the admixtures to be batched. The equipment shall be kept in a clean and fully operable condition.

6.6.2.5 TOLERANCE IN BATCHING WEIGHMENT ERRORS

The accuracy of weighing devices shall be as per Table 6.12:

TABLE 6.12

ACCURACY OF WEIGHING MECHANISM

Material	Percent of accuracy
Cement / Fly ash/GGBS	± 1 (by weight)
Water/Ice	± 1 (by weight)
Aggregate	± 2 (by weight)
Admixture	± 1 (by weight)
Micro silica	± 1 (by weight)

At least once in a month, the contractor shall check that the quantities of materials leaving the scales comply with the specified quantity within the tolerances. If discrepancies are noticed, he shall immediately make necessary required corrections and shall undertake re-calibration.

6.6.3 MIXING TIME

a) The mixing time required should be based upon the ability of mixer to produce uniform concrete throughout the entire manufacturing process and for this; the manufacturer's specifications shall be followed. However, final mixing time should be based on the result of mixer performance test (uniformity test) made at frequent intervals throughout the duration of job. The mixing time shall be measured from the time all ingredients are in the mixer. Batch time with audible indicators used in combination with interlocks, to prevent under or over mixing of the batch and premature discharge, should be provided. The mixer shall be design for starting and stopping under full load.

b) In case of concrete with micro-silica, to ensure that agglomerates of densified micro silica break fully, mixing time required would generally be 1.5 times the time

required for normal concrete and the same shall be established by conducting trials. Micro silica concrete needs additional mixing time. It is preferable to charge micro silica into the mixer along with coarse and fine aggregate, premix it for 10 seconds followed by charging of remaining ingredient i.e. cement, fly ash, water, ice and admixture into the mixer and final mixing of around 30 to 60 seconds. The time and sequence of loading shall be established by conducting trials.

c) Mixer is considered to pass the uniformity test if two samples taken after discharge of approximately 15% and 85% of the load meet the requirement given in Table 6.13**.**

TABLE 6.13

MIXER PERFORMANCE REQUIREMENTS

Sl. No.	Test	Requirement, expressed as maximum permissible difference in result of tests of samples taken from two locations in the concrete batch
1	Air entrainment	1.0 %
2 a) b)	Slump Average slump is less than 100mm Average slump is more than 100mm	 25 mm 40 mm
3	Average compressive strength at 7 days for each sample, based on the average strength of all compressive test specimens	7.5 %

d) Once the batching plant passes the performance test, for further compliance only slump test will be conducted at the frequency specified in Table 6.13.

6.6.4 RECORDS AND CHARTS

a) The Contractor shall maintain accurate records of the following at the batching plant for each batch:

i) The weight of cement, fly ash, GGBS, micro silica, water and admixture.
ii) The weight of coarse aggregate for each size recorded separately.
iii) The weight of fine aggregate for each size separately.
iv) The concrete Temperature immediately after mixing.
v) Mixing time of each batch, after all the materials are loaded into the mixer.
vi) Time of delivered of the concrete is from the mixer.
vii) Ambient temperature

b) The record shall be maintained by automatic recording and printout. Computer printouts shall also indicate the preset quantity of each ingredient, actual quantity discharged and error in it. The limits specified in the Table 6.12 shall be met (as an average) at the end of loading cycle of each transit mixer.

6.6.5 MAINTENANCE

The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free from hardened concrete. Mixer blades shall be replaced when worn down more than 10 percent of their depth. Should any mixer at any time produce unsatisfactory results or mortar leakage is observed, its use shall be promptly discontinued, till it is repaired.

6.6.6 PROVISION FOR INSPECTION

The complete plant assembly shall include provisions to facilitate the inspection of all operations at all times.

6.6.7 SAMPLING FACILITIES

Suitable facilities shall be provided for readily obtaining representative samples of concrete ingredients from any of the batchers and suitable devices for obtaining representative samples of concrete for determination of properties of fresh and hardened concrete to be made by the Contractor. All necessary platforms, tools and equipment for obtaining samples shall be made available at the start of work and shall be maintained throughout contract period.

6.6.8 CONCRETE SPECIMEN

Concrete specimen shall be prepared from the mixes used in the work and tested to determine the adequacy and accuracy of control for the materials entering into the concrete mix. The Contractor shall perform preparation, storage and testing of the specimen in presence of the Engineer to his entire satisfaction.

6.6.9 TEST WEIGHTS AND CALIBRATION

The Contractor shall provide standard test weights and any other auxiliary equipment, required for checking the operating performance of each scale or other measuring device. All the weighing scales shall be calibrated every month or whenever doubts arise or before any major pour, as directed by Engineer. Batching plant shall be allowed to use for production of concrete only if it meets the specified requirements.

6.7 PRE-REQUISITIES OF CONCRETE

6.7.1 CLASSES OF CONCRETE

Unless otherwise specifically stated as Nominal Mix, all concrete, contemplated under this specification, shall be taken to mean as "**Controlled Concrete**".

6.7.2 CONTROLLED CONCRETE

Controlled concrete is a concrete where the mix proportions are determined by mix design, preliminary mix proportioning and laboratory tests. These shall be carried out at specified intervals and also whenever the Engineer has reasons to believe that there

has been a change in the quality, properties, or grading etc of any of the constituents of concrete, which, in his opinion, would impair the strength and /or durability.

Each class of concrete shall be identified by designation consisting of a prefix and two numbers like N/25/40. Prefix 'N', 'H' and 'SH' signifies Normal concrete, Heavy concrete made with hematite aggregates and Super Heavy concrete with a combination of hematite aggregates and chilled iron shots or steel punching respectively. Next two numbers e.g. 25 and 40 would denote the Uniaxial characteristic compressive strength at 28 days in MPa (25 MPa and maximum size of coarse aggregate in mm (40 mm) respectively.

6.7.3 NORMAL CONCRETE

Class designation of concrete shall be as specified on the drawing. Maximum size of aggregate shall be 20 mm unless specified otherwise. However, when concreting has to be carried out in congested areas, maximum size of aggregate may be suitably reduced, with the approval of the Engineer.

Unless otherwise specified on drawings or called for in the schedule of Quantities, the class designation of normal concrete to be used shall, generally, be selected from Table 6.14.

TABLE 6.14

GRADES OF NORMAL CONCRETE

Class	Characteristic Compressive Strength of 15 cm cubes at 28 days in MPa	Maximum size of aggregate in mm
N/10/20	10	20
N/20/20	20	20
N/30/20	30	20
N/35/20	35	20
N/40/20	40	20
N/45/20	45	20
N/50/20	50	20
N/60/20	60	20
Normal Grout	30*	Fine Aggregate

Normal concrete shall have a net unit weight of not less than 2400 Kg/cu.m.
* The compressive strength for grout shall be on cubes having area of face 50 cm^2.

6.7.4 MIX PROPORTIONING CRITERIA

The mix proportioning, in case of OPC concrete shall be based on 28-day characteristic strength. For concrete containing fly ash, GGBS or any other mineral admixture, the concrete acceptance criteria shall be based on 56- day strength. Any other specific requirement, if any, will be as indicated on the construction drawings.

6.7.5 DURABILITY OF CONCRETE

To meet the requirement of durability, the water content as well as water to binder ratio shall be as low as practicable. In addition, there shall be adequate compaction and immediate curing as well as curing for longer period is necessary.

6.7.6 EXPOSURE CONDITIONS

Various conditions for which the concrete will be exposed during its service life are given in the Table 6.15.

TABLE – 6.15

ENVIRONMENTAL EXPOSURE CONDITIONS

Sl. No	Environment	Exposure Condition
1	Mild	Concrete surface protected against weather or aggressive conditions except those situated in coastal area.
2	Moderate	Concrete surface sheltered from severe rain or freezing whilst wet Concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non-aggressive soil / ground water. Concrete surfaces sheltered from saturated salt air in coastal area.
3	Severe	Concrete surface exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in seawater. Concrete exposed to coastal environment.
4	Very Severe	Concrete surface exposed to seawater spray, corrosive fumes or severe freezing conditions whist wet. Concrete in contact with or buried under aggressive subsoil / ground water.
5	Extreme	Surface of members in tidal zone Members in direct contact with liquid/solid aggressive chemicals

Unless otherwise specified in the drawing, **'Severe' and 'Moderate'** exposure conditions shall be considered for Coastal and inland sites of NPP respectively and mix proportioning of all types of concrete shall be carried out accordingly.

6.7.7 MINIMUM CEMENT CONTENT, MAXIMUM W/C

Unless specifically mentioned in the drawings, the values for minimum cement content and the maximum free water-cement ratio given in the Table 6.16 for different exposure conditions and for 20 mm maximum size aggregate may be used in the mix design.

TABLE 6.16

MINIMUM CEMENT CONTENT, MAXIMUM WATER-CEMENT RATIO AND MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH NORMAL WEIGHT AGGREGATE OF 20MM NOMINAL MAXIMUM SIZE

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum Cement Content kg/m^3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m^3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete
Mild	220	0.60	-	300	0.55	M 20
Moderate	240	0.60	M 15	300	0.50	M 25
Severe	250	0.50	M 20	320	0.45	M 30
Very Severe	260	0.45	M 20	340	0.45	M 35
Extreme	280	0.40	M 25	360	0.40	M 40

Notes:

a) Cement content prescribed in this table is irrespective of grade of cement and is inclusive of mineral admixture like fly ash, micro silica, GGBS etc

b) Maximum quantity of fly ash that shall be taken into account in the concrete composition for minimum cement content computation specified above shall be 35 % of Minimum cementitious material specified in above table, which is in line with IS 1489 requirements. However, 35% is not a maximum limit on fly ash content of concrete mix proportion.

c) Maximum quantity of GGBS that shall be taken into account in the concrete composition with respect to minimum cement content requirement specified above shall be 65 % of Minimum cementitious material specified in above table, which is in line with IS 455 requirements. However, 65% is not a maximum limit on GGBS content of concrete mix proportion.

d) Minimum cement content shall be increased by 40 kg/m^3 for 10 mm maximum size of aggregate and shall be reduced by 30 kg/m^3 for 40 mm maximum aggregate size.

6.7.8 EXPOSURE TO SULPHATE ATTACK

Requirements for concrete exposed to sulphate attack shall be as per relevant provisions of IS 456. All the recommendations for the type of cement, maximum free water/cement ratio and minimum cement content, which are required at different sulphate concentrations in near-neutral ground water having pH 6 to 9, given in the Table 6.17, shall be followed.

For the very high sulphate concentrations in Class 5 conditions, some form of lining such as polyethylene or polychloroprene sheet; or surface coating based on asphalt, chlorinated rubber, epoxy, or polyurethane materials should also be used to prevent access by the sulphate solution.

The decision of Engineer shall be followed in this regard. Such liner shall be measured and paid separately.

TABLE 6.17

REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK

Class	Concentration of sulphates expressed as SO_3			Type of Cement	Dense fully compacted concrete made with 20mm nominal Max. Size of Aggregate complying with IS 383	
	In soil		In ground water (g/l)		Minimum cement content kg/ m^3	Maximum W/C ratio
	Total SO_3 (%)	SO_3 in 2:1 water soil extract(g/l)				
1	Traces <0.2	< 1	< 0.3	OPC, PPC or Portland Slag cement	280	0.55
2	0.2 to 0.5	1 to 1.9	0.3 to 1.2	OPC, PPC or Portland Slag cement	330	0.50
				Super sulphated cement or Sulphate resisting Portland Cement	310	0.50
3	0.5to 1	1.9 to 3.1	1.2 to 2.5	Super sulphated cement or Sulphate resisting Portland Cement	330	0.50
				PPC or Portland Slag cement	350	0.45
4	1 to 2	3.1 to 5	2.5 to 5	Super sulphated cement or Sulphate resisting Portland Cement	370	0.45

5	More than 2	> 5	> 5	Sulphate resisting Portland Cement or Super sulphated cement with protective coatings	400	0.40

Notes:

a) Cement content given in this table is irrespective of the grade of cement.

b) Use of Super sulphated cement is generally restricted where the prevailing temperature is above 40ºC.

c) Supersulphated cement gives an acceptable life provided that the concrete is dense and prepared with a W/C ratio of 0.4 or less in mineral acids, down to pH 3.5.

d) The cement content given in above table is the minimum recommended. For SO_3 contents near the upper limit of any class, cement content above these minimums are advised.

e) For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, consideration should be given to a further reduction of W/C ratio.

f) Portland Slag Cement conforming to IS: 455 with slag content more than 50% exhibits better sulphate resisting properties.

g) Where chloride is encountered along with sulphate in soil or ground water, ordinary Portland cement with C_3A content from 5 to 8% shall be desirable to be used in concrete, instead of sulphate resisting cement. Alternatively, Portland slag cement conforming to IS: 455 having more than 50% slag or a blend of ordinary Portland cement and slag may be used provided sufficient information is available on performance of such blended cements in these conditions.

6.8 PROPERTIES OF CONCRETE

6.8.1 CONCRETE MIX PROPORTIONING

Concrete shall be proportioned to obtain workable mixes for intended purpose and to meet the strength and finish requirements.

Preliminary mix proportioning shall be established by conducting trials by the contractor, well in advance, so as to meet the time schedule. Mix proportion adopted shall meet the specified properties of green as well as hardened concrete.

While conducting trials, contractor shall use the ingredients that are qualified for actual work. All efforts shall be made to carry out the trials in laboratory and after the mix is finalized, final trials shall be done at batching plant for final qualification of the mix proportion.

6.8.2 TARGET MEAN STRENGTH

The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times standard deviation. The standard deviation for each grade of concrete shall be calculated separately. When sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in Table 6.18 may be assumed for mix proportioning in the first instance. As soon as the test results on sufficient number of samples are available, actual standard deviation shall be calculated and used in mix proportioning. However, when adequate past record for a similar grade exists the same may be used for deciding target mean strength.

TABLE 6.18

ASSUMED STANDARD DEVIATION

Grade of Concrete	Assumed Standard Deviation MPa
M 10 M 15	3.5
M 20 M 25	4.0
M 30 M 35 M 40 M 45 M 50 M 60	5.0

Note:

a) The above values correspond to the site control having proper storage of cement; weight batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. In case there is deviation in the control measures at site, the value of standard deviation given in the Table-6.18 shall be increased by 1 MPa.

6.8.3 MIX PROPORTIONING METHOD

Concrete mix proportioning may be done by methods given in IS 10262, SP-23, ACI 211.1, or on the basis of past experience or by any other suitable method so that the final product meets the specified requirements for green as well as hardened concrete. Efforts shall be made to keep cement content as well as unit water content as minimum as possible, with the use of suitable quality of chemical admixture.

6.8.4 POZZOLANIC MATERIAL

Fly ash, micro silica or ground granulated blast furnace slag (GGBS), individually or in combination, may be used in concrete along with OPC of 43 or 53 grade with the approval of Engineer. The upper limit for use of these pozzolanic materials is as given below:

a) Fly ash - 50% (max.) of total cementitious material for RCC and Prestressed concrete and 70%(max) for PCC
b) Micro silica - 7.5% (max.) of total cementitious material
c) GGBS - 65% (max.) of total cementitious material for RCC and Prestressed concrete and 80%(max) for PCC

However, minimum cement content requirement specified in 6.7.7 above shall be fulfilled. It has to be ensured that desired concrete characteristics are met with. In case of self-compacting concrete, fly ash quantity in excess of 50% can be used to meet the requirement of higher fines content.

6.8.5 WORKABILITY AND SLUMP

The workability measured in terms of slump shall be determined by slump tests as per IS 1199. As majority of concrete is desired to be placed using pumps, the workability of concrete shall be such that mix is pumpable. As a general guideline, slump of 125 mm at placement point is suitable for pumping of concrete. The requirement of slump for various pours, based on the placement methods and reinforcement congestion shall be decided at site with the concurrence of the Engineer.

6.8.6 UNIT WEIGHT

Normal concrete should have a net dry theoretical unit weight of 2400 kg/m^3, when tested as per IS 1199. The unit weight of concrete of any grade shall not be lower than 2375 kg/m^3.

6.8.7 AIR CONTENT

Air content of the concrete shall be tested as per IS 1199. While deciding on mix proportioning, air content for different aggregate sizes shall be as per Table 6.19

TABLE 6.19

AIR CONTENT OF CONCRETE FOR DIFFERENT MAXIMUM AGGREGATE SIZE

Maximum Aggregate Size	Max Air Content
40 mm	1%
20 mm	2%
10 mm	3%

The actual air content of concrete mix shall not exceed by more than 1% of the values given in Table 6.19.

6.8.8 SETTING TIME

Setting time of concrete shall be determined as per IS 8142. As the setting time depends on the temperature of concrete at the time of production as well as ambient conditions, it is required to check the setting time of concrete under same temperature and ambient conditions, as envisaged in the work.

Final setting time of concrete may be kept around 10 hours during summer and around 12 hours during winter. This parameter is required to be established for different ambient conditions for deciding time at which green cutting at construction joints is to be carried out.

6.8.9 BLEEDING

Bleeding of concrete shall not exceed 5% of the water content of the concrete, when tested as per IS 9103.

6.8.10 CHLORIDE CONTENT IN CONCRETE

The total acid soluble chloride in fresh concrete determined as per IS 14959 Part-1 shall not exceed 0.6 kg/m^3 and 0.4 kg/m^3 for reinforced and pre stressed concrete respectively.

6.8.11 CUBE COMPRESSIVE STRENGTH

Uniaxial Compressive cube strength shall be determined on 150 mm size cubes, as per IS 516.

6.8.12 CYLINDER COMPRESSIVE STRENGTH

Uniaxial Compressive cylinder strength shall also be determined on 150 mm diameter 300 mm long size cylinder, as per IS 516.

Uniaxial characteristic compressive cylinder strength shall not be less than 80% of characteristic compressive cube strength.

6.8.13 Deleted

6.8.14 FLEXURAL STRENGTH

Flexural strength of concrete shall be determined as per IS 516. Flexural strength shall not be less than $0.7\sqrt{f_{ck}}$ MPa where f_{ck} is the characteristic compressive cube strength of concrete in MPa.

6.8.15 MODULUS OF ELASTICITY

The modulus of elasticity of concrete shall be determined as per IS 516. The modulus of elasticity shall not be less than $5000\sqrt{f_{ck}}$ MPa, where f_{ck} is the characteristic compressive cube strength of concrete in MPa.

If the actual measured value differs by more than ± 20% from the value obtained from the above expression then it shall be reported to the Engineer.

6.8.16 PERMEABILITY

Permeability shall be determined by conducting Rapid Chloride Penetration Test (RCPT) as per ASTM C-1202. RCPT value shall not exceed 2000 Coulombs at 56 days.

6.8.17 TRIAL MIX AT LABORATORY

Based on the guidelines given above concrete mix design and proportioning shall be carried out so that it meets the requirements of strength, workability and durability.

Preliminary trials shall be carried out to optimize the quantity of cement, pozzolanic materials and other ingredients of concrete. To qualify a mix proportion, at least 4 trials shall be carried out in the laboratory using the preliminary mix design. Following tests shall be carried out on these mixes.

(a) Slump at 0 min, 30 min and 60 min.

(b) Unit weight

(c) Air content

(d) Initial and final setting time

(e) Compressive cube strength at 7, 28 and 56 *days

(f) Split tensile strength**

(g) RCPT at 56 days

* Only for concrete containing fly ash, GGBS or other pozzolana
** Only for containment structure or specified elsewhere

The concrete shall meet the specified values for all the above properties. The mean of 28 days cube compressive strength of all the four sets shall be more than or equal to fck + 4.0 MPa and individual test value shall be greater than or equal to fck, where fck is the characteristic cube strength of the concrete in MPa.

6.8.18 ACCEPTANCE TEST AT BATCHING PLANT

To ensure that laboratory proportioned concrete mix meets all the requirements when produced using the actual batching plant and other equipment, at least 4 trials shall be conducted at batching plant. It has to be ensured that all the requirements specified in above clause are met with. At least one test shall be conducted to check the yield of the concrete. In case of significant difference from the theoretical yield and the observed yield, it shall be investigated and rectification measures shall be taken.

Contractor shall submit a detailed report on the concrete mix proportioning to the Engineer for his approval. This report shall include the test results on concrete ingredients, laboratory trial results and batching plant trial results.

6.9 TESTS ON CONCRETE

Samples from fresh concrete shall be taken as per IS 1199 at the placement point or pumping point. Frequency of testing shall be as given in Table 6.20

TABLE 6.20

FREQUENCY FOR DETERMINATION OF PROPERTIES OF FRESH AND HARDENED CONCRETE

Sl. No.	Description of test	Frequency of testing
1	Slump	First 3 transit mixers and then from every 5th transit mixer
2	Temperature	First 3 transit mixers and then from every 5th transit mixer
3	Unit weight	At the time of casting of cubes one sample per day for each grade
4	Air content	One sample per week for each grade
5	Initial and final setting time	One sample per week for each grade
6	Bleeding	Whenever required
7	Cube compressive strength 7, 28 and 56* days	One sample per 50 cum up to 100 m^3 of concrete, there after one sample for each 100 m^3 or part thereof. At least one sample on each day of concreting for each grade.
8	RCPT	One sample per week for each grade
9	Chlorides and sulphate content test	One sample for each grade of concrete per six monthly

- Only for fly ash concrete/GGBS concrete.
- One sample for strength test means sufficient number of cubes to determine average of at least 3 cubes at specified time

6.9.1 ACCEPTANCE CRITERIA

Concrete of each grade shall be analyzed separately. The concrete shall be deemed to comply with the compressive strength requirements when both the following criteria are met with:

a) The mean strength determined from any group of four consecutive test results compiles with the value given in column (2) of Table 6.21

b) Any individual test result complies with the value given in column (3) of Table 6.21

TABLE 6.21

COMPRESSIVE STRENGTH COMPLIANCE REQUIREMENT

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in MPa	Individual Test Result in MPa
(1)	(2)	(3)
M 15	$\geq (f_{ck} + 0.825$ X established standard deviation (rounded off to nearest 0.5 MPa) or $(f_{ck} + 3)$ MPa Whichever is greater	$\geq f_{ck} - 3$ MPa
M 20 or Above	$\geq (f_{ck} + 0.825$ X established standard deviation (rounded off to nearest 0.5 MPa) or $(f_{ck} + 4)$ MPa Whichever is greater	$\geq f_{ck} - 4$ MPa

NOTE:

a. In the absence of established value of standard deviation, the value given in Table 6.18 may be assumed, and attempt should be made to obtain result of 30 samples as early as possible to establish the value of standard deviation.

b. Concrete is liable for rejection, if criteria mentioned in Table 6.21 is not met with.

c. If the concrete, after opening the shutter, is found to be porous or honeycombed, or concrete placing is interrupted without providing a proper construction joint or the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met with, it is liable to be rejected.

d. However, the same may be accepted if remedial measures are feasible and if the same are carried out to the satisfaction of the Engineer-in-charge.

6.9.2 USE OF 7 DAYS TEST

For any mix, a correlation between 7 day and 28 day strengths may be established in the laboratory. Soon after a job starts, a similar correlation shall be established during actual progress of the work. After the correlation has been established, the results of

the 7 day test may be used as the precursor for the expected compressive strength at 28-days. If 7-day test indicates low compressive strength, corrective measures shall be taken without waiting for 28-day strength results. Similarly for concrete with fly ash, GGBS and micro silica, co-relation shall be established between 7, 28 and 56-day compressive strength.

6.9.3 FAILURE TO MEET STRENGTH REQUIREMENT

In the event of concrete, tested in accordance with the relevant standards, fails to meet the acceptance criteria specified in Table 6.21 above with the approval of Engineer, any or all of the following measures shall be taken by the contractor, with no extra cost to the owner.

1. Taking cores from the structural element, where the test has failed, (IS: 456).
2. Extended curing of the concrete represented by the specimen.
3. Load tests on part of structures as per IS: 456.
4. Non -destructive test on structure.
5. Replacement of affected part / parts of the structure.

6.9.4 NON DESTRUCTIVE TESTS

In case of doubts about the quality of concrete in the construction, non -destructive tests shall be conducted as directed by the Engineer. The tests shall be carried out by a specialized agency as per the provisions of IS 456. Based on the NDT evaluation, decision on acceptance of structure or otherwise shall be taken by the Engineer.

6.9.5 CORE TEST

Three cores shall be extracted from the structure for determination of compressive strength represented by that structural element. The diameters of core shall be at least 3 times the maximum size of aggregate used in the concrete and height to diameter ratio shall be 2.0. Core shall be tested as per IS 516. Concrete in the member, represented by a core, shall be considered acceptable, if the average equivalent cube strength of the core (computed as 125% of the core cylinder strength) is equal to at least 85 percent of the specified characteristic strength and no individual average equivalent cube strength of core has strength less than 75% of the specified characteristic strength.

6.10 CONCRETE PRODUCTION, TRANSPORTATION & PLACEMENT

6.10.1 TEMPERATURE CONTROL

a) The concrete placement temperature shall be specified in the construction drawing. Normally, four different placement temperatures i. e. not exceeding 19^0C, 23^0C, 29^0C & 38^0C may be specified in the drawings. Generally, concrete temperature at the production point shall be maintained lower than the specified placement temperature so as to meet the criteria of specified placement temperature. Required temperature shall be achieved by reducing the temperature of water, replacement of part of mixing water with ice flakes and also by controlling the temperature of coarse and fine aggregate.

b) The stockpiles of the aggregate shall be protected from direct sunlight to avoid heating of aggregate. Wherever water is sprayed, suitable correction shall be applied so that the mix proportioning is not altered. Water shall be sprayed on the aggregate stockpile at every 300 mm or 450 mm height as the stockpiles are built up. The stockpiles, thereafter, shall be kept cool by water sprays. Fine aggregate may be stored under shed / in covered area, if the contractor so chooses.

c) If necessary, the coarse aggregate shall be taken into the bins and chilled water at temperature not more than 8^0C shall be sprayed on it through perforated pipe and allowed to be drained through screen fixed at the bottom. Draining screen shall remove excess water from the aggregate. The capacity and arrangement of the bins shall be such as to supply moisture free cooled aggregate to the top of the batching plant so that continuous supply of temperature controlled concrete is maintained.

6.10.2 TRANSPORTATION

a) The concrete shall be transported from the batching plant to the placement point as rapidly as possible by using insulated transit mixers for preventing segregation and loss of any of the ingredients. During hot weather, transit mixer shall be insulated to reduce loss of water by evaporation and heating of concrete from the ambient heat.

b) Once the concrete is mixed in the batching plant, no further water shall be added.

c) Concrete shall be placed and compacted in its final position within the forms within 90 (Ninety) minutes after the addition of water to the mixer or initial setting time of the concrete whichever is less.

d) The Concrete that has been left standing and has become stiff, such that it cannot be placed in satisfactory condition, shall be removed from the place of work immediately.

e) All equipment, used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, transit mixers and other equipment shall be thoroughly cleaned periodically during placement and after completion of concreting.

6.10.3 RE-DOSING OF ADMIXTURES

a) In case, when transit mixer reaches placement point, the loss of slump is observed, re-dosing of admixture may be carried out, to get required consistency for getting pumpable mix. However, basis for re-dosing shall be established by conducting trials in advance to establish re-dosing requirement for getting required slump. The total quantum of admixture established at the trial stages shall, however, not be exceeded during re-dosing.

b) Suitable arrangements for re-dosing of admixture with dispensing unit shall be made to ensure accurate re-dosing and proper mixing.

c) Record shall be maintained for each such re-dosing and shall be incorporated in batch weight record of batching plant. Samples for determination of compressive strength and other parameters shall be taken only after re-dosing.

6.10.4 PLACING OF CONCRETE

a) The concrete shall be preferably placed to its final position in the structure using pumps and placer booms in such a manner that both quality and uniformity of concrete, in terms of W/B or W/C ratio, slump, air content and homogeneity is preserved.

b) Before any concrete is placed, the entire placing programme detailing equipment, layout, and proposed method shall be submitted to the Engineer for approval. No concrete shall be placed until the Engineer's approval is obtained. Such plan shall include all the standby arrangements and shall be submitted at least 48 hours prior to actual concreting.

c) Sufficient plant capacity and transportation equipment shall be available to ensure continuous delivery of concrete at the desired rate of pour. The rate of delivery of concrete shall be such as to ensure proper handling, placing, vibrating and finishing of the concrete and to ensure that the cold joint is avoided. No concrete shall be transported in open, while it rains. If there is any sign of washing of cement and sand, the concrete shall be removed immediately. If the concrete is to be placed at night, sufficient illumination shall be ensured. Safe working condition shall also be ensured.

d) The method of delivering and handling of concrete shall be such as to facilitate placing with minimum of re-handling and without damage to the structure or the concrete.

e) All items to be embedded in concrete shall be correctly positioned and securely held in position, well in advance of placing of concrete. However, shutter alignment shall be checked and cleared only after fixing and correctly aligning the embedded parts.

f) Concrete shall be deposited at or near its final position in the form. The concrete shall not be pushed laterally with the help of vibrator. Struts, stays and braces serving temporarily to hold the forms in correct shape and alignment during the placing of concrete, shall be removed only when the concrete placing has reached an elevation

rendering their service unnecessary. These temporary members shall be entirely removed from forms and not buried in the concrete.

g) While preparing for placing of concrete, all sawdust, wood chips and other construction debris, shall be removed from the forms. Prior to placing of concrete on a rock surface, it shall be thoroughly cleaned and soaked with water for about 24 hours and surface shall be remain moist condition.

h) Concrete shall be placed in such a way that segregation is avoided and also the displacement of the reinforcement and embedment is avoided. Open troughs and chutes shall be of metal or metal lined. Where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths to adjust the direction of movement. The addition of water, at any point in the system of transportation, to facilitate the movement of concrete shall not be permitted. All chutes, troughs and pipes, shall be kept clean and free from coatings of hardened concrete by thoroughly flushing them with water after each placement. Water used for flushing shall be discharged clear of the structure. Concrete shall neither be permitted to fall freely from a height of more than 1.50 m nor to strike the forms at an angle. Where drop chutes are used, a sufficient numbers must be provided so that the concrete discharged from the chutes are not required to flow laterally more than 10 m However, SCC can flow horizontally upto approx. 12 m to 15 m without segregation. Where a drop chute is swung from the vertical, the bottom two sections must be maintained in a vertical position to avoid segregation. Flushing water quality shall be same as that of the water, which is being used, for making concrete. Based on the work demand, if lift height is to be increased beyond 1.5 m proper arrangements for vibration shall be ensured. In locations, where direct placement is not possible and in narrow forms, suitable drop chutes or “elephant trunks” shall be provided to confine the concrete during placement.

i) Concrete shall not be placed into the forms, until the cleaning of concrete surfaces of previous pours and the placement of reinforcing steel and embedded parts have been inspected and cleared by the Engineer.

j) Storm water or water from curing of concrete, which may get accumulated on the surface of the bedding layer, shall be removed by suitable means before start of placement. No concrete shall be placed on a water-covered surface. However, the surface must be sufficiently soaked and shall be in saturated surface dry condition.

k) Concrete shall be placed in successive layers ranging in thickness not exceeding 500 mm or as directed by the Engineer. The bucket loads or other units of deposit shall be spread progressively along the face of the layer with such overlap as will facilitate spreading the layer of uniform depth and texture with a minimum hand shoveling. Any tendency to segregation shall be corrected by shoveling stones into mortar rather than mortar on to stones. If such condition arises, the cause or causes shall be investigated and corrective action shall be planned. If required, mix proportion can be revised or method of placement can be modified.

l) When less than a complete layer is placed in one operation, it shall be terminated at a vertical bulkhead. Each layer of concrete shall be placed and compacted before initial setting of concrete of the previous layer takes place, to prevent injury to green concrete and to avoid separation between the consecutive layers.

m) During hot weather and rains, the concrete shall be covered with tarpaulins. Transportation, placement and consolidation of concrete shall be done in shortest possible time. Adequate precautions shall be taken to cover the transit mixer and chilled water may be sprayed over the transit mixer and the pipelines to maintain the temperature during the hot weather.

n) When concrete is to be placed in hot weather conditions, special provision shall be made for handling, placing and protecting the concrete, to ensure that concrete of full strength and free from damage, is obtained. For meeting the desired objective, means such as concreting during cooler hours of the day, use of chilled water, cooling of pipes etc., shall be resorted to. Commencement of concrete pour shall be avoided during heavy rains, storms and high winds.

6.10.5 COMPACTION

a) Vibrator should be inserted and withdrawn vertically at close intervals, using a systematic pattern of vibration to ensure that all concrete is adequately consolidated. As long as a vibrator needle sinks into the concrete by its own weight, it is not too late for the concrete to benefit from re-vibration, which improves compressive and bond strengths. Vibrators should not be used to move concrete laterally

b) On vertical surface, where air void holes are expected, voids can be reduced by the use of form vibrator or light tamping with wooden mallets.

c) Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into corners and angles of the forms.

d) Internal vibrators shall be inserted in a vertical position only, at intervals of about 450 mm depending upon the mix, the equipment used, the type of structure and experience gained on job. The vibrator needle shall be inserted by minimum 100mm in the previously laid layer. The zone of influence of needle vibrator is approximately 100 times cross sectional area of the needle being used. The vibrators shall be withdrawn slowly, approximately at the rate of 75 mm/sec. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to move concrete laterally inside the forms. Vibrator needle shall be kept clear of forms least by 100 mm. Over-vibration as well as under vibration shall not be done.

e) The internal-immersion type vibrators shall be high frequency vibrators with speed of not less than 7000 rpm when immersed in the concrete. Vibrators shall be used in sufficient numbers and power of each unit to properly consolidate all concrete in each layer immediately after it has been placed in the forms. It shall be ensured that sufficient numbers of vibrators are available at site along with adequate standby units.

f) While placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be taken to ensure adequate vibration, blending and melding of the concrete between the succeeding layers. The vibrator shall penetrate full in the layer being placed and also penetrate the layer below by about 50 mm while the under-layer is still plastic, to ensure good bond and homogeneity between two layers and prevent formation of cold joints.

6.10.5.1 USE OF FORM VIBRATORS

In case of the columns having congestion of reinforcement, supplemental form vibration may be used in addition to needle vibrators. Care should be taken to avoid excessive vibration, which would cause a weak paste on surface. However, this shall be preplanned activity and shutter as well as staging shall be designed for the additional loads form the vibrators.

6.10.5.2 USE OF SURFACE VIBRATORS

Surface vibrators may be used for horizontal elements like slabs. The vibrator operator shall be qualified before deploying on a job. Re-qualification shall be carried at suitable interval.

6.10.6 CONSTRUCTION JOINTS AND KEYS

When the work is to be interrupted, horizontal and vertical construction joints and bonding keys shall be located and shall conform to the details given on the drawings. In case of water retaining structure, containment structure and other structures, water stops as specified on the drawing shall be provided.

In case of columns, beams and slabs etc, the location of the joints shall be as indicated in the drawing or as directed by the Engineer. Concrete in a beam shall be placed throughout, without a horizontal joint. Before fresh concrete is placed, cement skin or any loose or porous material of partially hardened concrete shall be thoroughly removed and cut back until the solid face is exposed and surface made rough by hacking, or any other method. Rough surface shall be thoroughly wetted for about two hours and shall be in surface dry condition before new layer of concrete is placed over it.

6.10.7 TREATMENT ON SUSPENSION OF WORK

Whenever work is suspended on any section for more than two hours, the horizontal edges of the concrete next to the forms on surfaces that will be exposed shall be brought to a horizontal plane perpendicular to the plane of the forms and treated, so that the finished work will show smooth straight lines.

6.10.8 EXPANSION JOINTS AND SEPARATION JOINTS

These joints in concrete structures shall be provided, as specified in the drawing. The thickness of polythene sheet, if used, shall not be less than 500 microns. For Expansion joints relevant specification shall be followed.

6.10.9 WASH WATER

Wash water shall be removed in a manner to prevent running down and staining of concrete surfaces, exposed on completion of the job. Should unsightly wash-water streaks develop on the exposed surface, the same shall be removed to get a uniform colour and texture.

6.10.10 PLACEMENT INTERVAL

Placement interval between two subsequent or adjacent pours shall be as specified in the drawing.

6.10.11 CONSTRUCTION JOINT TREATMENT

Green cutting shall be made to treat the entire construction joint. Suitable surface retarder shall be used to retard the setting of concrete to a depth of 5 to 7 mm from the exposed surface that is going to receive subsequent concrete.

Green cutting shall be done by using air water jet at a suitable pressure to remove laitance from concrete surface at construction joint, exposing aggregate matrix, and shall be done only after the concrete is in final set condition. The water from the air water jet, used for green cutting of the concrete surface, shall be properly drained so as not to harm the quality of the concrete already placed. It shall also be ensured that this water does not get stagnated on the surface of concrete, depositing washed cement particles. As a pre-qualification, field mock-ups shall be conducted to check the adequacy of the material and method to be deployed on the job, before adopting in the field. In case of change in material source / type or methodology of green cutting, pre-qualification shall be redone. In areas where green cutting is not feasible, spraying of retarders followed by wire brushing immediately after final setting shall be adopted.

Approved brand of surface retarding (set retarding) agent shall be used for preparation of construction joint by green cutting of concrete. It shall be solvent free poly-hydroxyl compound and shall have a distinctive colour, which could be easily identifiable on its application over concrete. It shall be suitable for removing the cement-sand matrix between 5 to 7 mm depth after final setting time, when air water jet with a pressure of around 7 Kg/cm^2 from distance of approx. 500 mm is used. It may be noted that there is no specific testing for qualification of surface retarders other than its meeting desired performance specified above.

6.10.12 PLACEMENT OF CONCRETE AROUND LARGE OPENINGS

While placing concrete around large openings in walls, adequate care shall be taken to ensure proper flow and compaction of concrete on the underside of such openings. Adequate number of windows shall be provided in the formwork for air to escape and also for insertion of vibrators. Once the concrete reaches the level of such window, the same shall be properly closed before proceeding with further concreting.

6.10.13 PLACING CONCRETE BY PUMPING

a) As far as possible, concrete shall be placed using pumping. A steady supply of pump-able concrete is necessary for satisfactory pumping. Concrete pumps to be deployed on the work shall be able to deliver concrete at a desired rate up-to the placement point uninterruptedly.
b) Requisite numbers of concrete pumps, capable of pumping concrete at required rate, together with a complement of pipelines, accessories, spare parts, power controlled placer booms, experienced pump operators and maintenance staff shall be deployed.
c) The pumping plant shall be installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of concrete, to enable conducting pump-ability tests and necessary adjustments for the mix proportioning, prior to use in actual work.

6.10.14 PUMPABILITY TRIALS

No mix shall be used in actual work until pump-ability trial is conducted. The actual field condition shall be simulated. The batching and conveying by transit mixers shall be in the same way as that will be in actual work. The pipe and hose layouts shall simulate the actual condition, as far as practicable. The system shall be able to meet uninterrupted desired supply of cohesive mix at the placement point. The samples shall be collected at batching plant, at pumping point and at placement point after pumping for slump and determination of compressive strength.

6.10.15 FIELD PRACTICES

a) Proper planning of concrete supply, pump location, line layout, placing sequence and the entire pumping operation shall be done by the Contractor, before commencement of concreting.

b) The pumps shall be as near to the placing area as practicable and proper access roads shall be available for movement of transit mixers and other equipment around the location.

c) Direct communications shall be maintained between the pump operator, concrete placing crew and the batching plant. As a final check, the pump shall be started and operated without concrete to assess that all moving parts are in operating conditions.

d) The mortar shall be pumped into the line to provide initial lubrication for the pump and pipeline. The mortar used for lubrication shall be collected in the bucket and disposed off. This mortar shall not be placed in the forms. As soon as concrete is received, the pump shall be run slowly until the lines are completely filled and the

concrete is slowly moved. Once the pumping starts, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking.

e) Continuous pumping should be ensured. If delay occurs due to supply of concrete, form repairs, or any other reason, the pump shall be slowed down to maintain some movement of the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be kept moving in the line by giving one stroke of the pump at longer interval. In confined areas, attempt shall be made by the Contractor to run a return line back to the pump, so that the concrete can be re-circulated during such delays.

f) Minor blockages shall be cleared by operating a few strokes of the pump in reverse direction and then by returning to normal forward pumping. If this fails, a succession of reverse and forward strokes shall be carried out to remove the blockage. Should this fail, the blockage may be due to air lock and the entrapped air has to be removed.

g) Blockages in the pipe are usually assessed by the sound when the pipe is struck. To remove the obstruction, the concrete pipe shall be taken out at the assessed location and cleaned. The pumping process shall then be started again.

h) This method of checking the blockage and setting it right shall be done as early as possible, as excessive delay will cause setting of concrete in the pipeline downstream of the blockage. When the blockage is being found out and remedial measures taken, the pump shall periodically be given one or two strokes forward to keep the concrete in motion. If blockage occurs in the placer boom, a pipe joint near the base of the placer boom shall be opened and the boom made vertical to drain the concrete by gravity.

i) The termination of pumping operation shall be carefully planned to utilize the concrete dormant in the pipeline and the hopper, when the pump is stopped. However, concrete at placement point shall be kept green, avoiding cold joint, by operating standby pump or by any other standby arrangement.

j) When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a go-devil be inserted and forced through the line to clear it out. Water under pressure shall be used to push the go-devil. The go-devil shall be stopped about one meter from the end of the line, so that the water in the line does not spill over into the placement area. After flushing, water in the pipe shall be removed by drain cock provided for this purpose, in the lowest part of the line. After all concrete has been removed from the line, pipes and equipment shall be immediately cleaned.

6.10.16 QUALITY CONTROL

Contractor shall ensure good workmanship and also the plant shall be maintained to meet peak demand. Degree of control on all the concrete operation, right from

selection of the ingredients to the final testing of specimen, shall be in line with the approved Quality Assurance Plan.

The Contractor shall engage experienced supervision at all levels. Complete crew, engaged in each of the concreting activity, shall be duly qualified for a particular activity and shall demonstrate their skills and capabilities to produce the final product meeting specified parameters.

6.10.17 CURING OF CONCRETE

a) Exposed surface of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least 7 days (10 days for hot weather condition) from the date of placing concrete in case of OPC Concrete and at least 10 days (14 days for hot weather condition) where mineral admixture or blended cement is used. The Quality of curing water shall be the same as that used for mixing concrete. Any type of the covering that would stain or damage the concrete during or after the curing period shall not be permitted. Covering shall be kept continuously wet during the curing period.

b) The structural elements with concrete having low water binder ratio and also when cement is partially replaced by pozzolanic material, the curing shall be done in two stages viz., initial curing and final curing.

c) **Initial Curing:** The initial curing shall start immediately after finishing. The concrete surface exposed to environment shall be kept covered by plastic sheet or other type of impermeable covers. The wet curing shall start immediately after the final set. This shall be carried out with the help of placing wet burlaps over the concrete surfaces.

d) **Final curing:** The final curing shall be done with water. It shall commence immediately after initial curing and continue upto a minimum period specified above. Hessian cloth can be wrapped on to columns and on vertical surfaces and the same shall be kept wet all the time by a suitable arrangement.

e) Contractor shall make suitable arrangement for continuous water supply, along with necessary equipment for getting a nozzle pressure of not less than 7 kg/cm^2, even at the highest elevation, for convenient and effective jetting on concrete surfaces for green cutting, for cooling aggregate, for curing and for other requirements. All necessary appliances such as hose, sprinklers, spraying devices etc. may be made available.

f) For curing of concrete in pavements, sidewalks, floors, flat roof or other level surfaces, the ponding method of curing is preferred. Special attention shall be given to edges and corners of the slab to ensure proper protection. The ponded area shall be kept continuously filled with water throughout the curing period.

g) **Membrane Curing:** Curing compound may be used in lieu of moist curing with due qualification of material and process, if permitted by the Engineer. Such compounds

shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

6.10.18 PROTECTING FRESH CONCRETE

Newly placed concrete shall be protected from rain, sun and wind. Concrete placed below the ground level shall be protected from falling earth during and after placing. Concrete placed in ground, containing deleterious substances, shall be kept free from contact with such ground or with water percolating from such ground during placing of concrete and for a period of at least 3 days. The ground water around newly poured concrete shall be maintained to a level lower than the fresh concrete layer by pumping or other means of drainage. Adequate steps shall be taken to prevent flooding. Fresh concrete shall be protected by, leaving the forms in place, prevention of disturbing shocks and vibrations and avoiding premature stressing until the concrete attains sufficient strength to sustain such loads or shocks.

6.11 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

A procedure shall be prepared by the contractor for carrying out inspection, repair and replacement of unsatisfactory concrete. Repair of unsatisfactory concrete shall be carried out by means of removing the unsatisfactory portion and replacing it with new concrete. Suitable keys, dovetail slots etc. may be provided to get proper bond between new concrete and old concrete. Prepared surface shall be kept wet for 24 hours immediately before the patching material is placed. However, surface shall be dry. Repair of concrete shall be carried out using skilled workmen. Repairs shall be undertaken as soon as practicable, after removal of forms, so as to meet the requirements of finish in that particular location. The portion of the concrete to be repaired may be reinforced with steel mesh, if directed by the Engineer. The contractor shall carry out all such repair with no extra cost to the owner.

The complete methodology for the repair shall have approval of the Engineer before undertaking such repair job. Proper curing shall be ensured for the repaired portion.

6.11.1 USE OF EPOXY

For bonding fresh concrete with old concrete epoxy shall be used if specifically directed by the Engineer. The type of epoxy and its application shall be as directed by the Engineer. Epoxy shall be applied in strict accordance with the instructions of the manufacturer. Approved material shall be arranged by the Contractor to undertake this activity.

The epoxy shall meet the requirements of ASTM C-881 and shall be used as per manufacturer’s recommendations.

6.11.2 REPAIR WITH EPOXY MORTAR

The defects in concrete (within the acceptable limits, as decided by the Engineer) may be repaired using Epoxy mortar as per the instructions of the Engineer. No extra payment shall be made for such repairs.

6.11.3 MATCHING OF PATCH SURFACES

Filling material used in repair of surfaces, which will be exposed after completion of the project, shall be used with cement from the same source as that used in concrete and blended with a sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. Patched surface shall be given a final treatment to make the texture of the patch to match with the surrounding area.

6.11.4 CURING OF PATCH WORK

Immediately after any patchwork is completed, the area shall be covered with non-staining, water-saturated material and the same shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the area shall be kept continuously wet by a fine spray or sprinkling of water. The layers of patch may be reinforced with steel wire mesh, if directed so by the Engineer at no extra cost to the owner.

6.11.5 APPROVAL BY ENGINEER

All materials, procedures and activities for repair work as well as finishing work shall be subject to the approval of the Engineer.

6.12 FINISHING & OTHER GENERAL WORKS

6.12.1 FINISHING

a) Unless otherwise specified, concrete finishes shall conform to the following classifications and shall be provided as specified in the drawing.

b) Finish F1, F2 and F3 shall describe formed surfaces.

c) Finish U1, U2 and U3 shall describe unformed surfaces.

d) Offsets or fins caused by displaced or misplaced form panels, lining or form section or by defective form lumber shall be referred to as ‘abrupt irregularities’. All other irregularities shall be referred to as ‘Gradual irregularities’. Gradual irregularities shall be measured as deviation from a plane surface with a template 1.5 m long for formed surfaces and 3.0 m long for unformed surfaces.

6.12.2 FORMED SURFACE

a) Finish F1 shall apply to all formed surfaces for which finish F2, F3 or any other special finish is not specified.

b) Finish F1 shall include filling all form tie holes and localized air holes.

c) Finish F2 shall apply to all formed surfaces as shown on the drawings. Finish F2 shall include filling all form tie and localized air holes, repair of gradual irregularities exceeding 6 mm, removal of ridges and fins and abrupt irregularities by grinding.

d) Finish F3 shall apply to all formed surfaces exposed to view or where shown on the drawings. It shall include all measures specified for finish F2. In addition, filling air holes with mortar and treatment of the entire surface with sack rubbing shall include in F3 finish. It shall also include clean up of loose and adhering debris. The surfaces shall be prepared within two days after removal of the forms. The surfaces shall be wetted and allowed to dry slightly before mortar is applied by sack rubbing. The mortar used shall consist of one part cement to one and half part by volume of fine sand passing IS No. 16 sieve. Only sufficient mixing water, to give the mortar a workable consistency, shall be used. The mortar shall then be rubbed over the surface with a fine burlap or linen cloth so as to fill all the surface voids. The mortar in the voids shall be allowed to stiffen and solidify after which the whole surface shall be wiped clean with burlap so that the entire surface presents a uniform appearance without air holes and irregularities. The finished surface shall be cured for a period of 3 days.

6.12.3 UNFORMED SURFACES

a) Finish U1 shall apply to all unformed surfaces for which finish U2, U3 or any other special finish is not specified. Finish U1 shall include screeding the surface of the concrete to the required slope and grade, as specified on drawings.

b) Surfaces, to be covered with concrete topping, terrazzo etc., shall be smooth, screeded and leveled to produce an even surface and irregularities not exceeding 6 mm.

c) Finish U2 shall apply to all unformed surfaces, as shown on the drawings. Finish U2 shall include screeding and applying a wood float finish to the surface of the concrete to the required slopes and grade, repair of abrupt irregularities unless a roughened texture is specified and repair of gradual irregularities exceeding 6 mm.

d) Finish U3 shall apply to unformed surfaces for which a high degree of surface smoothness is required, where shown on the drawings. Finish U3 shall include screeding, floating and applying a steel trowel finish to the surface of the concrete to the required slope and grade, repair of gradual irregularities exceeding 6 mm, finishing joints and edges of concrete with edging tools.

6.12.4 FOUNDATION BEDDING, BONDING AND JOINTING

a) All surfaces or concrete beds shall be prepared by suitable shaping, thorough cleaning, washing and keeping the surface in SSD condition

b) All soil surfaces, upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or yielding soil shall be removed and replaced with lean concrete or with selected soil and compacted to the same density as the surrounding area. The surface of absorptive soil, against which concrete is to be placed, shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete.

c) The concrete surfaces, upon which additional concrete is to be placed, shall be prepared by green cutting technique. Surface retarder shall be spread on the surface of newly laid concrete, just after finishing work is completed. After the concrete attains final set, high-pressure air water jet shall be used to remove cement matrix, exposing aggregate matrix. The water shall be drained properly along with cement particles. In case where green cutting is not adopted, with approval of the Engineer, scarifying and cleaning while the concrete is between its initial and final set shall be done. Great care shall be taken in performing this work to avoid removal of too much mortar and weakening of the surface by loosening of aggregate.

d) Concrete surfaces, upon which new concrete is to be placed, shall be cleaned and wetted, immediately before placement of the concrete. The bonding shall be with mortar having the same cement-sand ratio as that of the concrete being placed. Cost of the same will be deemed to have been included in the rate for concrete. However, no bonding mortar is required when green cutting technique is adopted for surface preparation.

Similar treatment shall be given at vertical construction joint.

6.12.5 WORKMANSHIP OF CONCRETE

Workmanship shall be conforming to relevant Indian Standards and good engineering practices. The mix proportioning shall have prior approval of the Engineer. Concrete shall be produced at fully automatic batching plants. In case, where the tilting drum mixer is used, adequate and accurate weight batching arrangement shall be provided. Tilting drum mixer shall be fully discharged before taking new batch. Partly set concrete shall be immediately removed. On completion of work the mixer as well as all other equipment shall be thoroughly cleaned.

6.13 SELF-COMPACTING CONCRETE (SCC)

Self-Compacting Concrete shall conform to European specification for Self-Compacting Concrete – Specification, Production and Use. All the ingredients of SCC are same as that of normal concrete, except Viscosity Modifying Agent (VMA) as an additional ingredient Quality of all the ingredients shall be the same as that for normal concrete. VMA shall be added to increase shear resistance of the concrete. All

the test equipment as well as desired parameters for fresh concrete shall be as detailed in European specification. After the mix proportion is finalized, adequate mock-ups shall be done, to ensure consistent quality of self-compaction. SCC may be used for casting all the structural elements of the plant buildings. It shall be kept in mind that formwork design shall be carefully done for SCC, as the SCC remains in liquid form for a longer period. As far as possible, pumping shall be resorted to. All other requirements for testing shall be the same as that of normal concrete, specified elsewhere in these specifications.

Properties of the fresh concrete are to be checked as per the provisions in the European specification. The desired parameters are given in Table 6.22. Testing methods and testing equipments like flow table, V-funnel, L-box, U-box, fill box and segregation resistance test shall be as per European specification. The tests to be carried out to establish various properties are given in Table 1.24. Once it is established that the mix proportion is meeting the desired parameters and after establishing the consistency of the results, the flow table test and V- funnel test are to be conducted at production point and placement point as a quality control measures. For hardened concrete, the tests specified in Table 6.20 are to be carried out. These Two (2) tests shall be conducted for first 3 transit mixers and subsequently one for every set of 5 transit mixers.

TABLE 6. 22
PARAMETERS FOR SCC

Sl. No.	Test	Unit	Minimum	Maximum
01	Slump flow	mm	650	800
02	T50 cm slump flow	Sec	2	5
03	“V” funnel	Sec	5	15
04	‘L’ box	h_2 / h_1	0.8	1.0
05	‘U’ box	$(h_2 - h_1)$ mm	0	30
06	Fill box	%	90	100
07	Segregation Resistance test	%	-	20

TABLE 6.23
PROPERTIES TO BE ESTABLISHED BY TESTS

Slump flow test	Stability of mix (Cohesiveness)
T-50 cm time slump flow test	- do -
V-funnel test	Flow ability
L-Box test	Passing ability
U-Box test	- do -
Fill box test	Filling ability
Segregation Resistance test	Segregation

6.14 MATERIAL TESTING LABORATORY

The contractor shall establish a state of the art material-testing laboratory at site for testing of all the concrete ingredients, fresh concrete and hardened concrete. Fully automatic cube testing machines of adequate capacity and numbers shall be installed in the laboratory. Facilities for water permeability test as per DIN 1048 and Rapid Chloride Permeability Test (RCPT) as per ASTM-C-1202 shall also be available in the laboratory. Laboratory pan type mixer shall be available with the Contractor.

7. FORM WORK

7.1 SCOPE

The work covered under this section shall include the providing, erection and removal of formwork for all normal, and pre-cast concrete in walls, columns, foundations, slabs and beams, including its supporting members.

7.2 GENERAL

7.2.1 The formwork shall consist of but not limited to shores, bracings, sides of beams, columns, walls, rafts and bottom of slabs including ties, anchors, inserts, hangers, false work, wedges, etc. complete which shall be properly planned for the work. For the floors, supports can be taken from the floor down below with prior permission of the Engineer. Wherever required, provision shall be made to support the floor shuttering by means of trusses, which shall be spanned from the nearby walls/columns. Wherever specified, the left-in shuttering of adequate capacity shall be used.

7.2.2 The Contractor shall prepare, before commencement of actual shuttering work, design and drawing for formwork and centering and get them approved by the Engineer well in advance before fabrication and erection of formwork. Formwork shall be designed to fulfill the following requirements.

a) Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

b) Made of suitable materials.

c) Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.

d) Capable of withstanding without deflection the worst combination of self-weight, reinforcement and concrete weight, all loads including lateral pressure on vertical surfaces and dynamic effects arising from construction and compacting activities, wind and weather forces.

e) Capable of easy striking without shock, disturbance or damage to the concrete.

f) Soffit forms capable of imparting a camber if required.

g) Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete, design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

7.2.3 Forms shall conform to the shapes, lines, grades and dimensions including camber of the concrete as called for on the drawings. Ample struts, walers, braces, etc. shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of forms. Unless otherwise specified all forms in contact with concrete having F-3 finish shall be plywood panel formworks. Forms will be firmly bolted to previous pour of concrete. No through bolts embedded in concrete will be permitted in any underground structures. Threaded mild steel sleeves designed for holding in concrete and standard coil nuts/cone anchors shall be embedded in preceding concrete pours to anchor tie rods on lower end, while on the other end tie rods shall be provided beyond the lift under construction. Tie arrangement with baffle plate within the concrete may also be used as substitute for through tie with prior approval of the Engineer. The Contractor should finish all the coil nuts by dry packing. The recesses, if any, formed by removable timber wedges shall be filled with caulking compound or Epoxy mortar if depth is less at the Contractor's own cost. Formwork for removable hatchways and plugs shall be installed in place wherever possible. Back form for sloping concrete surfaces shall be provided as decided by the Engineer at no extra cost.

7.3 DESIGN AND FIXING OF FORMWORK

The formwork shall be designed and fixed to meet the tolerance in various areas as specified elsewhere in this specification. All floors and beam centering shall be crowned not less than 8 mm in all directions for every 5-meter span. Forms in contact with concrete shall be free from adhering grouts, projecting nails, splits or other defects. Formwork shall be so designed and erected with the forms for slab so that the sides of beams, columns and walls may be removed first, leaving the formwork to the soffits of beams and their supports in position. Where formwork for column is erected for its full height, one side shall be left open and built up in sections as placing of concrete proceeds, if so directed by the Engineer.

7.4 DESIGN LOADS

7.4.1 Unless prior approval in writing has been received from the Engineer all vertical wall forms shall be constructed for the minimum pressure as per CIRIA/ European Guidelines recommendations. The Contractor shall ensure that the constructions of the forms are adequate for all concrete placing condition and all the applicable CIRIA/European Guidelines recommendations are followed. However, in case of self-compacting concrete, the entire height of the pour shall be considered to be in fluid state and the lateral pressure shall be w x h, where "w" is the unit weight of green concrete and "h" is the height of pour.

7.4.2 All horizontal forms shall be constructed for pressures from the dead load of concrete including embedment and a minimum live load of 200 Kg/sq.m.

7.4.3 Forms constructed for retaining heavy concrete shall be built for pressures which have been increased by the ratio of the unit weight of heavy concrete to normal concrete.

7.4.4 Further, the formwork shall be designed to withstand all pressures arising out of placement of concrete using pumps, incidental loads if any and live load on the working platforms.

7.4.5 The form work shall be designed and fixed to meet the tolerances in various areas specified by the Turbine Manufacturer or as specified in the relevant drawings

7.5 TEMPORARY OPENINGS

Temporary openings, which can be conveniently closed, shall be provided at the base of the columns and wall forms and other places necessary to facilitate cleaning, inspection and vibration of concrete. Immediately before concrete is placed the forms shall be made sufficiently rigid and tight, thoroughly cleaned properly treated and free from foreign material. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected.

7.6 MATERIALS

7.6.1 Materials for the formwork shall be of plywood, formed steel plates, timber form covered with steel sheets, oil tempered hard board. Sliding forms and slip form shall be used for tall structures where specified and after approval by the Engineer. The supporting system shall be either adjustable props made of mild steel pipes for heights up to 6 meter or composite columns fabricated using M.S. Structural steel members.

7.6.2 Shuttering arrangement for concreting shall be of 12 mm/16 mm thick plywood backed with steel/DOKA framework and supports of horizontal and vertical walers connected to turn buckles. In case steel shuttering plates are used for formwork, the joints between the panels shall be sealed with suitable foam to make the formwork leak tight. Flat bar at top of soldier to be provided for maintaining thickness. Supports shall be rigid and strong enough to withstand effect of vibration without any deflection, bulging, distortion or loosening of its supports and shall be so as to prevent loss of slurry from the concrete. Plywood used shall be waterproof plywood conforming to IS: 4990. Test certificates from the manufacturers will be obtained and verified. Form strips or any other suitable sealing tapes will be used to prevent loss of slurry through the joints of formwork.

7.6.3 Suitable working platform will be provided for execution/ inspection of reinforcement, embedded parts and concreting.

7.7 CENTERING REQUIREMENTS

Centering using steel tubular props, H frames, built-up sections, with provisions to adjust heights of props shall be used and they shall be to true levels and rigid. They shall be adequately braced horizontally and vertically. For faster construction, quick strike decking system/ Acro/Doka systems shall also be used for shuttering supported on floors below, vertical props shall be so supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the shuttering. Bamboos or wooden poles shall not be used as props or cross bearers. Centering supported on structural steelwork shall also be designed for the conditions mentioned above.

7.8 TIE RODS

As far as possible MS tie rods left in type shall be used for supporting all forms. Retrievable type can also be used with prior approval of the Engineer. Tie rods shall have provisions for removal of a section of each rod at surface of the concrete to a depth of approximately 50 mm. All holes left by the removal of conical nuts or other removable fixtures embedded in the face of the concrete shall be filled and finished with sand-cement mortar in a manner specified in the finishing specification. Threaded inserts embedded on each face of the wall be cut for attaching the forms to previously placed concrete and when permitted shall be out off flush with the face of concrete or countersunk, filled and finished as required by the Engineer in the manner specified in the finishing specification. Measures shall be taken to prevent rust stains on concrete.. Through left-in Tie rods shall be permitted only upon approval of the Engineer.

7.9 FORM OIL

7.9.1 *Use of form oil shall not be permitted on the* surfaces, which require painting. If the Contractor desires to use form oil on the inside of the formwork of the other concrete structures, a non-staining mineral oil or other approved oil may be used provided it is applied before placing reinforcing steel and embedded parts. Such form oil shall be insoluble in water and not injurious to concrete and shall not become flaky or be removed by rain or wash water. Form oils that retard the setting of concrete shall not be used.

7.9.2 All excess oil on the form surface and any oil on metal or other parts to be embedded in the concrete shall be carefully removed. Before treatment with oil, forms shall be thoroughly cleaned of dried splatter of concrete from placement of previous lift.

7.9.3 The Contractor shall clean the concrete surfaces from any leftover form oil at his own cost if form oils are used.

7.10 SUSPENDED FORMWORK

7.10.1 In certain areas, as identified by the Engineer, metal decking/ and supported on structural steel framework shall be used as self-supporting shuttering as an alternative to the conventional shuttering in places where the area below has to kept free of scaffolding and centering works. The fixing of metal sheets to structural steel members shall be done by bolting / welding or any other alternative as advised by the Engineer .

7.10.2 Plate inserts may be embedded in the sidewalls during concreting, from which bracket supports can be obtained. Structural steel built-up sections or trusses shall be used for supporting the formwork. The Contractor shall submit the design and detailed drawings for the above scheme for the approval of the Engineer. The scope of work shall include design, fabrication, erection and dismantling of the supporting structure.

7.11 CHAMFERS AND FILLETS

Unless shown on drawings or elsewhere to the contrary, all corners and angles shall be formed with 45 Degree mouldings to form chamfers or fillets on the finished concrete. The standard dimension of chamfers and fillets, unless otherwise detailed or specified shall be 25 mm by 25 mm. For heavier work, chamfers or fillets may be 40 mm to 50 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the mouldings shall be planed or surfaced to the same texture as the forms to which it is attached. Unit rates quoted shall include providing the chamfers as specified or shown in the drawings.

Vertical construction joints on faces, which will be exposed at the completion of the project, shall be chamfered as above except where not permitted by the Engineer.

7.12 JOINTS

Joints in forms shall be truly horizontal or vertical unless otherwise specified and shall be sufficiently tight to prevent any leakage of cement slurry to avoid formation of fine or blemish. Faulty joints shall be sealed as directed by the Engineer. Suitable devices shall be used to hold adjacent edges together in accurate alignment. The Contractor shall use sealing tapes to avoid leakage of slurry through the formwork joints. On removal of forms the Contractor shall finish marks left by sealing tapes so as to merge with other concrete surface. The Contractor shall take care to maintain symmetry in formwork in slabs, walls, columns etc. so as to give a pleasant appearance to finished concrete surface. All forms shall be so made that they can be removed without hammering or prying against the concrete.

7.13 REUSE OF FORMS

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired or re-oiled before resetting. Formwork shall not be used/ reused, if declared unfit or unserviceable by the Engineer.

7.14 CLEANOUT PROVISIONS

Forms with limited working space within, shall be provided with temporary clean-out doors or openings for cleaning, washing, blowing and removal of water, wood chips, trash etc.

7.15 WORKING PLATFORM

The Contractor shall provide safe working platform for workmen, when working above ground level. Safe method of approach shall be provided to reach locations above ground level. Handrails shall be provided for all working platforms. Hanging platforms shall have safety net provisions. All ladders shall have handrails and shall not be kept vertical. All platforms, ladders, handrails etc. shall be firmly secured to ground or on supports. No loosely supported ladders or platforms shall be used in the work. All ladders and platforms shall have a kick plate 150 mm high either MS or wooden board for safety of personnel. Ladders and platforms shall be periodically cleaned of loose debris etc.

7.16 REMOVALOF FORMS

7.16.1 In the determination of time for removal of forms, consideration shall be given to the location and character of the structure, the weather and other conditions including the setting and curing of the concrete and materials used in the mix.

7.16.2 Forms and their supports shall not be removed without approval of the Engineer. Improper methods of removal of formwork likely to cause overstressing or damage to the concrete shall not be used. Supports shall be removed in such a manner so as to permit the concrete to uniformly and gradually take the stress due to its own weight.

7.16.3 The supports can be reinstated in anticipation of abnormal conditions. Re-propping of beams shall not be done except with the approval of the Engineer.

7.16.4 The minimum period for removal of forms shall be as mentioned below. However, The seven-day test results shall be as per IS: 456 (latest revision). If the strength requirements are not met with, the formwork shall be removed as per the instructions of the Engineer.

TABLE 7.1

MINIMUM PERIOD FOR REMOVAL OF FORMWORK

Sl. No.	Class of Structures	Earliest Concrete age at stripping for placing Temperature above 20 deg. C	
		Where ordinary Portland cement is used	Where mineral admixture is used
1.	Walls, Columns & Vertical sides of Beams	24 to 48 hrs. as decided by the Engineer	48 to 96 hours
2.	Slabs (props left under)	3 days	7 days
3.	Beam soffits (props left under)	7 days	14 days
4.	Removal of props to slabs		
	For thickness above 300mm		
	a) Spanning upto 4.5M	14 days	21 days
	b) Spanning over 4.5M	21 days	28 days
	For thickness upto 300mm		
	a) Spanning upto 4.5M	7 days	14 days
	b) Spanning over 4.5M	14 days	21 days
5.	Removal of props to beams and arches		
	a) Spanning upto 6M	14 days	21 days
	b) Spanning over 6M	21 days	28 days
6.	Cantilever construction	Not until adequate fix-ity is developed subject to a min. of 10 days	Not until adequate fix-ity is developed subject to a min. of 21days

7.16.5 For rapid hardening Cement Concrete 3/7 th of the period specified for ordinary Portland Cement will be sufficient subject to the minimum period of 24 hours.

7.16.6 Striking shall be done with utmost care to avoid any damage to concrete surfaces or any projections on it and without shock and vibrations, by gently easing the wedges/jacks. If after removing the formwork, it is found that timber has been embedded in the concrete, it shall be removed and made good as approved.

7.16.7 Tie rods, clamp form bolts etc., which must be entirely removed from the walls or similar structure, shall be loosened not sooner than 24 hours after the concrete was deposited. Works damaged due to premature or careless removal/withdrawal/ loosening/striking of forms shall be reconstructed at Contractor's cost.

7.17 STOPPER FORMWORK

Stopper formwork (Bulkhead) shall be provided at all vertical construction joints. Such formwork shall be leak-tight and shall not allow leakage of cement slurry. Wherever specified in the drawings, gas barrier/water stopper shall be provided in the stopper shutter. In addition to the erected stopper, emergency stopper formwork shall be kept ready before starting large concrete pours, with provision for gas barrier/water stopper if required. All stopper formwork shall be measured and paid in the item of

formwork only.

7.18 SLOPING FORMWORK

The bottom formwork shall be made out of plywood with wooden backing members. For slope above 15 Degree with the horizontal it is recommended to have plywood formwork for the top surface and supported on steel or wooden truss. These shall be divided into panels, which shall be fabricated in the shop to the required profile. The bottom of truss will be closed by plywood formwork at the time of concreting. Subsequently further closer formwork for the top surface will be extended after concreting and compaction of the lower portion The entire formwork shall be supported on structural steel/scaffolding supported on a firm base.

7.19 FORMWORK FOR SELF COMPACTING CONCRETE

The formwork shall be made out of plywood with wooden backing members. These shall be divided into panels, which shall be fabricated in the shop to the required profile. Special care should be taken so that there is no gap in the formwork joints so as to ensure not leakage of slurry due to increased workability and slump achieved by using appropriate admixtures. The lateral green concrete pressure on the formwork shall be governed as per Para titled “DESIGN LOADS” of this specification.

7.20 POCKETS FOR FOUNDATION BOLTS

Pockets for foundation bolts shall be made out of plywood or timber. These shall be made slightly tapered for ease of removal. The bottom of such formwork shall be necessarily closed so as not to allow entry of concrete from bottom. The timber pocket may have to be broken to withdraw after concreting. Templates shall be provided wherever required or as directed by the Engineer.

7.21 CURVED FORMWORK

This shall cover all such formwork, which is curved in plan. The formwork shall be fabricated to the required curvature at shop before use. Mismatch if any at site, shall be rectified by cutting or replacing the panel/members.

7.22 FORMWORK FOR PRE-CAST CONCRETE WORKS

All pre-cast units shall be cast in a suitable yard, bed or platform with firm foundation and free from wind. The platform shall have a smooth plaster finish. The yard shall be fenced and shall have a curing tank of adequate size and capacity. The Contractor shall be responsible for the accuracy of the level and shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or printed on each unit. Each unit shall be concreted in one operation. Reinforced concrete members shall be marked to indicate the upper surface.

The form shall be of steel sheets with only rigid steel frames. All components of

formwork shall be so held that during casting there is no deformation of the form resulting in the concrete units not confirming to dimensions indicated in the drawings. The shuttering shall be made with a tolerance of (±) 3 mm in all directions.

The side shutters shall not be struck in less than 24 hours for ordinary Portland cement after concreting and no pre-cast unit shall be lifted during striking the form.

7.23 METAL DECK SHEETING WORKS AS LEFT IN SHUTTERING

7.23.1 GENERAL REQUIREMENT

This part of the specification covers the technical requirements for deck sheeting to be used as left in shuttering for floors & roofs. Supply and installation of the deck sheeting shall be done by same agency. During handling / stacking, if any damage is done to sheet like distortion of edges, scratches on sheet etc., then such damaged sheet shall stand rejected and shall be immediately replaced by the contractor.

7.23.2 MATERIAL

7.23.2.1 Troughed permanently metal decking sheet for Floor / roof decking shall be made by steel feed material of minimum 1.0 mm (bare metal thickness i.e. metal thickness excluding thickness for coating and galvanizing) galvanised to grade 275 as per as per IS 277, of minimum yield strength of 250 Mpa of drawing grade as per IS 513 of approved profile, sectional properties.

7.23.2.2 For metal decking the sectional modulus and moment of inertia of troughed profile per meter width shall be so as to limit the deflection of sheets to span/250 over a span of 1.5 m under total super imposed loading (DL +LL) of minimum 1000 kg per Sq.M.

7.23.2.3 The maximum spacing of the fasteners shall be 390 mm c/c along the length of purlins/runners. However exact spacing shall be as per the design done by the bidder for the fasteners considering the wind load, self-load and other associated loads. Minimum diameter of the fastener shall be 5.5 mm and at least 3 nos. of fasteners shall be used per sheet.

7.23.2.4 Percentage elongation of the mild steel sheet having minimum yield strength of 250 MPa, shall be 23% as per IS:2062.

7.23.3 INSTALLATION AND FIXING

a. The sheeting shall be fixed as per the approved drawings. Sheets shall be supplied in required sizes (based on supporting member spacing) according to the cutting schedule. Generally cutting of sheets to length shall not be permitted at site. Specific approval under exceptional circumstances shall be obtained before cutting of any sheet at site. Power tools shall be used for cutting. Cutting and trimming of small openings which were not finalised at the time of working drawings can be allowed at site. Wherever possible, site cut edges shall be concealed at laps or with flashings.

Suitable steel members for stiffening shall be provided at the cut edges. No gas cutting shall be done on the sheet. If any sheet is found with gas cut mark, same shall stand rejected and shall be immediately replaced.

b. Distorted, blemished or water stained sheets shall not be used.

c. Before installing decking sheet, it shall be ensured that the purlins / supporting members are in true planes, correctly placed and securely fixed.

d. Side and end laps of the sheets shall be made weather proof by securing them with the fasteners not less than 4.0mm dia with 2.0 mm thick neoprene washer. Maximum spacing of the fasteners shall not to exceed 500 mm.

e. Precautions shall be taken during the erection of the sheets to ensure that partially erected decking sheets are protected during inclement weather and damage at all times.

f. Side and end of decking sheet shall be located and positioned in such a manner as to provide the maximum weather protection taking into account the direction of the prevailing wind.

g. Length of the sheet shall be such as to cover minimum 3 span purlin/ supporting members spacing.

h. The roof decking sheets shall be fixed to the purlins/ supporting members with the help of self drilling and tapping type fasteners and neoprene washers.

i. Sheets shall be laid over the supporting members/ purlins with a minimum bearing of 50 mm and end projection of 75 mm at lap joints.

j. End and side laps between the sheets shall be sufficiently large to ensure the weather tightness. In no case, the end laps shall be less than 150 mm and side laps less than one trough length with proper weather tight arrangement.

k. As required the suitable shear connectors shall be provided on deck sheeting for proper shear transfer between sheet & floor/ roof concrete.

7.24 CONSTRUCTION JOINTS & GROOVE FOR CAULKING

These shall provided as shown in the approved drawings or as desired by the Engineer. A trapezoidal groove tapering from the face of the wall to inside will have to be provided on containment walls and roof at all construction joints. For construction joints in thin sections a steel cover plate exposed from one side of the surface will be provided replacing the water stop within the thickness and concrete will be cast against the plate. Suitable grooves will be provided at the junction of the plate and the concrete. Also embedded parts passing through the wall will be provided with grooves around its periphery on the containment walls. All such

grooves shall be caulked by the flexible polysulphide compound or epoxy mortar as directed by the Engineer.

7.25 TOLERANCES

The following tolerances are permitted unless otherwise mentioned in the relevant drawings. The tolerances shall be taken as the departure from the true position at any point after completion of the structure.

Sectional dimensions	:	(±) 5 mm for cast-in-situ concrete.
Plumb	:	5 mm in 5 m but not cumulative. Tolerance in various sections should be compensatory and not cumulative
Levels	:	2 mm before any deflection has taken place for both cast-in-situ and pre-cast works.

Tolerances for climbing type of form work. Variation in walls: Not more than (+) 3 mm.

Total deviation at any point of climbing form / other formwork measured in horizontal plane with respect to the projection of a corresponding reference point at the base of the structure. (Total deviation consists of translational and rotational components.) : 3 mm per 6m height unless specifically required otherwise.

Latest computerised survey instruments shall be used for checking the verticality and alignment of the form works.

7.26 SUBMISSION OF CONTRACTOR'S SCHEME

Bidder shall submit along with his tender the scheme for shuttering, centering, scaffolding for important elements. These should be supported by preliminary drawing and design calculations. Final drawing shall be submitted before start of work.

The scheme submitted by the Contractor should be for all the different type of centering and shuttering schemes proposed and should be so elaborate keeping in mind the entire cross-section of the respective structures in general. The scheme should be such that the construction of one part of any building should not hinder the work on the other parts and keeping in mind the construction schedule.

For centering and shuttering of walls, columns, beams & slabs all the working drawings, details of erection methods calculation of stress and of deflections shall be supplied to the Engineer for approval at least six (6) months in advance of erection.

7.27 ALTERATIONS AND MAINTENANCE

Any modification that the Engineer may require shall be made by the Contractor. Notwithstanding the approval of or alteration suggested by the Engineer in the submitted design for any of the temporary work etc., the Contractor shall remain wholly and entirely responsible until the final acceptance of works, for the efficiency, security, safety and maintenance and for all obligations and risks in regard to such work specified or implied in the contract. The Contractor shall reinstate the same at their own cost, should any mishap or accident occur causing damage or injury thereto, subject however to such provisions of the conditions of contract as may be applicable in the case of such damage or injury.

8. WATERPROOFING OF UNDERGROUND CONCRETE STRUCTURES

8.1 SCOPE

This specification covers waterproofing of underground concrete structures viz. basement, sump, pit, tunnel and trenches against ground water.

The specification described here covers material description, physical and mechanical properties, testing, applicable codes and standards, acceptance criteria, surface preparation, placing in position, lapping and QA requirement etc of water proofing treatment of basement slab and walls.

8.2 GENERAL REQUIREMENTS

As a general guidance, the provisions contained in the contract shall be followed unless otherwise mentioned. Considering safety requirement, Nuclear Power Plant structures should meet special requirement regarding leak tightness.

The contractor shall do the proper concreting so that concrete is water tight in itself without waterproofing treatment. Quality control of concrete construction shall include inspection of preparations for concreting, mixing, transportation, placement, compaction, curing and protection.

The work of waterproofing of underground concrete structure shall be entrusted by the contractor to expert agency approved by NPCIL. The specifications of waterproofing mentioned here are generic in nature. The Contractor shall submit the detailed specification of waterproofing for NPCIL's approval.

8.3 MATERIAL

The plasticized PVC membrane shall be minimum 2.0 mm thick, single ply, twin colored preformed flexible membrane. The single ply plasticized PVC membrane shall be thermoplastic membrane manufactured by co-extrusion process. The membrane shall be of twin colour to provide visual indication of damage, due to any movement or any other reason. The sheet shall be minimum 2 meter wide and appropriate length to minimize the number of joints. The compartmentalization shall be done using specified size of water stop to confine any accidental damage within 100 square meters. All lap joints shall be tested for water tightness upto 2 Kg/sq cm

pressure prior to concreting. The membrane shall be suitable for defect free installation on all type of surfaces viz. horizontal, vertical and overhead and it shall be loosely laid (unbounded) to act independent of structural movement. Adjacent sheets shall be laid with an overlap of at least 80 mm.

The PVC membrane used for waterproofing membranes shall exhibit the following properties.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Thickness	UNI EN 1849 -2	mm	Minimum 2.00 mm
Specific weight	UNI EN 1849 -2	kg/m2	2.600
Ultimate Tensile strength	UNI EN ISO 527-3 Transverse Machine direction	 N/mm2 N/mm2	 Minimum 14.9 N/mm2) Minimum 15.2N/mm2)
Ultimate Tensile Strength (Ageing by complete immersion in ground water for 16 months at 50 ^{0}C)	UNI EN ISO 527-3 Transverse Machine direction	 N/mm2 N/mm2	Minimum 14.9 N/mm2) Minimum 15.2N/mm2)
Elongation	UNI EN ISO 527-3 Transverse Machine direction	 % %	 min 280 (-30%) min 280(-30%)
Mean Tensile Strength Variation	DIN 53455	%	3.5
Impact strength	DIN 16726 - 5.12	mm	> 600
Puncture resistance	DIN 16726 - 5.12	mm	> 1000 mm
Hydrostatic pressure resistance (6 hours at 5 bar)	UNI EN 1928 meth.B		Waterproof
Tear resistance	ISO 34 /ASTM D624	MPa	> 45
Resistance to static punching (CBR)	UNI EN ISO 12236	N	> 1700 N
Root resistance	DIN 4062		No penetration
Fire Behaviour	EN ISO 11925-2		Class E

For Sub-soil applications the chemical resistance of the PVC membranes shall be as fully resistant to the chemicals along with the respective compositions as listed below

as per ASTM D 6943 (i.e. complete immersion of sample in respective solutions for 15 days).

CHEMICAL NAME	NATURE OF CHEMICAL	% CONCENTRATION
Sulphuric Acid	Inorganic Acids	≤ 25
Sulphurous Acid	Inorganic Acids	≤ 6
Nitric Acid	Inorganic Acids	≤ 5
Benzoic Acid	Organic Acid	≤10
Acetic Acid	Organic Acid	≤10
Oxallic Acid	Organic Acid	≤ 25
Phthalic Acid	Organic Acid	≤ 25
Tartaric Acid	Organic Acid	≤25
Citric Acid	Organic Acid	≤ 25
Ammonium Hydroxide	Inorganic Bases	≤ 5
Potassium Hydroxide	Inorganic Bases	≤ 5
Sodium Hydroxide	Inorganic Bases	≤ 10
Chlorides	Salt Solutions	≤ 25
Sulphates	Salt Solutions	≤ 25
Nitrates	Salt Solutions	≤ 25
Soap Solution	Salt Solutions	≤ 25
Drinking Water	Salt Solutions	Any Concentration

8.4 THICKNESS & SPECIFIC WEIGHT OF SHEET

The thickness of the single ply plasticized PVC membrane shall be 2.00 (minimum as per UNI EN 1849). The specific weight of 2.0 mm thick single ply plasticized PVC membrane test piece shall be determined in mass per unit area.

8.5 TENSILE STRENGTH & ELONGATION TEST

The tensile strength and elongation requirement shall be as per UNI EN ISO 527-3. In this test, dumbbell shaped single ply plasticized PVC test pieces are cut using the standard dumbbell die are stretched in a tensile testing machine at a constant rate of traverse of the driven grip. Readings of transverse loads and elongation are taken as required during the uninterrupted stretching of the test piece and when it breaks. For the tensile strength of the joints they are subjected to varying tensile stresses for the overlap joints as per ASTM D638.

8.6 PUNCTURE RESISTANCE

The puncture resistance requirement shall be as per DIN 16726 - 5.12. This is measured using the truncated cone test, in which truncated cones are used as puncture points. The heights of the truncated cones are varied to determine the critical cone height, which is the height at which the puncture occurs for a given pressure. The

minimal permissible height for a 2.0 mm thick single ply plasticized PVC membrane used for waterproofing in case of basements is >800 mm.

8.7 HYDROSTATC PRESSURE RESISTANCE

The hydrostatc pressure resistance requirement shall be as per UNI EN 1928 meth.B. In this test the lateral hydrostatic pressure is exerted on below-grade foundations and slabs on grade by an elevated water table. Tests to quantify resistance to the passage of water should be specific as to the maximum pressure the membrane must be capable of withstanding. In case of single ply plasticized PVC membranes the minimum amount of pressure that the membrane can withstand is tested for a water table of 60mts as per the code. Subjected to these conditions there should be no penetration of water as per the specifying needs.

8.8 ROOT PENETRATION RESISTANCE

Root resistance is tested for single ply plasticized PVC waterproofing membrane through the composition of the membrane which provides an impenetrable barrier to root growth. Root resistant 2.0 mm thick single ply plasticized PVC membrane is quicker to install than separate waterproofing and root barrier layers.

8.9 TEAR RESISTANCE

This test method measures the force per unit thickness required to rupture, initiate, or propagate a tear through a sheet of 2.0 mm thick single ply plasticized PVC membrane. This testing is done so that the specified waterproofing membrane does not fail in service due to the generation and propagation of a special type of rupture called a tear. Tear strength is calculated as T= F/d, where T is the tear resistance, F is the load acting on the membrane and d is the thickness of the membrane. Tear strength of 2.0mm thick single ply plasticized PVC membrane should at least be 45MPa.

8.10 STATIC PUNCHING RESISTANCE

CBR Puncture is an index of puncture resistance that measures the force required to push a flat ended plunger through a 2.0 mm thick single ply plasticized PVC membrane. Instead of an 8 mm diameter probe with a beveled edge; this test utilizes a 50mm diameter, flat-ended probe (plunger) that is pushed slowly through the PVC membrane. The relatively large size of the plunger provides a multidirectional force on the PVC membrane and simulates big stones pressed onto the PVC membrane laying a relatively soft sub-base. The minimum value for a static punching resistance should be at the very least of 1700 N for subsoil applications.

8.11 FIRE RESISTANCE

This test determines the ignitability the specimen is subjected to direct impingement of a small flame at the edge or at the surface. The test specimen of size 250 mm × 90 mm is attached vertically on a U shaped specimen holder. A propane gas flame with a

height of 20 mm is brought into contact with the specimen at an angle of 45 °. For subsoil applications of 2.0 mm thick single ply plasticized PVC they should belong to Class E as per the ISO 11925-2 (Reaction to fire tests-ignitability of products subjected to direct impingement of flame-Part 2:single flame source test).

8.12 TESTING

For acceptance of material listed in above table, Manufacturer Test Certificate (MTC) from manufacturer confirming to above specified properties shall be submitted to NPCIL. However, membrane supplied from each batch shall be got tested for Thickness, Ultimate Tensile Strength, Elongation & Puncture Resistance. Testing of the membrane shall be carried out by the contractor as per approved QAP in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL as per above mentioned relevant standards at no extra cost to NPCIL.

8.13 PACKAGING SHIPMENT AND STORAGE

Materials delivered at site shall be clearly marked with legible and intact labels with manufacturer's name, brand name, product identification and batch number. The products (adhesives etc.) shall be in original, unopened containers.

Materials shall be stored in areas where temperatures conform to manufacturer's recommendations and instructions. All materials shall be stored in covered clear away from reinforcements, coarse aggregates and heavy engineering activities at site. All the materials like membranes, sealants etc. shall be kept away from sources of ignition.

All empty containers of various chemicals employed, left over chemicals shall be disposed off; in a safe manner on a dumping site approved by the site authorities.

All personnel of the applicator should wear all safety gears like gloves, helmet, goggles etc during installation.

8.14 INSTALLATION AGENCY

The works shall be carried out only by trained and certified applicator of the specialized agency carrying water proofing treatment/ membrane supplier.

8.15 INSTALLATION OF MEMBRANE

The plasticized PVC membrane shall be fixed on PCC surfaces strictly as per the detailed application guidelines of the manufacturer. Broadly the installation steps shall include

- Removal of Sharp protrusions
- Installation of Geo textile made of needle-punched 100% pure polypropylene yarns, with a minimum weight of 300 gsm.

- In case of Vertical walls, installation of roundels with mechanical fixtures.
- Laying of plasticized PVC membrane with specified lap joints
- Welding of Joints and testing for water tightness up to 2 Kg/Sqcm
- Water tightening of Pile heads/ rock anchors etc as applicable
- Compartmentalization of the PVC membrane using PVC surface water stops
- Laying of Second layer of Geo textile.
- Laying of Protective screed on horizontal surfaces
- Laying of minimum 25mm thick Protective boards / 115 thick Brick wall protection (the protective board shall be used in case of back filling done with soil / crushed sand , having no boulder/aggregate bigger than 80mm size) for the vertical walls.

A detailed scheme shall be submitted by the contractor including the layout of PVC water stop arrangement and injection ports etc (if proposed) for NPCIL approval prior to its application.

The main contractor shall ensure that all areas of the finished basement waterproofing system shall be protected from site related work traffic and other trades until completion of all works.

Adequate temporary protection shall be provided over the installed membrane during the works program, particularly at temporary walkways, access points to the basement, concreting material stockpiles etc. in order to prevent damage.

8.16 PREPARATION OF THE SUBSTRATE

The substrate shall be PCC concrete of sufficient thickness (minimum 50 mm) to ensure a firm substrate that will not crack or deform under normal trafficable conditions during waterproofing installation, and structural concreting operations. It should be smooth, free from debris and other irregularities, which may puncture and damage the waterproof liner.

The surface will be made clean, dry, smooth and free of contaminants such as grease, animal fats, coal tar and oil based products. Accumulation/ ponding of water shall be removed from the work surface prior to installing the system.

All horizontal or vertical surfaces should be covered with a uniform adjustment layer using Non-Woven Geotextile. It has the purpose of ensuring the uniformity of the substructure in order to avoid irremovable debris or other roughness in the underlying layer which may cause damage, perforate or punch, the waterproof layer.

8.17 WATERPROOFING SYSTEM FOR BASEMENT RAFT SLAB

The 2.0mm thick single ply twin colored plasticized PVC loosely laid membrane waterproof system should be installed over the hardened well leveled surface of the PCC overlaid with first layer of Geotextile. The Geotextile shall be resistant to micro-organisms, needle-punched 100% pure polypropylene yarns, with a minimum weight of 300 gsm. The PVC membrane system shall be compartmentalized using PVC

surface water-stop maximum size of compartmentalization shall be limited to 100 sq m). The PVC water stop used for compartmentalization shall be minimum 320mm wide, min thickness of 2.5mm and shall have minimum 4 ribs of 15 mm depth. These PVC water stops shall be welded with PVC membrane by hot air welding. The membrane shall be further covered with second layer of Geotextile ensuring no gaps in the Geotextile. The geotextile should be checked prior to laying of protection screed.

After checking all the joints & any visible damage, second layer of geotextile shall be laid over the member followed by laying of minimum 50mm thick layer of protection PCC (Minimum Grade M20) screed. The damage if any found, shall be recorded and the necessary patch repairs shall be conducted before laying of second layer of geotextile and protection layer.

8.18 WATERPROOFING SYTEM FOR VERTICAL/RETAINING WALL

The first layer of Geotextile Membrane shall be laid over the hardened well leveled surface. Over the Geotextile membrane 2.0mm thick single ply, twin colored, and plasticized PVC membrane waterproofing system shall be installed using rondels having maximum C/C spacing 1.0m .The rondels are provided to anchor & hold the Membrane at its position. The membrane is to be protected after installation with a 300gsm geotextile followed by protective layer of 25 mm thick expanded polystyrene boards (in case of back filling done with soil / crushed sand, having no boulder/aggregate bigger than 80mm size) or 115 mm thick brick wall. The PVC membrane system shall be compartmentalized using PVC surface water-stop at required locations, based on the site requirements (maximum size of compartmentalization shall be limited to 100 sq m).

8.19 CHECK FOR MEMBRANE TO MEMBRANE JOINT

Two adjacent membranes shall be welded using hot air welding. It shall be a double seam weld to maximum clear length of the membrane installed; double seam weld shall allow pressure testing of every length of joint. The double seam joint shall be tested to a pneumatic pressure of maximum 2 bars kept for minimum duration of 8 minutes. The loss of pressure after holding for 8 minutes shall not exceed 20%.

Wherever the double seam welding machine cannot be used, the single seam welding shall be done after obtaining prior permission from engineer, in such case the weld width shall be preferable 40mm, but shall not be less than 20mm in any case. The single seam weld shall be tested using a seam probe hook to check for any opening in the weld. In addition to above if any destructive testing is found necessary shall also be performed.

8.20 PILE HEAD TREATMENT

The single ply plasticized PVC membrane is dressed up to the outer surface of the pile head or anchor or up stand. The membrane is then encapsulated in with a high strength flowable epoxy mortar having a minimum thickness of 10mm below the

membrane and mini 20mm on top of it and extended to the edge of outer surface of the interface. The key properties of the high strength flow able epoxy mortar shall be as mentioned in the following table.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Solids Content	DIN 53213	%	100
Tensile Strength	BS 6319, Part 7	MPa	11
Compressive Strength	BS 6319, Part 2	MPa	100
Flexural Strength	BS 6319, Part 3	MPa	25

8.21 QUALITY ASSURANCE & SUPERVISION

A detailed work procedure and inspection and test plan (ITP) in line with this specification and manufacturer's specification with resources deployment shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work. Contractor shall carry out testing of materials as per direction of Engineer and shall submit testing reports and manufacturer's test certificates to the Engineer. A strict check on membrane properties and installation shall be exercised by Contractor's QA Engineer and necessary records in this regard shall be submitted to NPCIL. Contractor shall provide necessary assistance to NPCIL in supervision of water proofing work.

During the entire process of work under this specification, the Contractor shall arrange at his own cost the supervision of the work on water proofing by the manufacturer's/ specialized agency's representative to ensure that the work is being executed as per manufacturer's specifications and instructions.

8.22 GUARANTEE

The Contractor shall make periodical inspection and repair the waterproofing for any apparent defects to ensure complete waterproofing during the guarantee period. The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for an amount of 10% of the cost of water proofing works carried out. The bank Guarantee shall be valid for a period of ten (10) years from the date of acceptance of the water proofing work by NPCIL.

9. DELETED

10. REINFORCEMENT

10.0 SCOPE

The work covered under this section shall include supplying, cleaning, cutting, bending, placing, binding and securing of reinforcement in position for all structures.

For use of Fusion Bonded Epoxy Coated bars the relevant specification shall be followed.

10.1 STANDARDS AND SPECIFICATIONS

The provisions of the latest revisions with amendments, if any, of the following Indian Standards and other relevant codes shall form part of this specification to the extent they are relevant. Where the provisions of these Standards/Codes are in conflict with the stipulations of this specification, the specification supersedes the respective Standard or Codes.

10.1.1 BUREAU OF INDIAN STANDARDS

IS – 1786	High strength deformed steel bars and wire for concrete reinforcement-Specification.
IS – 456	Plain and reinforced concrete – code of practice
IS – 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS – 9417	Welding cold worked steel bars for reinforced concrete construction – recommendation for welding.
IS – 2751	Code of practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
IS – 822	Code of procedure for inspection of welds.

10.1.2 OTHER STANDARDS

1. ASME Section III DIVISION
2. Qualification of splicing system

10.2 MATERIAL

Material covered under this specification is a high yield strength deformed bar (HYSD) and TMT bars of grade Fe 500 conforming to IS: 1786, as specified in the drawing. For Fe 500 grade steel, the total elongation shall be more than 14.5 % and the ultimate tensile strength of the bar shall be 15 % more than the specified 0.2 % proof stress/ yield stress. This requirement is over and above the requirements specified in IS 1786. The Contractor shall submit the manufacturers test certificate for the material. Random tests i.e. minimum 1 sample per 150MT or at least one sample from each heat, for each diameter of bar shall be performed as required by the Engineer in his presence. All costs, incidentals to such tests shall be borne by the Contractor and shall be deemed to have been included in his quoted rates. Steel not conforming to the specifications shall be rejected. All reinforcement shall be clean, free from grease, oil, paint, dirt, loose mill scales, loose rust, dust, bituminous material or any other substance that will destroy/ reduce bond. All bars shall be thoroughly cleaned before fabrication and placement. Pitted and defective bars shall not be used.

The steel shall be supplied by main manufacturers like SAIL, TATA Steel & RINL etc., who manufacture the rebars using billet produced from ore itself and not by rerolling of steel.

10.3 STORAGE

10.3.1 The reinforcement steel shall not be kept in direct contact with ground but stacked on top of an arrangement of concrete pedestal or timber sleepers. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deteriorations.

10.3.2 It shall be stored under cover, as desired by the Engineer without any extra cost. If necessary, the reinforcement steel, other than Fusion Bonded Epoxy Coated bars, shall be coated with cement wash before stacking, to prevent scale and rust. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage. Any reinforcement, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for the work.

10.4 FABRICATION

10.4.1 The reinforcement bars shall be straightened, cut to size using cutting machine & shall be cold bent using bar bending machine, without the use of heat, to the shapes mentioned in the Drawings, as per relevant Indian Standards. Bars having cracks or splits on the bends shall be rejected. The bar bending schedules shall be prepared by the contractor in general (except for critical structure as decided by the Engineer) according to the reinforcement drawings and shall get it approved by the Engineer. In any case, the details given in the drawings shall be final. The high strength deformed steel bars/ TMT Bars shall not be re-bent or straightened without the approval of the Engineer. Crossing bars shall not be tack welded. Bars shall be properly tagged for easy identifications.

10.4.2 Where reinforcement bars are bent aside at construction joints and afterwards bend back into their original position, care should be taken to ensure that at no time the radius of the bend is less than 6 times the dia for HYSD TMT bars.

10.5 FIXING / PLACING

10.5.1 Rough handling, shock loading (prior to embedment) and the dropping of reinforcement from a height shall be avoided. Reinforcement shall be accurately placed and fixed by any approved means to maintain the correct position of bars as shown on the drawings for this purpose. The contractor shall use cover blocks, spacers and chairs as per IS: 2502 to prevent displacement during placing & compaction of concrete. Concrete cover blocks as directed by the Engineer shall be used for providing specified cover to the rebars. Bars intended to be in contact at crossing joints shall be securely bound together at all such points with 1.6 mm dia soft annealed Iron wire (Binding wire). The vertical and horizontal distance required between successive layers of bars in beams, walls or similar members shall be

maintained by the provisions of spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bar. The dia. of such spacer bar shall not be less than the dia. of the main bar. No reinforcement shall be bent when in position in the work, without the approval of the Engineer. In-situ bending of embedded bars using oxy-acetylene flame shall not be done. However, if it can be proved that cold bending is not possible the same may allowed at the discretion of the Engineer by taking due precautions. Erected and secured reinforcement shall be inspected and approved by Engineer prior to placement of concrete.

10.5.2 When reinforcement of the specified diameter is not available, Contractor may be allowed to replace with diameter higher than originally specified in the drawing on written approval of the Engineer at no extra cost to NPCIL. However, this option shall be used under exigency situations only and not as a general practice.

10.5.3 Exposed ends of dowel bars for underground structures shall be protected if necessary, by encasing the same in lean concrete, at no extra cost. Bars for the portion of structures above ground shall be given adequate coat of cement wash and if additional protection is needed as per the Engineer, shall be wrapped with plastic tape at no extra cost.

10.5.4 Wherever necessary/ as directed by the Engineer, before placing the reinforcement in the congested areas full-scale mock-ups shall be carried out and approval from Engineer shall be obtained. Such Mock-ups will be paid as per relevant items of BOQ.

10.5.5 For supporting the horizontal bars at height, supports drawings shall be prepared by the Contractor & shall be approved by the Engineer. Reinforcement chairs, spacers & support embedded in concrete as mentioned in the drawing or specified by the Engineer will be measured & paid separately.

10.6 TOLERANCE ON PLACING OF REINFORCEMENT

Unless otherwise specified in the drawings, reinforcement shall be placed in accordance with IS: 456.

10.7 LAP SPLICING OF REINFORCEMENT BARS

Lapping of reinforcement bars shall be done at locations shown in the drawings or as directed by the Engineer. The lap length shall not be less than that specified in the drawings and unless otherwise specified, the lap length shall be as per IS: 456. At locations where lap splice gives rise to congestion of reinforcement, such splice shall be replaced with welding/ mechanical splicing. For mechanical splicing of bar the relevant specification of mechanical splices (Threaded Coupler) shall be followed.

10.8 WELDING

10.8.1 Generally bars joints are to be made using mechanical splicing using threaded

couplers or lapping. In exceptional cases only joints shall be made by welding or any equivalent splicing system like CADWELD etc. The splicing system shall be qualified as per ASME Section III DIVISION 2.

10.8.2 Field welding of reinforcement will not be permitted, without the written permission of the Engineer. Such approval will require identification of the type of steel used. Where welding is permitted, detailed welding procedure shall be submitted to the Engineer for approval. Welding of reinforcement to structural steel if required shall be done as per standard practice. Welding of reinforcement if required will be paid for as per relevant item of schedule. Welding of High Strength Cold Twisted deformed bars/TMT bars conforming to IS 1786 shall be made in accordance with the relevant Indian Standards (IS 9417).

10.8.3 The material shall be examined and compared with the manufacturer's test certificates, ISI certification marks and inspection stamps. Special attention shall be paid to the chemical composition of the material and its general weldability to meet the required standards for strength. The material shall be examined for surface defects, rust and corrosion products, presence of contaminants and any other factors, which may hamper the production of a satisfactory weld.

10.8.4 The qualifying tests for welders engaged in arc welding shall be in accordance with IS: 2751.

10.8.5 The Procedure to be adopted for the welding shall be arc welding with double V butt joints. Oxy-acetylene welding is not permissible.

In addition to the requirements specified in IS 9417, the requirements given below shall also be followed:

10.8.6 All welding operations shall be controlled to prevent a supply of more heat to the steel at a time than can be dissipated by the steel owing to its high thermal conductivity without adversely affecting the strength of the welded bars. The non-twisted portion of the deformed bar at weld junctions (25 to 50 mm) must always be cut off. Scraping of rust at joint- surfaces prior to welding is essential.

10.8.7 For edge preparation, the bar ends to be welded should be shaped by power shears and grinders. If oxyacetylene torches are used for shaping the edges (chisel edge) last 2-3 mm of the cut faces shall be removed by grinding. The amount to be ground off may be determined by tests, but should not be less than 2 mm. To avoid crookedness in bars after welding, their axes should be properly aligned prior to the welding operation. During the welding procedure, the bar may be supported to about 1 m. on each side of the joint over steel channels 2 m. to 3 m. long. Removal of slag after each alternate welding run is to be effected by brushing. The electrode shall never be lighted from the hot bar, to avoid notch effect.

10.8.8 Fusion faces and surfaces adjacent to the joint for a distance of at least 50 mm on either side shall be absolutely free from grease, loose scales, moisture or any other substance which may interfere with welding or adversely affect the quality of the

weld.

10.8.9 Each layer of the multiple layer weld may be moderately peened with light blows from a blunt tool. Care must be taken to prevent scaling or flaking of weld.

10.8.10 Welded junctions of all reinforcing bars may be carried out at same section provided there are no bends, curved parts in reinforcement bars, or zones where variable loads predominate. It is recommended that all welds be located at least 50 dia away from bends.

10.8.11 Assessment after welding shall first be done to ascertain the correctness of the whole weldment by visual and dimensional inspection.

10.8.12 Mechanical testing in the form of tensile tests and 180-degree bend tests shall be carried out on prototype or sample welds. The choice of the samples will depend entirely on the Engineer, and will be made at random. Specimens for tension tests are to be chosen 1 out of every 100 joints prepared. The bend tests are to be conducted on 2 prototype specimens in 2 perpendicular directions, for every 200 joints. The specimen shall be bent by 180 degree for qualification.

10.8.13 The welded joint should be capable of resisting 90% of the actual bar strength and should not fail to develop at least 100% of the specified ultimate strength of the variety of steel under use. The failure shall not occur at the joint location.

Weldments incapable of developing full strength shall not be used as reinforcement.

Apart from tensile testing of weldments, liquid penetrate flaw detection test as recommended in IS: 822 shall also be made on 10% of total joints on root & final pass.

10.9 FUSION BONDED EPOXY COATING BARS

10.9.1 SCOPE

These specifications cover coating of reinforcement bars with fusion bonded epoxy coating (FBEC) to be provided as corrosion protection measure, in construction of Nuclear Power plant. This coating shall be used, wherever specified so in the drawings.

10.9.2 REINFORCING BARS

The reinforcing bars to be provided with Fusion Bonded Epoxy Coating shall conform to I.S. 1786. In spite of producing test certificates by contractor for the proper quality of reinforcing bars, the quality of steel should also be tested by the FBE coating agency for bend test before undertaking coating and that if the reinforcing bar fails in bend test, it shall be rejected.

Reinforcing bars to be coated shall be fresh from rolling mills as far as possible. If

the bars are rusted in quality before providing FBEC, the same shall be rejected.

10.9.3 Coating on Bars with FBEC

10.9.3.1 SURFACE PREPARATION

The surface of the steel bars to be coated shall be cleaned using shot blasting near to white metal .The surface profile shall be free from mill scale, rust and foreign matter.

10.9.3.2 The Coating shall be applied to the cleaned surface as soon as possible after cleaning. In no case the coating be delayed beyond 8 hours after cleaning.

10.9.3.3 The FBEC coating shall be done confirming to I.S. 13620 as well ASTM A775/775M.

10.9.3.4 The Fusion Bonded Epoxy Coating shall be carried out by an authorized FBE coating agency approved by Engineer.

10.9.3.5 Patch-up materials shall be procured in sealed containers with certificates from coating agency for supply of such patch-up material.

10.9.3.6 The Quoted rate for FBE coated bars shall include the use of PVC coated GI wire (Binding Wires) of 1.6 mm dia.

10.9.4 Tests for FBE Coating on Reinforcing Bars

10.9.4.1 The contractor shall produce certificate from the FBE coating agency that the quality of powder epoxy material and other components of FBEC conform to I.S. 13620 as well ASTM A775/775M. Such certificates shall accompany each delivery challan of coated bars. The Engineer may carry out such tests at plant to confirm use of proper quality of coating material.

10.9.4.2 The Coated reinforcement bars shall be tested for following properties at a specified frequency. Following tests on coated bars shall be as per I.S. 13620 at the specified frequency on routine basis and Test reports shall be jointly signed by authorized representatives of contractor and the coating agency:

Thickness of coating: One full-length bar for every twenty bars for each size of bars

Continuity of coating: One full-length bar for every twenty bars for each size of bars

Adhesion of coating: As per following frequency based on dia of bar

- Upto 16 mm dia: - 1 for every 1 tons
- Above 16mm and upto 25mm dia: - 1 for every 2 tons
- Above 25 dia: - 1 for every 4 tons

10.9.4.3 Inspite of conducting above tests and test certificates produced by the contractor and coating agency, Engineer reserves the right to carry out independent tests at coating plant for cross checking. The contractor's agreement with coating agency shall include the provision for Engineer's cross checking and that if the coating quality is not approved by the Engineer, the decision of the Engineer to reject or repair the coating shall be final and binding on all parties.

10.9.4.4 Thickness of Fusion Bonded Epoxy Coating shall be 250 (+/- 50) microns.

10.9.4.5 Holidays in coating shall not be more than two holidays per linear foot (six holidays per meter) of coated bar. All the damaged coating incurred during handling & fabrication, to the point of shipment to the job site shall be repaired. Damaged coating on a bar is permitted to be repaired if the amount of damaged coating does not exceed 1 % of the total surface area in each 0.3 m length of bar. The limit on the amount of repairable damaged coating does not include sheared & cut ends of the bars that are required to be coated with patching material. Repaired areas of damaged coating shall have a minimum coating thickness of 250 microns.

10.9.4.6 The Coating shall also meet all other requirements specified in IS 13612 as well ASTM A775/775M.

10.9.5 Handling

10.9.5.1 The coated bars shall be carefully handled in order not to drop them, not to rub them on hard surface or against another coated bar while conveying, stacking, placing or stacking of fabricated bars. For this purpose, wooden packing batons shall be used at spacing of not more than 60 cms.

10.9.5.2 The Coated bars shall be tied to make bundles with PVC binding material to avoid damages to coating.

10.9.5.3 The cut ends of bars shall be touched up with special touch up material of the same specifications as provided by coating agency. There shall be minimum time gap to repair the cut ends and damaged portions with touch up materials and that failure to do so may cause complete rejection of the coated bars. The cut ends and damaged portions shall be touched up with repair patch-up material within four hours time gap. All damages to coating in handling etc. shall be repaired irrespective of their size. This stipulation supersedes provision of clause 13 of IS 13620.

10.9.5.4 The Contractor will be paid for the same quantity of reinforcement bars used in the work and paid under relevant item.

10.9.5.5 While bending the bars, the pins of workbenches shall be provided with PVC or plastic sleeves. It is preferable that contractor install bar bending machines suitable for FBE coated bars and that each bending operation is done in a time of not less than 90 secs.

10.9.5.6 The coated steel shall not be directly exposed to sun rays and rains and shall be protected with opaque polythene sheets or such other approved materials.

10.9.5.7 While Doing concreting, the workmen or trolleys shall not directly move on coated bars, wooden planks shall be placed on the bars for movement of workman & trolley of material, by the contractor.

10.9.5.8 In spite of all test certificates, if the coated bars are roughly handled by the contractor either during transport, fabrication, stacking, placing and concreting etc. or handled in such a manner as to damage the coating for area or portion more than reasonable, the Engineer reserve the right to reject the FBE coated bars and such rejected bars shall be removed by contractor from work site within three days. The decision of Engineer will be final as to reject the bars with damage coating or to allow repairing the coating, or to get it recoated entirely at the contractor's cost.

10.9.6 STORAGE

10.9.6.1 The Bars shall be stored as close as possible to the area of the structure where they will be placed (fixed) to keep handling operations to a minimum. Deliveries of the coated bars to the job site should be well coordinated to avoid any long term storage at site when stored in open. If circumstances or other conditions make it necessary to store FBE coated bars outdoors for an extended period of time, the coated bars should be protected from sunlight & salt spray, and sheltered from the weather.

10.9.6.2 FBE coated bars shall be stored above ground on protective timbers, supports shall be provided at regular interval to avoid sagging of the bundle. Such wooden or padded contact shall be at spacing of not more than 60 cms.

10.9.6.3 If a relatively large quantity of FBE coated bars is to be stored in a small area, bundles of straight bars shall be stacked with adequate blocking between the layers of bundles.

10.9.6.4 FBE bars shall be covered with opaque polythene sheets or other suitable protective material. The protective cover shall be draped over the sides of the bundles around the perimeter of the stack. The cover shall be properly secured with provision of air circulation to minimize the condensation under the covering.

11. REINFORCEMENT, SPLICING AND MECHANICAL FASTENERS & MECHANICAL COUPLERS

11.0 SCOPE

These specifications cover threaded couplers to be used for joining reinforcement bars, in lieu of laps/welding/mechanical splicing.

11.1 GENERAL

The couplers shall be of standard parallel square thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that thread diameter is not lesser than the parent bar to be joined. The

material of the coupler shall be of same quality or of superior quality than the quality of material of the parent bars (i.e. reinforcement bars to be joined). The joint shall have guaranteed bar break i.e. when the joint is tested in universal tensile testing machine, the bar shall fail away from the coupler i.e. not within the coupler as well as within 2 times the diameter of bar from the ends of the coupler, which can be considered as affected zone. The Guaranteed Bar break condition is not mandatory, if the failure load of coupled specimen is higher than 1.15 times of its minimum specified yield stress. The coupler shall be qualified as per ASME, Section III, and Div.2. Additionally it shall meet all the requirements of "Class H" type coupler as specified in IS 16172. The safety margin in coupler design shall be such that guaranteed bar break is ensured even if 15% of the total threads length are out of coupler during installation.

The hand tightening of coupler shall be sufficient in the field and no mechanical means shall be essential for tightening. During testing, the coupler should only be hand tightened.

The process of manufacturing of the coupler, cold forging and threading including testing shall be carried out as per ASME approved quality assurance programme. The manufacturer of coupler shall hold a valid Quality System Certificate (QSC) from ASME. Installation of the coupler and supervision shall be done by the qualified personnel.

11.2 MANUFACTURING OF COUPLERS

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number, heat number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties.

11.3 THREADING OF ENDS OF THE REINFORCING BARS

This threading activity shall preferably be done at site. The various stages involved in threading are as given below

11.3.1 CUTTING

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain end surface, perpendicular to the axis of the bar.

11.3.2 COLD FORGING & THREADING

After cutting, the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done, preferably on lathe machine.

The threads shall be square parallel type, to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic caps, before taking the bars out of the shop.

11.3.3 QUALITY CONTROL IN MAKING OF THREADS

The work in shop shall be fully supervised by the Manufacturer representative. Double forging of bars is not permitted. In case of improper cold forging, the forged end of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges.

For threaded coupler systems, every prepared bar end shall undergo a load test prior to actual use. The minimum test loading shall be equivalent to 80% of specified yield strength of bar. For this purpose contractor shall deploy the machine having facility of integrated load testing. The "Integrated" means that the testing operation is performed automatically by the same machine used to prepare the bar ends. A positive indication shall be punched on the rebar to indicate that this operation has been carried out and bar end has qualified for specified strength.

11.4 INSTALLATION OF COUPLERS IN THE FIELD

The installation of couplers in the field, for joining reinforcing bars, shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned with acetone or any other solvent, just before installation.
Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached & then cleaned before joining the next bar.

11.4.1 The contractor shall arrange for a suitably qualified manufacturer's representative, experienced in mechanically connecting reinforcement, to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary.

11.4.2 The contractor shall submit to the Engineer, for his acceptance, a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

(a) requirements for cleanliness
(b) equipment for threading bars
(c) method of locking the connections on both rebars

(d) method of verification of final rebar alignment and coupler integrity.

11.4.3 Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance standards shall be completely removed and the bars re-connected, as required.

11.5 QUALIFICATION TESTS

The splices shall be qualified as per ASME Section III Div-2, IS 16172 and by conducting following tests:

11.5.1 STATIC TENSILE TEST

Mechanical connections shall be tested in all reinforcing rebar sizes. All rebar transition connectors shall also be tested. For each rebar size, a minimum of six connections in each load direction shall be tested in accordance with ASTM A 370. A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength.

- The average tensile strength of the splices shall not be less than the followings:

  a) 90% of the actual tensile strength of the reinforcing bar being tested.
  b) 100% of the specified minimum tensile strength

- The tensile strength of an individual splice system shall not be less than the 115% of the specified minimum yield strength of the spliced bar.

11.5.2 CYCLIC TENSILE AND COMPRESSIVE TEST

Cyclic tensile and compressive test: Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return. The test shall be performed as per Annexure D of IS 16172.

11.5.3 PERCENTAGE ELONGATION

The minimum uniform elongation (Elongation at maximum force) in the reinforcement bar outside the length of mechanical splice as measured as per Annexure B of IS 16172 shall be 3 % before failure of test piece.

11.5.4 SLIP TEST

The total slip value when measured in accordance to test procedure described in Annexure C of IS 16172 shall not exceed 0.10 mm.

11.5.5 TEST FOR AVOIDANCE OF STAGERRING

The strain measured over the full length of the splice at 90% of the specified minimum yield strength of the bar shall not exceed that of a bar that is not mechanically-spliced by more than 50%. The test shall be performed for all diameter of couplers.

11.5.6 LOW CYCLE FATIGUE TEST

The mechanical splice shall withstand 10000 cycles of alternating tension & compression load, when tested as per Annexure E of IS 16172.

11.5.7 HIGH CYCLE FATIGUE TEST

The mechanical splice when tested accordance to Annexure E of IS 16172 shall withstand 2 million cycles (2000000 Nos)of varying axial tensile load with a stress range of 60 MPa with upper stress in the test equal to 0.6fy.

11.5.8 PRODUCTION TESTS & ACCEPTANCE CRITERIA FOR A LOT

Static Tensile tests, as per ASTM A370, shall be conducted on each bar size & grade for each lot as follows. The criteria mentioned below are in variance with the above referred codes.

Sr No	No of Coupler in the Lot	No of sample to be tested	Acceptable Defective couplers
1	Upto 500	14	NIL
2	501-1200	20	NIL
3	1201-3200	32	1
4	3201-10000	50	2
5	10001 and above	50+ 2 for each 1000 Nos beyond 10000	Not more than 4% of the samples tested

The lot is defined as the group of couplers which are of same size, type, class, material traceable to same cast and manufactured under similar conditions of production. All the tests shall ensure guaranteed bar break at a load not lower than the specified tensile strength of the bar. The quoted rate shall be inclusive of carrying out above tests and no separate payment shall be made for these tests.

11.5.9 The Contractor shall submit to the engineer for acceptance a report on these Proving Tests, within seven working days of the tests. The report shall provide full details including:

(a) Results of all tests
(b) Details of dimensions, geometry.
(c) Details of test procedures
(d) Description of test rig/load cell
(e) Description of load monitoring, strain measurements
(f) Calibration certificates.

11.5.10 From each test on the coupler and control bar specimens, the following information shall be provided:

(a) Stress-Strain (or Load Displacement) curves
(b) Yield Load & Yield Strength
(c) Elongation of the mechanical connection
(d) Ultimate load & Ultimate Tensile Strength
(e) Mode of failure
(f) Gauge length used for strain measurement and statement of how gauge length was determined.

12 PILING WORKS

12.0 SCOPE

This specification covers the works involved for bored cast in situ reinforced cement concrete (RCC) piles including all specific requirements for installation/casting of pile, testing (initial, routine and other NDT) and analysis of the various test results to assess their vertical, horizontal and pull out load carrying capacities, confirm pile integrity, apportion skin friction and end bearing capacity of the pile and arrive at dynamic properties of soil-pile system. *All the piles within the scope of this tender needs be toe grouted. The procedure for Toe grouting shall be finalized by the contractor in consultation with Engineer.*

12.1 CODES, STANDARDS & SPECIFICATION

12.1.1 Latest Indian Standards on Piles

IS 2911 : Part 1: Sec 2 Code of practice for design and construction of pile Foundations: Part 1 Concrete piles, Section 2 Bored cast-in-situ piles
IS 2911 : Part 4: Load test on piles
IS 5121 : Safety code for piling and other deep foundations
IS 9716 : Guide for lateral dynamic load test on piles
IS 14362 : Pile boring equipment - General requirements
IS 14893 : Non Destructive integrity testing of piles-Guidelines

12.1.2 **Latest ASTM**

ASTM D 4945: Standard Method of test for High Strain Dynamic Testing of Piles
ASTM 6760: Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross-hole Testing
ASTM D 5882: Standard Test Method for Low Strain Integrity Testing of Piles

Reference to any code shall always mean reference to the latest revised edition of the code including all its amendments up to date, unless otherwise specified. In the event of any conflict between the requirements of this specification and those of the referred codes, the former shall govern.

12.2 DESCRIPTION

12.2.1 **GENERAL**

Specifications to be followed for providing RCC bored cast in situ piles wherever required as per design . The scope in general consists of constructing the RCC bored cast in situ pile foundation .

The testing of piles shall be carried out by the contractor in line with relevant BIS codes, and / or ASTM codes, as specified above and procedures to be developed by the contractor/Vendor and approved by NPCIL. Initial and Routine (static and dynamic) tests shall be carried out on test piles and working piles, respectively as per provisions of BIS/ASTM and as approved by NPCIL.

The work involves but is not limited to the following:

1. Construction of Pile foundation .
2. Conducting Initial, Routine Load tests (Static and dynamic) on designated Test / working piles namely Vertical, Lateral, Pull out and Dynamic load tests.
3. Conducting Non-Destructive Testing (NDT) to assess pile integrity.
4. Toe grouting of pile

The contractor shall submit the work procedures for different items of piling works in line with IS/ASTM, Technical Specification herein under and get it approved from Engineer.

Upon completion of the piling work, all casing equipments, construction tools, protective covering and debris resulting from the piling operations shall be removed from the works site with the permission of the NPCIL.

12.2.2 **MINIMUM REQUIREMENT OF PILING EQUIPMENT**

The equipment & accessories should be compatible with the type of sub-soil, method of construction, type of founding strata & required penetration in the founding strata. The capacity of rig shall be adequate so as to bore up to required depth with specified diameter. Rig shall be equipped with suitable chisel to penetrate through any local obstruction/ hard strata.

Hydraulic self-propelled rotary piling rigs complete with adequate torque capacity and crowd value shall be deployed to complete the entire job as per the time schedule and specifications provided in this tender document. The Contractor shall mobilize adequate spares; cutting tools (e.g. flat teeth bits, round shank bits, holders, etc.) to avoid any stoppage of work.

The Contractor shall provide all the equipment, tools and plants required for the work.

12.2.3 SURVEYING AND LAYOUT

It is the sole responsibility of the contractor to bring to site all surveying instruments necessary for the marking out, fixation of levels, etc. and conduct these survey operations with utmost accuracy. The contractor shall put-up stable bench marks etc. as necessary for the work. NPCIL will provide benchmark location and elevation with respect to plant grid. The contractor shall be entirely responsible for accurate setting out of the work and he shall at his own expense make good any defects arising from errors in line and levels.

12.2.4 BORING

The boring shall be done as per specific requirements of soil strata and the procedure / methodology shall be approved by Engineer-In-Charge.

The Contractor, while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classifications, these shall be immediately reported to the Engineer. Rig register and weekly report as per the format, approved by NPCIL shall be submitted to Engineer-In-charge of the project.

12.2.5 CLEANING OF PILE BORE

After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/bored material etc. Necessary checks shall be made to confirm the thorough cleaning of the pile bore as per the recommendations of IS 2911-Part1-section 2.

Pile bore spoil shall be disposed of from site within 1 Km. away as directed by the Engineer.

12.2.6 DEWATERING

The dewatering for the area will be carried out by the Purchaser through some other agency.

12.2.7 INFORMATION TO BE SUBMITTED AS PART OF THE TECHNICAL BID

If piles are envisaged in the structure, bidder shall submit the following information along-with the bid:

1. Number of the piling rigs proposed to be deployed.
2. Full Technical details of piling rigs and accessories in the form of catalogues, data sheets, etc.
3. Piling procedure, piling program and accessories to be mobilized by the contractor.
4. Complete Construction Methodology. However, work procedures and quality assurance plan (QAP) for the work will be required before start of the work. The contractor shall use only Ready mixed concrete from the batching plant for the proposed piling works.
5. All data sheets, rig register, test reports, Soil profile data.
6. Details of toe grouting to be done for all piles.

12.3 REQUIREMENTS

All work shall be carried out in accordance with this specification and contractor shall ensure meeting of all the requirements as laid down hereunder:

The work shall include supplying and providing necessary materials, mobilization / demobilization & operation of all necessary equipment, consumables providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labor etc. as required to carry out the complete piling work, and submission of records & reports as per schedule.

The Contractor shall confirm the "Safe Load" capacities by conducting both initial and routine load test on piles.

It is essential that all equipment and instruments are properly calibrated at the commencement of test so that they represent true values. The instruments shall be re-calibrated at the frequency as per manufacturer’s specification. Certificates to this effect from an approved institution/National Accreditation Board for Testing and Calibration Laboratories (NABL) shall be furnished to the Engineer. If the Engineer desires to witness such tests Contractor shall arrange to conduct the test in his presence.

The contractor shall assure the quality of piling work including cleaning of pile bore, quality of concrete, integrity of piles, etc.

Each pile shall be identified with a reference number. Sequence of piling shall be such that there is no damage caused to the concrete recently laid in the adjacent pile and as per approved drawings. Construction of piles shall be done in accordance with the priority of construction of various buildings. The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed pile. Sequence of piling shall be approved by the Engineer.

12.3.1 TERMINATION OF PILES

The casting of piles shall start from levels strictly as per approved construction drawings. In no case casting of piles should start from levels higher than those indicated in the approved drawings. The top of the pile shall be cast above the cutoff level so as to permit removal of all laitance and weak concrete before embedment into raft. The pile top shall be terminated at minimum 600mm above Pile cutoff level. The same will be chipped off up to cutoff level before the commencement of pile-raft construction to progress the job further.

12.3.2 SAFE LOAD CARRYING CAPACITY

The contractor shall conduct the tests as specified in the drawing or as per the direction of Engineer and determine the minimum safe load for the piles constructed for Vertical Compression/Lateral/Uplift.

12.4 MATERIALS

Materials shall conform to specifications for materials included in the specification of 'normal concrete', 'reinforcement' and 'coupler' in this tender document.

12.4.1 CONCRETE

The concrete shall be of M35 grade or as specified in the approved drawings. The minimum cement content shall be 350 kg/m^3 (including fly ash as defined in technical specifications for plain and reinforced cement concrete) and allowable slump shall be between 150mm to 180mm as specified in IS 2911 Part 1/Sec 2. The tests on concrete for piles shall be tested as per the relevant specification given in this tender. Suitable cylindrical cover blocks with center hole shall be used to maintain the specified cover as per the approved drawings. The re-steel ties used for holding cover blocks for re-steel.

12.4.2 REINFORCEMENT & COUPLERS

Reinforcement & couplers shall conform to relevant technical specifications given in this tender.

12.4.3 STABILISING MUD/BENTONITE/POLYMER

The drilling mud for stabilizing the borehole in bored piling work should have properties and quality control conforming to the requirements of IS 2911-(Part1-Sec-2). In case polymer is used, the specification and methodology for its use shall have prior approval from NPCIL.

The bentonite / polymer slurry and the cuttings, which are carried to the surface by the rising flow of the slurry, shall pass through setting tanks of adequate size to remove the sand and spoils from the slurry before the slurry is re-circulated back to the boring. The bentonite slurry mixing and re-circulation plant shall be suitably

designed and installed. The bentonite slurry shall be maintained at 1.5 m above the ground water level during boring operations and till the pile is concreted. When DMC (Direct mud circulation) or RMC (Reverse mud circulation) method is used the bentonite slurry shall be under constant circulation till start of concreting.

For tremie concreted piles, a sample of drilling fluid shall be taken from the base of the borehole by means of an approved sampling device in the first few piles and at a suitable interval of piles thereafter. The concreting operations shall not be taken up when the fluid density is more than 1.25g/ml.

After completion of piling work, area around piles shall be restored with compacted soil-cement mix after removal of bentonite slurry /muck, at no extra cost to NPCIL.

12.5 CONSTRUCTION

12.5.1 Construction of piles shall be carried out only after excavating ground up to the desired founding levels/levels as per requirement of ground improvement technique to be adopted and as per the approved drawings.

12.5.2 Pile shall be constructed by using temporary casing up to required depth as per site conditions. This is to ensure not only the stability of side soil and also to ensure good quality concrete in the entire length of pile. Adequate bentonite mud / polymer or any other suitable material (if required) may be used during the boring below temporary casing. The contractor shall ensure the stability of bore by adopting suitable combination of temporary casing pipe and bentonite/ polymer slurry for stabilization.

12.5.3 Immediately before placing of reinforcement and concreting, the bored hole shall be cleaned of all the loose material and debris. The pile tip zone shall be thoroughly cleaned by flushing the bore with fresh bentonite slurry/polymer to completely replace the old bentonite slurry / polymer used during the previous operations. This shall be carried out for about 45 minutes in two stages. Cleaning for about first 30 minutes shall be done before lowering of reinforcement cage & cleaning of about second 15 minutes after lowering the reinforcement cage.

12.5.4 The time interval between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs the pile bore shall be abandoned. However, the Engineer may allow concreting provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth and clean the pile bore.

12.5.5 The soil profile and design requirements shall dictate length of temporary casing pipe for construction purposes and shall be withdrawn during casting of the pile. The temporary guide casing shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

12.5.6 Cut-off level of the piles shall correspond to those given in the approved drawings. To ensure dense and sound concrete up to cut-off level, concreting shall extend minimum 600 mm above cut-off level. The vertical reinforcement shall project above the cut-off level as per the approved drawings.

12.5.7 In case the reinforcement cage is made up of more than one segment, the same shall be assembled by threaded couplers before lowering. Reinforcement as required shall be made into stiff cages with stiffener rings of appropriate diameter at suitable spacing to withstand handling without any damage or distortion.

Borehole shall be thoroughly cleaned to make it free from sludge or any foreign matter before lowering of reinforcement cage. The full length of reinforcement cage should be in place before start of concreting. Reinforcement shall be placed immediately after cleaning and inspection of the bottom of bore holes. The reinforcement should be supported away from the sides of the shaft by means of suitable spacer blocks to ensure concentric alignment in the shaft. Care shall be taken to preserve correct cover and alignment of reinforcement and avoid damage to it throughout the complete operation of placing concrete.

12.5.8 Concrete shall be so placed as to fill the entire volume of the tube or bore without the formation of voids caused by the faulty consolidation or entrapped air. Proper care shall be taken to ensure that the fluid alluvial soil does not penetrate the concrete.
Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS: 2911 (Part1-Sec2). Concrete shall be placed by means of tremie pipe, which will be suitably closed at bottom at the start of concreting. The tremie pipe must extend up to the bottom of the borehole at the start and may be withdrawn in sections as the level of concrete rises in the borehole; but its discharge end shall at all times be embedded in the concrete to a minimum depth of 2m. Placing of concrete should be continuous and the pile holes will be maintained full with the bentonite slurry where used throughout the concreting operation. Slurry displaced from the borehole by the concrete shall be channeled away or pumped into suitable mud pond for re-use or disposal to waste.

12.5.9 The record of volume of concrete poured in each of the piles shall be maintained. After concreting the actual quantity of concrete shall be compared with the average obtained from observations made in the case of a few piles already cast. If the actual quantity is found to be considerably less, the matter should be investigated and appropriate measures taken.

12.5.10 **Control of alignment**: Piles shall be constructed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS-2911 (part 1/Sec2).

12.5.11 **Preparation of pile head:** Before casting the piled raft, the excess concrete shall be cut off up to pile cut-off level as shown in approved drawings. In case sound concrete is not met with at such elevation the piles shall be cut up to an elevation where sound concrete is met. Care shall be taken not to damage the reinforcement or the concrete below cut off elevation during such stripping operations. Where chipping to be done to a level lower than the specified cut off elevation to obtain dense and sound concrete, the Piling Contractor shall build up the pile up to cut off elevation at his own cost.

The exposed part of concrete above the Cut off level shall be removed/chipped off and made square at cut off level not before seven days of casting of pile. The projected reinforcement above Cut off level shall be property cleaned and bent to the required shape and level to be anchored into the pile raft as shown in the drawing.

The pile top shall be embedded into the pile cap/raft by minimum 50 mm or clean cover to reinforcement, whichever is higher.

12.6 DEFECTIVE PILES

The Engineer reserves the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawing on account of load capacity, structural integrity, position, alignment, concrete quality, improper cleaning of borehole before concreting, etc. Piles that are judged defective shall be pulled out or left in place as decided by the Engineer without affecting the performance of adjacent piles. If the adjacent pile is affected, the contractor shall install additional piles to substitute the adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the EIC at no extra cost to NPCIL.

12.7 QUALITY ASSURANCE PROGRAMME

The Contractor shall submit and finalize a detailed Field Quality Assurance Program within 30 days from the date of award of the contract, according to the requirements of this specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of field quality plan, etc., the Engineer shall identify, customer hold points, on finalized field quality plan, beyond which work shall not proceed without written approval from the Engineer. The testing apparatus/equipment installed in the field laboratory shall be calibrated/ corrected by the qualified persons as per manufacturer's instructions to give accurate testing results.

12.8 RECORDING OF DATA

Daily site records shall be maintained by the Contractor for the installation of piles against each Rig and shall contain the number and dimension of the pile, depth bored, time taken for boring and concreting. Contractor shall maintain field bore log. When drilling mud /polymer is used, amount of bentonite / polymer needed for stabilization of bore, specific gravity of the fresh supply and contaminated mud in the bore hole before concreting shall be checked and recorded regularly. Record of concrete volume actually cast per pile against required volume shall be maintained. Detail of any obstruction encountered its nature, depth and obstruction time. Any deviation from the designated location alignment or load capacity of any pile shall be noted. Typical data sheet in triplicate for facility of recording piling data to be prepared by the Contractor before starting of actual piling operation at site and information to be recorded against each pile in the data sheet shall be signed by the contractor and countersigned by NPCIL. One copy of the data sheet shall be retained by the

Contractor and the other two copies to be submitted to NPCIL for records & future reference.

A full record of pile load test results shall be submitted in triplicate to the Engineer immediately on completion of each test. The record shall also include the plots of load settlement (for various stages of loads) characteristics of pile and also the interpretation of the pile load test curve as per criteria for safe loads mentioned in the specifications for testing concrete piles forming a part of this tender. Any special observations shall be duly explained by the contractor.

Contractor's competent supervisor (geotechnical engineer) shall always be present to record the necessary information during the installation of piles. The data to be recorded shall include:

1. Pile number and location
2. Existing ground level, cut-off-level and level of top of the casting
3. Nominal shaft and inside diameter of casing
4. Data and time of setting up of rig at the pile location.
5. Data and time of start of boring.
6. Length of casing driven and depths bored vs time.
7. Description and thickness of various strata bored.
8. Details of any obstructions encountered (depth from existing ground level, thickness and time taken to penetrate through the same)
9. Chiseling depth and time.
10. Final depth of boring (founding level).
11. Standard penetration test at the bottom of the bore hole, if any.
12. Date and time of completion of boring.
13. Data and time of start and completion of flashing of the bore hole with fresh Bentonite fluid before Concreting.
14. Time of lowering Reinforcement cage and tremie pipes with total length thereof.
15. Date and time of start of concreting
16. Level of concrete inside the bore hole and tremie pipes at various stages of concreting.
17. Concrete grade, mix proportion, water cement ratio and slump test results.
18. Empty boring length and concrete length below cut-off-level.
19. Results of tests on Bentonite slurry used.

Typical data sheets of recording piling data shall be as given in Appendix-D of IS: 2911(Part I/ Sec.2).

Any deviation from the designed location, alignment or load carrying capacity of any pile shall be noted and promptly reported to the Engineer..

On completion of each pile construction, pile record in triplicate shall be submitted to Engineer-in-Charge within two days of completion of concreting of the pile.

On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Engineer, to ensure that it is free from pile bore

spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of Engineer.

12.9 PILE TESTING

The contractor has to prepare work procedure for conducting the tests in line with IS/ ASTM, Technical Specification herein under and get it approved from Engineer before start of test .

Pile Load Test: Both initial and routine load tests shall be conducted for all the types of testing i.e. vertical, lateral and pull-out. The load tests shall be carried out after concrete attains full strength.

Non-destructive testing of piles: NDT of piles (Low strain integrity test, high strain dynamic testing and cross-hole sonic logging test as per ASTM codes) shall be carried out by expert team or by engaging an expert agency. The staff of the team shall have experience of carrying out these types of tests and knowledge of analyzing the data. Credentials of expert team/expert agency shall be submitted for acceptance by NPCIL.

12.9.1 PILE LOAD TEST DETAILS

12.9.1.1 General

1. For pile load tests, the test set up shall be as per relevant BIS, ASTM standards and specifications for testing of concrete piles.
2. The testing shall be done by specified method of loading in successive increments as per the relevant clauses of IS: 2911 Part 4.
3. Tests shall be carried out at the cut-off level.
4. Maximum test loads for different types of piles shall be as per the approved drawings.
5. All the piles shall be provided sonic logging tubes to carry out Cross hole Sonic Logging Test.
6. The number of tests (other Cross hole Sonic Logging Test) required shall be as approved by the engineer.
7. A method statement for all the load tests shall be submitted to NPCIL and testing shall be carried out after approval of the same.
8. The details of tests to be carried out on piles are presented below.

PILE TESTING MATRIX

Tests on Piles		
Initial Load Tests	Routine Load Tests	Non-Destructive Tests (Both Initial and Routine)
1. Vertical Load Test	1. Vertical Load Test	1. Low Strain Integrity Test
2. Lateral Load Test	2. Lateral Load Test	2. High Strain Dynamic Test
3. Uplift Load Test	3. Uplift Load Test	3. Cross Hole Sonic Logging Test

12.9.1.2 INITIAL LOAD TEST

Initial load test shall be carried out on separately cast test piles following purposes:

1. Confirmation of estimated pile capacities at founding level.
2. To provide guidelines for setting up the limits of acceptance for routine tests.
3. To confirm suitability of piling system.
4. To have a check on calculated load by dynamic or static approaches.

The number of tests to be conducted for each mode (vertical compression, pull out and lateral) and each type of pile and maximum test load shall be as per approved drawings.

The following initial load tests shall be carried out as per IS 2911(Part 4):

1. Initial vertical load test.
2. Initial lateral load test
3. Initial pull-out load test.
4. Initial vertical cyclic test

12.9.1.3 ROUTINE LOAD TEST

Routine load tests shall be carried out on job (working) piles as per approved drawings. Routine load tests shall be carried out for following purposes:

1. To confirm the safe load of the pile.
2. Checking safe load and extent of safety for the specific functional requirement of the pile at working load
3. Detection of any unusual performance contrary to the findings of the initial test, if carried out.

The following routine load tests shall be carried out as per IS 2911(Part 4):

1. Routine vertical load test.
2. Routine lateral load test
3. Routine pull-out load test.

For routine lateral load test the loading shall be continued till one and half times the safe lateral load or 5mm deflection, whichever occurs earlier.

12.9.2 RECORDING OF DATA AND PRESENTATION

12.9.2.1 The initial and routine pile load test data essentially concerns three variables, namely, load, displacement and time. These are to be recorded sequentially for the tests under consideration and recorded in a suitable tabular form along with the information about the pile.

12.9.2.2 The initial and routine pile load test data may be suitably presented by curves drawn between the variables and safe loads shown on the graphs. Load-displacement curve should be an essential part of presentation.

12.9.3 REPLACEMENT OF DEFECTIVE/ REJECTED PILES

During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Engineer, fresh bore holes are to be executed at a suitable new position, as decided by the Engineer, which may demand for resizing of pile raft including possible increase in reinforcement quantity due to resizing of pile raft. In all such cases the abandoned bore holes are to be filled up with plain cement concrete of grade M15 so that no cavity remains in the bore hole of the abandoned pile. No extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile raft including increase in reinforcement quantity will be accepted and same is deemed to be carried out by the contractor at his own cost.

Piles showing unsatisfactory results as per load tests shall be treated as defective piles. Piles/boring/casing that are defective shall be left in place/ pulled out as directed by Engineer without adversely affecting the performance of the adjacent piles. In case the hole from which pile is pulled out is abandoned, the same needs to be filled up with concrete of grade M 15 at no extra cost to NPCIL. No payment shall be made for extra expenditure incurred in constructing alternative piles and implementing the changes in the design of raft on account of change in location of piles.

12.10 NON DESTRUCTIVE TESTING OF PILES

12.10.1 LOW STRAIN PILE INTEGRITY TEST

12.10.1.1 GENERAL

Low strain Pile Integrity Test (PIT) is a non-destructive integrity test method to establish the Integrity of the pile along its length and to identify the deficiency in quality of pile, if any.
In PIT the impact shall be made using small hand held hammer. The evaluation of PIT records shall be conducted according to the Pulse-Echo (or Sonic Echo – a time domain analysis) analysis method.

12.10.1.2 TEST METHOD AND REFERENCE CODE

The test requires the impact of a small hand held hammer on the shaft top and the measurement of motion of the pile top in terms of acceleration or velocity. The input compression wave from the hammer is reflected from pile toe (or a defect) and returns to the pile top at a time related to the speed of travel of the wave in the pile material. The test shall be performed as per ASTM D 5882 "Standard Test Method for Low Strain Integrity Testing of Piles".

The pile top velocity is displayed as a function of time with an exponentially increasing magnitude where high soil friction forces are present, such that the pile toe reflection is enhanced. Several records with consistent signals should be averaged. The averaged, amplified velocity shall be standard result of the Pulse Echo Method.

12.10.1.3 **TEST EQUIPMENT**

The test should be performed using digital data acquisition equipment. The signal conditioning and power supply must have very high signal-to-noise ratios to discern the reflected signals for long piles (and/or piles in high friction soils). The analog to digital resolution shall be at least 16 bits, and the sampling frequency at least 25,000 Hz. Data should be stored such that additional processing or further wave analysis is possible. The data must be displayed in the field for evaluations of preliminary data quality and interpretation. The apparatus shall include a graphic display of velocity. The equipment & software used for test and its data processing shall be compliant with ASTM D5882. The equipment shall have a provision of display of data on the field for preliminary evaluation and interpretation and the field print out shall also be feasible. The test agency shall deploy adequate number of equipment & spares to meet contingencies and achieve the desired progress of work to meet construction schedule.

12.10.1.4 **TEST PREPARATION**

Integrity testing shall be performed after the concrete has cured for a minimum of seven (7) days. The pile head shall have sound concrete, free from water, dirt or other debris and reasonably flat surface. The concrete at the pile top surface must be relatively smooth with sufficient space for both attachment of the motion sensing device 300mm away from the center and hammer impact area at the center of the pile.

Piles for integrity testing shall be selected by NPCIL.

The projecting re-bars need to be bent outside for easy access within core region. Safe and reasonable access to the pile is the responsibility of the contractor.

The data supplied to expert test agency at the time of test shall include length of the pile from testing level, cutoff level of the pile, pile diameter and pile reference as well as location. Soil information available for the location or in the vicinity shall be provided for valuable interpretation of test results. Additional data like pile installation records, load test results etc., shall also be supplied to the test agency.

12.10.1.5 **DATA PROCESSING**

The data collected using test equipment shall be processed using compatible software. To ensure that the signals are clearly visible for interpretation, data shall be processed in terms of Magnification (MA to enhance the energy lost), reduce reflections from soil to evaluate concrete (HI PASS Filter), and reduce reflections from reinforcement (Wavelet Filter). The MA shall be a factor of the length of the pile and normally must

be equal to the pile length. The magnification delay shall be default 20% to avoid errors in interpretation.

12.10.1.6 **RESULT PRESENTATION**

The testing agency shall submit test report within 2 working days, after performing the field test, clearly indicating the result of test results and Pile Integrity evaluation and further recommendations. For each pile tested, the averaged, amplified velocity versus time record shall be included in the report, with a table summarizing results and conclusions. On completion of field testing, a report shall be submitted and shall clearly describe the following:

- Uniformity of pile changes in cross-section qualitatively i.e. bulge or defect due to necking, etc.
- Sudden changes in soil stratum based on soil profile and graphs.
- Concrete quality in terms of wave speed.

12.10.1.7 **ACCEPTANCE AND REJECTION**

The report shall clearly indicate that tested piles are acceptable or questionable or needs to be rejected. The comments shall generally be based on the following guidelines.

1. Piles with toe response and no defect apparent shall be classified as acceptable.
2. Piles with no toe response and significant reduction or defect above the pile toe shall be rejected and replacement or any other remedial action may be considered. The test engineer should specify the approximate location of defect in such a case.
3. Piles with a sudden major increase in resistance or impedance may not show toe response and are termed as inconclusive and a typical such pile can be selected for static / high strain dynamic test at the discretion of the Engineer.
4. Piles that show toe response but some impedance reduction / defect maybe under-rated / replaced / repaired / or subjected to additional high strain dynamic or static testing at the discretion of the Engineer.

Acceptance / rejection of piles in 3 and 4 above shall also be based on construction records.

Construction records (concrete usage, grout pressure records, soil borings etc.) may be valuable in result interpretations. Based on the Expert agency recommendation, the decision to either reject and replace, or repair, any defective pile shall be taken by the NPCIL and replacement / remedial measure of such piles at no extra cost to NPCIL shall be binding on Contractor.
If the pile top appears questionable, further pile top cut-off and retesting may be advisable.
If a majority of piles diagnose as "inconclusive", partial or even complete pile excavation or another test method may be necessary for pile acceptance.

12.10.1.8 **REMEDIAL ACTION**

Rejected or questionable piles may be replaced or retested (e.g., static load testing, dynamic load testing, core drilling, ultra-sonic logging, etc.) based on the test results and recommendation of expert agency and as approved by NPCIL.

Remedial action may include pressure grouting through core holes wherever feasible as approved and accepted by NPCIL at contractor's own cost. The repaired piles shall be re-tested and accepted subject to qualifying the test. The cost of such re-testing shall be borne by the contractor.

12.10.2 CROSSHOLE SONIC LOGGING (CSL) BORED CAST-IN-SITU PILES

12.10.2.1 GENERAL

CSL testing shall be performed by sending ultrasonic pulses through concrete from one probe to another (probes located in parallel tubes). The CSL procedure inspects the structural integrity of the pile concrete between the tubes, and extent and location of defects, if any.

This work shall consist of furnishing all materials, equipment and labor necessary for conducting CSL tests on drilled and cast-in-place piles (hereafter each noted as test piles). The contractor shall be responsible for conducting the test through approved expert agency, including supply of material and labour as hereinafter specified and including prior to, during, and after the load test.

CSL testing is a non-destructive quick test and it is intended that the test pile be left in a condition, suitable for use in further construction and may be used as part of structure.

12.10.2.2 TEST METHOD & REFERENCE CODE

The Pile shall be instrumented & Tested as per recommendations of ASTM 6760 "Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross hole Testing" unless noted otherwise.

Both the time between pulse generation and signal reception ("First Arrival Time" or "FAT") and the strength of the received signal give a relative measure of the quality of concrete between transmitter and receiver. Dividing the distance between transmitter and receiver by the FAT value yields the approximate concrete wave speed which also is a relative indicator of concrete quality. For equidistant tubes, uniform concrete between the test tubes yields consistent arrival times with reasonable pulse wave speed and good signal strengths. Non-uniformities such as contaminated or soft concrete, honeycombing, voids and inclusions exhibit delayed arrival times with reduced signal strength.

12.10.2.3 TEST EQUIPMENT

The Contractor shall supply all materials and equipment required to prepare the test pile and restore the pile to a condition suitable for use in the permanent structure, wherever specified by the Engineer. Equipment required to perform the test includes but is not limited to following:

Provide a Cross Hole Analyzer (CHA) manufactured by Pile Dynamics, Inc., or equivalent CSL equipment. The equipment shall have the following minimum requirements.

1. A computer based CSL data acquisition system for display of signals during data acquisition, with a minimum 12 bit A/D converter with a sampling frequency of at least 250000 Hz, and recording of all pulse signals for full analysis and individual inspection. (Note: Converting signals with low noise using high A/D resolution and sampling rates is important to obtain quality data and allow proper full data interpretation.)

2. Ultrasonic transmitter and receiver probes with probe centralizer and signal transmission cables as per ASTM6760 capable of generating pulse with a frequency between 30,000Hz to 100,000Hz with good signal amplitude and energy through good quality concrete. The probes shall be less than 30mm in diameter and shall freely descend through the full depth of properly installed sonic logging tubes of at typically less than 50 mm diameter, in the piles.

3. Two depth sensors to independently determine transmitter and receiver probe depths.

4. Triggering of the recording system time base with the transmitted ultrasonic pulse.

12.10.2.3.1 Sonic Logging Tubes:

All Piles required to be tested shall be provided with sonic tubes for sonic logging tests cast into it. The tubes shall be manufactured from mild steel tubes. To form a single tube the pipes to be connected with Bell Mouth – push fit arrangement only. PVC or any kind of plastic material is strictly prohibited due to different coefficient of thermal expansion with respect to concrete which may affect the test result. The tubes should be of 50mm Internal Diameter and 1 mm thick.

Tests to be conducted for Sonic Tubes assembly and desired results.

The Sonic Tubes assembly should be tested for following tests:

a) External Pressure Test

The minimum 50 mm inside diameter tube, minimum 1 mm wall thickness should be applied with external pressure up to 5 Mpa . Following are the desired results:

Description	Pressure in Mpa	Hold Time	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 5 MPa	>= 60 Sec	No Leakages from Inner Surface of Tubes and No Distortion of Tubes

Minimum 3 test results should be obtained.

b) Pull Out Test for Tubes

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 0.5 KN	No Distortion / Elongation of Tubes till test load of 0.5 KN.

c) Pull out test for Joint

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick, Bell Mouth – Push Fit Joint.	>= 0.5 KN	Joint should withstand the Pull out load of 0.5 KN.

d) Pull Out Test for tubes 'Fixing Ears'

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 0.5 KN	Fixing Ears should withstand the Load up to 0.5 KN.

e) Crush Test

For 50 mm diameter and 1 mm tick Tube following is the criteria for Crush test.

Sr. No.	Descriptions	Test	Desired Results
1	Direction tube	1500 mm	No Cracks After test 30 mm Steel ball can go through the tubes.
2	Drop Weight	4000 + 150/-0g	
3	Diameter of Drop	m	

12.10.2.4 CSL ACCESS TUBE PREPARATION

Every drilled shaft shall be equipped with sonic logging tubes to permit possible inspection by CSL. Drilled shafts with different diameters at the same site may require a different number of sonic logging tubes. Sufficient number of sonic logging tubes shall be installed in all the Piles (minimum 2 nos.) prior to concreting as given in the drawing based on the Pile Diameter. The Number of tubes shall be generally one tube for every 0.3m of drilled shaft diameter unless specified otherwise, but not less than 2 nos. in any case.

The number of piles to be tested by CSL shall be as specified in drawings. If not specified in the drawing, minimum 20% of the piles shall be subjected to this test or as decided by Engineer.

The parallel steel tubes shall be supported and braced securely so that they maintain their position during the subsequent operations. The splice connection of parallel pipes shall be of good quality, easy installation and proven water-tight performance having Bell-Mouth Socket system with rubber gasket joint unless mentioned and approved otherwise.

The couplings locations shall be properly recorded. Tubes shall be installed by the Contractor in a manner such that the CSL probes pass through the entire length of the tube without bending. Ensure that the sonic logging tubes are in plumb and verify that unobstructed passage of the probes is achievable.

The Sonic logging tubes shall be fitted with a watertight shoe on the bottom and a removable cap on the top. Tubes shall be secured to the interior of the reinforcement cage at regular intervals not to exceed (1.0m). Tubes shall be installed uniformly and equidistantly around the circumference such that each tube is spaced parallel for the full length and at the maximum distance possible from each adjacent tube. Tubes shall be spaced as far as possible from the main axial reinforcing steel. The bottom end of the Tubes shall be kept approx. 100 mm above the bottom of the drilled shaft , and the top end shall be at least (1.0m) above the top of the concrete of the Pile, and to at least (0.6 m), but not more than (1.5m) above the ground surface. Tubes shall not be damaged during installation of the reinforcement cage.

The tubes should preferably be filled with water prior to concrete placement, in any case it must be filled with water within at most 1 hour after placing concrete to prevent de-bonding of the sonic logging tubes from concrete, due to differential temperatures. The top of the tubes shall be capped to prevent debris from entering the sonic logging tubes. Excessive torque, hammering or other stresses which could break the bond between the tube and concrete when removing caps from the tubes shall be avoided.

12.10.2.5 TIMING OF THE CSL TEST

The pile shall be tested no sooner than seven (7) calendar days after placement of all concrete (having minimum compressive strength as 2/3rd fck) and preferably within

90 days after casting of pile. The concrete strength and quality generally increases as the concrete cures, longer wait times are usually desirable. After all CSL testing has been completed, and after acceptance of the pile by NPCIL Engineer, the Contractor shall remove the water in the tubes, place grout tubes extending to the bottom of the access tube, and fill all sonic logging tubes in the pile with cement sand grout.

12.10.2.6 PROCEDURE

Prior to CSL testing, the Contractor shall provide the expert test agency with a record of all pile lengths with elevations of the top and bottom, and installation dates of all piles. The sonic logging tubes shall be clearly labeled for identification. The CSL testing shall be performed with the transmitter and receiver probes in the same horizontal plane in parallel tubes.

Using the labeling established for the tubes, CSL testing shall be performed between all adjacent perimeter access tube pairs and across at least all major diagonals within the pile.

Probes shall be lowered from the top, effectively measuring the access tube lengths. Probes shall be pulled simultaneously, with CSL measurements taken at intervals of 50 mm or less from the bottom to the top of the pile. Defects indicated by late pulse arrival times and significantly lower amplitude/energy signals shall be immediately reported to NPCIL Engineer. The equipment used for test shall be properly maintained and calibrated.

The tests shall be repeated for each pair of tubes, i.e. three runs for a pile with three tubes and six runs for a pile with four tubes.

12.10.2.7 REPORTING OF RESULTS

A report shall be prepared for each pile tested. The photographic record of the oscilloscope displays shall be analyzed in detail. Any deviation from the record to be expected from a pile constructed entirely of sound concrete and without defect shall be reported. The report shall indicate the nature, location and severity of the defect and recommendations shall be made for further testing. The implication of the existence of the defect on the performance of the pile shall be evaluated.

Results of the CSL shall be presented in a written report within five (5) working days of completion of testing. The report shall include presentation of CSL logs for all tested tube pairs including:

1. Presentation of the traditional nested signal peak (e.g. “waterfall”) diagram as a function of time plotted versus depth.
2. Computed pulse first arrival time (FAT) or pulse wave speed versus depth.
3. Computed relative pulse energy or amplitude versus depth.

A CSL log shall be presented for each tube pair. The rating of the shaft integrity considers the increases in "first arrival time" (FAT) and the energy reduction relative to the arrival time or energy in a nearby zone of good concrete. Pile is classified as satisfactory/ good provided the evaluation criteria for FAT increase and energy reduction are met. Pile is classified as having minor defect or poor concrete if either evaluation criteria of FAT increase or energy reduction are met. The criteria for evaluation of the concrete from the CSL test are given below.

Pile Classification	FAT Increase relative to good concrete	Energy reduction relative to good concrete
Satisfactory / Good	0-10%	<6 db
Minor Defect	11-20%	<9 db
Poor/Flaw	21 to 30%	<9 to 12
Poor/Defect	>31%	>12

Flaws must be addressed if they affect more than 50% of the profiles. Defects must be addressed if they affect more than one profile (a profile is the result of complete investigation from bottom to top between two tubes) at the same cross section. Flaws or Defects covering the entire cross section define a full layer concern requiring repair.

Immediately after testing, a signed copy of all the raw test data of a pile shall be handed over to the Engineer.

The piles with anomalous sonic logging results shall be rejected at the Engineer's discretion unless the contractor is able to demonstrate that the pile integrity is acceptable through proof coring.

12.10.3 HIGH-STRAIN DYNAMIC TESTING OF BORED CAST-IN-SITU PILES

12.10.3.1 GENERAL

High-strain dynamic testing shall be performed by obtaining and analyzing the records of pile force and velocity under drop weight impacts for evaluations of pile load carrying capacity, structural integrity, and load-movement and pile-soil load transfer relationships.

This work shall consist of furnishing all materials, equipment and labor necessary for conducting high-strain dynamic tests on bored cast-in-place piles (hereafter each noted as test piles). The contractor shall be responsible for conducting the test, including supply of material and labor as specified and including prior to, during, and after the load test.

High-strain dynamic testing is a non-destructive quick test and it is intended that the test pile be left in a condition, suitable for use in further construction and may be used as part of structure.

12.10.3.2 **TEST METHOD & REFERENCE CODE**

The Pile shall be instrumented & Tested as per recommendations of ASTM D 4945 'Standard Method of test for High Strain Dynamic Testing of Piles' unless noted otherwise.

12.10.3.3 **EQUIPMENT**

The test shall be conducted by the contractor through an approved expert agency. The Contractor shall supply all materials and equipment required to prepare the test Pile, dynamically load the Pile, and restores the pile to a condition suitable for use in the permanent structure, wherever specified by the Engineer. The test shall be conducted using Pile Driving Analyzer (PDA) to obtain and analyze the records of force and velocity under drop weight impacts. The field results shall be further analyzed with a signal matching technique such as CAPWAP (Case Pile Wave Analysis Program) or equivalent to refine the soil parameter assumptions.

In case of uncased pile – The Pile top shall be extended using a thin walled casing or equivalent, by a length equal to two pile diameters unless specified otherwise. This top length, shall be defined as the "test area" must be exposed and ready for test. Wherever the Pile top is below grade, the Contractor must remove surrounding soil (creating a safe working environment) so as to completely expose a test area of the Pile suitable for conducting the test to the satisfaction of expert agency engaged for the test. Windows on four opposite sides of the Pile have to be cut off in the steel casing to reach the concrete. The size of the windows shall be as suiting to the requirements of test agency and as approved by the NPCIL Engineer.

The pile top concrete shall be leveled above the casing. A drop weight shall be in the range of one to two percent (1 - 2%) of the anticipated pile capacity, or as determined by the expert agency and approved by the Engineer. A guide allowing variable drop heights typically between 3 and 13 ft (1 to 4 m), or as determined by the expert agency and approved by the Engineer shall be used for test.

Pile top cushion shall consist of new sheets of plywood with total thickness between 2 to 6 inches (50 to 150 mm), or as determined by the expert agency and approved by the Engineer.
A steel striker plate with a thickness of at least 2 inches (50 mm) and an area between 70 to 90% of Pile top area but not less than the area of the impacting surface of the drop weight to be placed on top of the plywood cushion.

Surveyors' transit, laser light, or equivalent for measurements of pile set under each impact.

12.10.3.4 **PROCEDURE**

a) The test Pile shall be constructed using the approved installation techniques.

b) If a permanent casing is not required, then the upper length equal to two Pile diameters, noted as the "test area", must be cased in a thin wall tube. Casing of this test area must be made as a continuation of the construction of the Pile.

c) Wherever, reinforcing bars are protruding out, the same shall either be encased within the concrete in the test area and on successful completion of the dynamic test, the surrounding concrete can then be removed to expose the bars using the same suitable for further construction, or a steel beam or pipe (cross sectional area approximately 20% of the Pile cross sectional area) shall be supplied with sufficient length such that the ram impact will not interfere with the reinforcing bars. Steel striker plates and plywood cushion must also be sized so that they cover as much of the impact area as possible. However, either of the above option shall be finalized in consultation with expert test agency with the prior approval of NPCIL Engineer.

d) There should not be any soil contamination or non-uniformities in the concrete located within or below the test area. Pile top shall be made level to the casing and smoothed.

e) Prior to testing time, the Contractor shall make the Pile test area length completely accessible to the suit the test.

f) Prior to the test four "windows" (approximate size of 6 by 6 inches (150 by 150 mm) diametrically opposite of each other shall be located and removed from the casing.

g) In cases where casing is not present, the circumferential area where transducer is to be fixed, shall be smoothened by grinding.

h) Gauges shall be attached to the exposed concrete or steel casing in a secure manner as to prevent slippage under impact.

i) Pile top should be examined to ensure that the concrete top is flush with or above the casing in any case it should not be below the casing level.

j) Apply plywood cushion and then striker plate to the Pile top.

k) At least two (2) hammer impacts should be applied to the pile top. First drop height should be minimal to assess the testing equipment, the driving system and pile stresses. Subsequent impacts can then be applied by utilizing higher drop heights.

l) Upon completion of the test, it is the Contractors' responsibility to return the pile to acceptable condition in a manner that the same can be used as part of structure.

12.10.3.5 **REPORTING OF RESULTS**

The Expert Agency shall submit a report of the field test results with its finding. In addition to the field results, results from at least one (1) set of wave equation analysis using CAPWAP or equivalent shall be submitted. The analysis shall be performed by same expert agency involved in the testing. The report must also provide the following:

1. Wave Equation analysis results obtained prior to testing.
2. Wave equation analysis results with a match quality preferably up to 5. If match quality is less than 5, reasons must be outlined for the same before acceptance by NPCIL.
3. For each impact, the maximum measured force, maximum calculated tension force, energy transferred to the gauge location, corresponding stresses, and the bearing capacity shall be tabulated.
4. Assessment of the test results both with respect to pile capacity and integrity.

The output from the test result shall provide:

a) Static capacity of the pile at the time of testing.
b) Simulated static load test curve
c) Total skin friction and end bearing of the pile
d) Skin friction distribution along the length of the pile
e) Compressive and tensile stresses developed in the pile during testing
f) Net and total displacement of the pile.
g) Pile integrity

12.10.4 EXPERT AGENCY TO PERFORM THE NDT ON PILES

The testing method and interpretation requires expertise and through understanding of wave mechanics. The agency employed for testing shall prove its competency by submitting previous reliability studies between static and high strain dynamic tests.

Contractor shall engage an Expert Agency of national repute and shall be approved by the NPCIL, to conduct the test. The Expert Agency shall be specialist having minimum of 5 years of experience in low & high strain integrity testing as well as sonic logging testing of the piles. The expert agency shall have sound knowledge of Wave Theory used for analyzing and interpretation of test results and at least performed minimum 5 nos. of correlation studies of Dynamic Pile Load Testing with conventional load test in various strata covering friction piles. The results of the correlation studies should have been accepted by the owners of the project, for whom tests were performed. Demonstration of case studies/correlation between CSL and HSDPT or PIT will be preferred. Performance certificates for completed projects shall be submitted.
The Expert Agency is required to perform wave equation analyses (using CAPWAP or equivalent) to determine the suitability of the proposed dynamic loading equipment and an acceptable range of ram drop heights so as not to cause damage in the pile

during the test. Performance certificates for completed projects shall be submitted. CV of the personnel carrying the test shall be submitted before performing the test.

The expert agency must possess, the following testing instrumentation in addition to that outlined in ASTM D 4945 Section 5: and other ASTM, in order to meet the project schedule and to maintain the redundancy. The test agency shall deploy adequate number of equipment & spares to meet contingencies and achieve the desired progress of work to meet construction schedule.

1. Pile Driving Analyzer (PDA)
2. Pile Integrity Testing Equipment.
3. Cross Hole Testing Equipment for Sonic Logging.
4. Required nos. of calibrated strain transducers.
5. Required nos. of calibrated accelerometers.

All other test equipment required for to conduct the above tests. The equipment and sensors shall be properly calibrated and the testing agency shall be able to obtain the calibration certificates upon request or prove the internal calibration of the system on site.

The Expert Agency shall study the Bore Log Data applicable to the test location, prior to perform the dynamic test, Pile installation records, concrete properties (strength, etc.) and submit the details regarding the anticipated dynamic loading equipment.

13 GROUT/ DRY PACK

13.0 General

Grout / Dry Pack shall be provided as specified on the drawings. The proportion of Grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage.

Concrete surfaces to be grouted / dry packed shall be thoroughly roughened and cleaned of all foreign matter and laitance. Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot strong caustic solution for this purpose may be permitted.

Prior to grouting/dry packing, the hardened concrete surfaces shall be saturated with water.

Forms around base plates shall be reasonably tight to prevent leakage of grout/dry pack. Adequate clearance shall be provided between formwork and base plate, to permit grout/ dry pack to be worked properly into place.

Grouting, once started, shall be done expeditiously and continuously to prevent segregation, bleeding and within the initial setting time. Grout shall be worked from one side to the other, to prevent entrapment of air.

Water in anchor bolt holes shall be removed before grouting is started.

Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least 24 hours after placing the grout. After the removal of forms and peripheral shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least after a minimum of seven days from the date of grouting. During this period, the grout shall be properly cured.

13.1 Dry Pack

The dry pack shall consist of 1:2.5 (Cement: Sand), sand passing through 1.18 mm square hole opening standard sieve. Only enough water shall be added to produce a mortar, which will stick together when moulded into a ball by a slight pressure of hand and will not extrude water but will leave the hands just damp. Dry pack material shall be placed and packed in layers having a compacted thickness of about 10mm. Each layer shall be solidly compacted over the entire surface by use of hardwood stick and hammer. Sand for this job shall be as pure as specified for concrete making.

13.2 Grout

13.2.1 Normal Grout

The contractor shall supply and place normal grout consisting of an approved mixture of cement, normal fine aggregate, water, admixture and when specified by the Engineer, a non-shrink agent. Normal grout shall be placed as shown on the drawings or specified by the Engineer.

Grouting through holes in base plates shall be, by pressure grouting. The pressure to be used for grouting shall be as directed by the engineer. The grout proportions shall be as follows:

Mix proportion	**W/C Ratio(max)**
Mix 1:1 Cement: Sand grout with anti shrink compound	0.44
Mix 1:2 Cement: Sand grout with anti shrink compound	0.44
Mix 1:1:2 cement: sand with 6mm down stone chips and anti shrink compound	0.44

Note: If the requirement arises, mixes other than the specified above, such as mix 1:1.5, 1:1.75, 1:2.25 etc. shall be used with the approval of the Engineer.

The W/C ratio shall be as per the manufacturer’s recommendation and in no case shall exceed the values specified above.

13.3 Inspection

All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Engineer

All materials supplied by Contractor and all works or construction performed by Contractor and rejected - as not in conformity with the specifications and drawings - shall be immediately replaced at no additional expense to NPCIL.

Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying grouting materials and or producing finished grout in accordance with the specifications and drawings.

All grouting shall be protected against damage until final acceptance by NPCIL or his representative.

Upon the completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

13.4 GROUT / DRY PACK FOR EQUIPMENT BASES

13.4.1 SCOPE

Scope of work covered in this specification includes supply and place normal free flow grout / dry pack at all places below equipment base plate, structural steel base plates / bearing plates, anchor bolts, pockets and other areas. Normal cement sand grout in various proportions with anti-shrink compound, non-shrink cementitious precision grout and dry pack with cement sand in proportion of 1: 2.5 are included in this specification.

13.4.2 GENERAL

13.4.2.1 Grout/ Dry Pack shall be provided as specified in the drawings. The proportion of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage.

13.4.2.2 Concrete surfaces to be grouted/ dry packed shall be thoroughly roughened and cleaned of all foreign matter and laitance. Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material.

13.4.2.3 Prior to grouting/ dry packing the hardened concrete surfaces shall be saturated with water.

13.4.2.4 Forms around base plates shall be reasonably tight to prevent leakage of grout/ dry pack. Adequate clearance shall be provided between formwork and base plate, to permit grout/ dry pack to be worked properly into the place.

13.4.2.5 Grouting, once started, shall be done expeditiously and continuously to prevent segregation, bleeding and within the initial setting time. Grout shall be worked from one side to the other, to prevent entrapment of air.

13.4.2.6 Water in anchor bolt holes shall be removed before grouting is started.

13.4.2.7 Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least 24 hours after placing the grout. After the removal of forms and peripheral shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least after a minimum of seven days from the date of grouting. During this period, the grout shall be properly cured.

13.4.3 DRY PACK

The dry pack shall consist of cement and sand in proportion of 1: 2.5. Sand passing through 1.18 mm square hole opening standard sieve shall be used in the dry pack. Only enough water shall be added to produce a mortar, which will stick together when molded into a ball by a slight pressure of hand and will not extrude water but will leave the hands just damp. Dry pack material shall be placed and packed in layers having compacted thickness of about 10 mm. Each layer shall be solidly compacted over the entire surface by use of hardwood stick and hammer. Sand for this job shall be as pure as specified for concrete work.

In case of heavy cement sand dry pack, heavy sand shall be used in place of normal sand.

13.4.4 NORMAL GROUT

13.4.4.1 The Contractor shall supply and place normal grout consisting of an approved mixture of cement, normal fine aggregate, water, admixture and when specified by the Engineer, a non-shrink agent. Normal grout shall be placed as shown in the drawings or as specified by the Engineer.

13.4.4.2 Grouting through holes in base plates shall be by pressure grouting. The pressure to be used for grouting shall be as directed by the Engineer. The grout proportions shall be as follows:

Mix Proportion		**W/C Ratio (Max)**
Mix 1:1	Cement: Sand with anti-shrink compound	0.44
Mix 1:2	Cement: Sand with anti-shrink compound	0.44
Mix 1:1:2	Cement: Sand with 6mm down stone chips and Anti-shrink compound	0.44

NOTE:

1. If the requirement arises, mixes other than the specified above, such as mix 1:1.5, 1:1.75, 1:2.25, etc. shall be used with approval of the Engineer.
2. The W/C ratio shall be as per the direction of Engineer and in no case shall exceed the values specified above.

13.4.5 NON-SHRINK CEMENTITIOUS PRECISION GROUT

Powdered non-shrink, high strength, free flow cementitious grout complying with the requirements of ASTM C348 & C109 that expands in two stages to counteract the plastic as well as the drying shrinkage normally associated with cement grouts. Mix proportion shall be as per manufacturer's recommendations. The compressive strength of the grout at optimum W/C ratio recommended by Manufacturer shall not be lesser than 55MPa, 65MPa & 75 MPa at 3days, 7days and 28 days respectively. It shall also possess following properties:

Property	**Acceptable Limit**	**Test Method**
Workability	Flowablility:	ASTM C 230
	Instantaneous, 240mm	
	After 20 mm, 220mm	
Setting Time	Initial Set, 4Hrs	IS 4031(Pt-5)
	Final Set, 5hrs	
Compressive Strength, 28 days	75 MPa	ASTM C 109
Tensile Strength, 28 days	8.1 MPa	ASTM C 1107
Flexural Strength, 28 days	9 MPa	ASTM C 378
Coefficient of Thermal Expansion	$11X\ 10^{-6}$ / ^{0}C	
Expansion in Plastic Stage	1.25%	ASTM C 940
Shrinkage	Nil	
Pullout Bond Strength	>17MPa	ASTM D4541

13.4.6 INSPECTION

13.4.6.1 All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer**.** Grout material shall be tested for cube compressive strength both for pre-qualifications and batch qualifications at no extra cost to NPCIL. No material exceeding the shelf life will be used and all such material shall be immediately removed from site.

13.4.6.2 All Materials supplied by the Contractor and all works or construction performed by the Contractor and rejected – as not in conformity with the specifications and drawings shall be replaced at no extra cost to NPCIL**.**

13.4.6.3 Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying grouting materials and or producing finished grout in accordance with the specifications and drawings**.**

13.4.6.4 All grouting shall be protected against damage until final acceptance by the NPCIL representative.

13.4.6.5 Upon completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

14 INJECTION GROUTING

14.0 SCOPE

14.0.1 The Scope of work covered under this specification is injection grouting at the following locations:

a) Where required impermeability of concrete is not achieved.

b) Where defective concrete is suspected and observed.

c) Where water seepage is observed.

d) Construction joints for all underground basements

e) Any other location specified in the drawing or as directed by the Engineer

14.0.2 The Grouting shall be carried out at specified locations as shown in the drawing or as directed by the Engineer

14.1 GENERAL

The injection grouting shall be carried out either through threaded GI nozzles of suitable length fixed in the area to be grouted or through non-return packer type nozzles either installed in the existing GI nozzles or in drilled holes. The nozzle length and spacing shall be as specified in the drawing or as directed by the Engineer. The diameter of the nozzle shall be as per site conditions and generally 16/12 mm diameter may be adopted for cement grouts (without non return valve) and 12 mm diameter (with non-return valve) for epoxy and polyurethane based hydrophilic grouting. The entire scheme shall be duly approved by the Engineer before commencing the work.

14.2 MATERIALS

The grouting material shall be epoxy, cement based with non-shrink additive or polyurethane based hydrophilic material as specified in the drawings, specifications

or as directed by the Engineer as per site conditions.

14.3 EPOXY GROUT

14.3.1 The epoxy grout shall comprise of an injectable solvent free, aggregate free, ultralow viscosity, free flowing, two-component epoxy injection resins, which shall be pumped through the nozzles (fixed prior to concreting or drilled after concreting) under pressure and rapidly cure to a high strength material. It shall comply with ASTM C-881-1987 Type I–Grade I Class (B+C) & class F as applicable. It shall be suitable for application in both dry and damp conditions,

14.3.2 The Generic name 'epoxy resin' covers a very diverse range of chemically and physically different polymers. To achieve durable repairs, careful selection of the resin composition appropriate to the application and service condition is essential.

14.3.3 The Proposed resin injection system is required to have following characteristics. The material shall comply with the requirement of ASTM C 881 Type I Grade I Class (B+C) & class F as applicable.

f) It should be two component (resin/hardener), low viscosity, solvent free, aggregate free, injection liquid based on high strength epoxy resin and suitable for deep impregnation. The epoxy and hardener system shall be able to cure in moist/wet conditions also.

g) It should rapidly cure to a high strength, shrinkage free hardening and without embrittlement.

h) It shall possess anti corrosion property, good adhesiveness and bond with the concrete with adhesive strength both under dry and damp conditions and should be capable for use under extreme ambient conditions and remain fluid during applications.

14.3.4 The proposed resin to be used shall be of two parts preferably supplied in different containers according to the manufacturers recommended proportions indicating identifications such as base hardener, recommended proportion, batch number, shelf life, date of manufacturing, grade, type, class, quantity, etc. Each batch shall invariably carry test certificates as per table 14.1 for tests conducted in NPCIL approved laboratory. The Engineer may at his discretion, appoint his representative to witness these tests at the laboratory. No separate payment will be made for testing. The chemical composition of epoxy resin constituent of component 'A' shall have an epoxy equivalent of 160-275 g/g mole and physical requirements shall be in line with ASTM C-881. A sample of proposed material intended to be used shall be supplied by the Contractor to the Engineer to verify the required parameters. The material shall be generally used within six months from the date of manufacture or date of expiry whichever is earlier.

TABLE - 14.1

LIST OF TESTS TO BE CONDUCTED AS PER ASTM C-881

SI. No	Property	Tested as per ASTM No.	Requirement
1.	Viscosity	D – 2393	2* poise (Max)
2.	Bond Strength		
	2 days (moist cured)	C – 882	10 N/mm^2 (Min)
	14 days (moist cured)	C – 882	14N/mm^2 (Min)
3.	Water Absorption (24 hours)	D – 570	1.0% (Max)
4.	Compressive strength 7 days	D – 695	70N/mm^2 (Min)
5.	Tensile strength 7 days	D – 638	50 N/mm^2 (Min)
6.	Flexural Strength	D – 638	55N/mm^2 (Min)
7.	Full Chemical Cure	7 days at 20 ^{0}C	
8.	Slant Shear Bond Strength 7 days	C-881	18N/mm^2 (Min)
9.	VOC Content	ISO11890-2	<1.5%
10.	Elongation at break	D638	2% (Min)

* Please note that requirement of viscosity is in variance with ASTM C-881.

14.4 CEMENT BASED GROUT

14.4.1 CEMENT AND WATER

The cement shall be Ordinary Portland Cement 43 Grade conforming to IS 8112. It shall be mixed with water to achieve required consistency for pumping. The quality standards of water to be used shall be same as that of RCC works.

14.4.2 ADMIXTURES

To achieve high consistency with low water cement ratio of around 0.3, suitable water reducing admixture as approved by the Engineer may be used. Suitable anti shrinkage compound shall be added in the mix if specified or as directed by the Engineer.

Proportion of cement & water shall be as directed by the Engineer. Quantity of admixture and type of mixing shall be as per manufacturer's instructions. Compatibility of admixture with the type of cement used shall be ascertained before

use of any admixture with cement.

Typically the properties of the resulting mix shall exhibit the following properties:

PROPERTY	ACCEPTANCE VALUE	TEST METHOD
Flow Cone test using Marsh Cone	23 secs at mix time	ASTM C 939
	34 secs after ½ hr	
	39 secs after 1 hr	
Specific Gravity	2.06	ASTM C 939
Setting time using Vicat's Apparatus	4 hrs for Initial Set	ASTM C 939
	5Hrs for Final Set	
Expansion	500 µm/m	ASTM C 878
Bleed Water	0.16%	ASTM C 232
Water Retention	96%	ASTM C 91

14.5 POLYURETHENE BASED HYDROPHILLIC GROUT

The material shall be one component high grade, low viscosity polyurethane injection foam resin which expands its volume to cure to very dense foam upon contact with water. This material shall be used to arrest excessive seepage of water through the concrete. Approval of the Engineer shall be obtained for the material, before use. The typical properties of the low viscosity polyurethane grouts are as follows:

PROPERTY	**ACCEPTANCE VALUES**
Density (at 20 ^{0}C)	1.16
Viscosity (at 23 ^{0}C)	320 mPa.s
Flash Point	180 ^{0}C
Application Temperature	+5 ^{0}C to 40 ^{0}C
Max foam expansion rate@10% accelerator dosage	25-30

14.6 GROUTING OPERATIONS

Grouting operations shall normally begin after six weeks of the last concrete poured. A high-speed mechanical mixer shall be used to mix the epoxy grout as per manufacturer's recommendation. The grouting shall be done by using hand pump and pressure will be decided based upon the nature of work and grade of concrete, or as directed by the Engineer. The grouting range can be achieved by injecting the grout with initial low pressure proceeding further with increasing pressure gradually. Slow and steady increase in pressure shall be followed to produce uniform impregnation of the zone under treatment. The injection pump shall be connected to the lowest tube and the injection allowed to proceed at gradually increasing pressures until grout appears at the adjacent/higher point or refusal of further grout entry at the operating pressure. Cement grouting shall be done normally starting with lean mix and slowly increasing the richness of mix. Cubes shall be cast to test the strength of the cement grout as directed by the Engineer. After successful completion of grouting the nozzles shall be cut and ground properly and finished with dry packing. Wherever specified in

the drawing, Contractor has to make suitable arrangements for placement of nozzles prior to concreting for its rigidity, thoroughness etc. complete with or without piercing through formwork. Contractor has to arrange adequate equipment/ manpower required for the work to carryout grouting in different areas simultaneously. Contractor at his cost may appoint a specialized agency to carry out grouting works. Detailed procedure of grouting shall be prepared by the Contractor and submitted to the Engineer for approval before commencement of work.

14.7 GROUTING AROUND PENETRATION EPs HAVING DIAMETER ABOVE 300 MM

Grouting is required to be done around penetration EPs having diameter above 300 mm and some special EPs. Procedure for grouting shall be generally same as above with the grouting pressure not exceeding the specified value in the drawing. The nozzles for grouting may be placed prior to concreting and the length and diameter of the nozzles shall be as given in the drawing.

15 CAULKING AND SEALANTS AROUND PENETRATIONS

15.0 SCOPE OF WORK

Scope of work covered under this specification is caulking of expansion joints, around embedded parts, penetrations and construction joints at various locations in all buildings as shown in the drawings and as directed by the Engineer.

- Caulking and sealing around penetrations.

15.1 MATERIAL

15.1.1 Polysuphide sealing compound shall conform to BS: 4254 and PP-M-400.

15.1.2 Epoxy quartz sand caulking compound shall be as per manufacturer's specifications.

15.1.3 Bituminous sealing compound (bitumen-polymer cold mastic) conforming to IS:1834-1984 Grade-B (working temperature 155°C to 165°C and density of 1200 kg/cu.m).

15.2 DESCRIPTION

Before proceeding with caulking, the grooves shall be cleaned for dirt, dust and grease if any. The grooves shall be finished to line and level.

15.3 CAULKING WITH POLYSULPHIDE SEALING COMPOUND

15.3.1 GENERAL

The work to be done under this specification covers the supply and applying of caulking polysulphide base sealing compounds and primer, all in accordance with the

requirements of this specification together with PP-M-400. Installation of the material will be done by the Contractor as per drawing, specification and direction of Engineer.

15.3.2 REFERENCES

ASA	:	116-1
ASTM	:	D676-59T
ASTM	:	1191-52
TTS	:	227 b
ASTM	:	E42-69
BS	:	4254
PP-M-400	:	NPCIL Specifications.

Wherever, this specification is at variance with the requirements mentioned in the above references, this specification shall govern.

15.4 DESCRIPTION

Materials covered under this specification are two-package system consisting of polysulphide base compound and an accelerator compound. The compounds shall be stable separately and when properly mixed, convert to a rubber like solid, which meets the requirements specified herein. The selection of base polymers, fillers and other components shall be optional with supplier, but shall be suitable for the application intended. Properties of base polymer should be similar to Thiokol and have low molecular weight. The consistency of the compound should be plastic.

15.5 INTENDED USE

The sealing compound is proposed to be used for caulking construction joints in RCC walls, slabs and expansion joints. The caulking may also be required around some embedded parts and concrete hatch covers. Size of 'V' groove to be caulked in construction may vary in size from 12 mm X 12 mm to 25 mm X 40 mm while the rectangular gap to be caulked in expansion joints may vary from 25 mm X 10 mm to 75 mm X 10 mm thick. The sizes given above are approximate only and intended to give general idea of work involved.

15.6 CLASSES OF MATERIAL

The sealing compound shall be applied in two classes as follows:

a) Class-A (Self-Leveling): shall be compound which when properly accelerated has sufficient flow to give a smooth level surface when applied in horizontal joints at ambient temperatures between 40°F & 120°F. The compound should also permit its application in joints sloped up to 1:10.

b) Class-B (Non-Sag): shall be compound which when properly mixed permits

application in vertical joints, without sagging at ambient temperatures between 40°F & 120°F.

15.7 COLOUR

The sealing compound may be supplied in any colour as agreed upon by the supplier and NPCIL.

15.8 MATERIAL REQUIREMENTS

Application life: A properly mixed compound shall be suitable for satisfactory application for at least 4 hours when maintained at a temperature of 77° ±2°F and relative humidity of 50% ±5%. It shall also be suitable for at least 1 hour when at a temperature of 110°F.

Stability: The base compound and accelerator in original unopened containers shall be stable for at least one year from the time of delivery when stored at a temperature not exceeding 110°F. When tested at the end of one year after the time of delivery, the compound shall meet the requirements specified herein.

Temp. Range performance: Continuous exposure 40 to 175°F
Continuous exposure 40 to 250°F

Recovery: The test assemblies shall be prepared and tested in accordance with ASA 116.1. The recovery of the compound in the test joint shall not be less than 25% within 1 hour at a temperature of 77°±2°F.

Resistance to crazing: The surface of compound of test panel prepared and tested in accordance with ASA 116.1 shall not craze more than 3 mils in depth.

Staining of concrete and masonry: The staining test shall be conducted on a test mortar in accordance with ASA 116.1 and there shall be no staining on the test mortar within 14 days. Staining on the test mortar indicates that the sealant is capable of staining.

Specific gravity: 1.6 to 1.7.

Toxicity: Safe lead content should not exceed 5%.

Properties required for Class A Compounds:

Hardness, Tensile Strength and Elongation

	Shore A Hardness	**Minimum Tensile Strength psi**	**Minimum Elongation %**
Original	35 ± 2	200	350
72 hrs. at 250°F	55 ± 3	325	150

Hardness shall be tested in accordance with ASTM D 676-59T, Tensile strength according to ASA 116.1 and Elongation according to ASTM 1191-.52.

Properties required for Class B compounds:

Sag: When tested in accordance with federal specification no. TTS-227b on a bead of ½" x ¾" there shall be no sag.

Hardness, Tensile Strength and Elongation:

	Shore A Hardness	**Min. Tensile Strength psi**	**Minimum Elongation %**
Original	22 ± 3	40	420
72 hrs. at 220°F	18	48	450
24 hrs. at 30°F	-	> 100	450

The testing method for these properties shall be same as specified for Class 'A' compounds.

Cohesive Strength: Surface-to-Surface Bond

	Aluminium	**Glass**	**Steel**	**Concrete**
Tensile (psi)	45	30	23	45
Elongation (%)	375	350	270	360

Cohesive strength shall be tested in accordance with ASTM 1191-52.

Durability:

Hours in weather-meter	**Equivalent in years**	**Shore A Hardness**	**Elongation %**
1440	5 years	23	340
2880	10 years	28	260

Durability shall be tested in accordance with ASMT E42-69.

The sealing compound shall be supplied separately in two parts the accelerator and the base compound. The quantities of the two component packs shall be such that when mixed they would readily produce the compound ready for application, giving the best performance.

15.9 CAULKING WITH EPOXY MORTAR

Epoxy mortar consists of epoxy resin and hardener mixed with quartz sand in the proportions as recommended by the manufacturer. The epoxy mortar shall be mixed thoroughly and shall be caulked in grooves. Epoxy primer consisting of epoxy resin and hardener without quartz sand shall be mixed as per the manufactures

recommendations and applied on the concrete surface prior to caulking of the epoxy compound. The top surface shall be finished smooth using trowel. It should be ensured that only such quantity is mixed which can be consumed before setting.

15.10 CAULKING WITH BITUMINOUS SEALANT

The joints shall be cleaned thoroughly and made free of debris. The bitumen based primer as per manufacturer's recommendations shall be cold applied prior to caulking with bituminous sealing compound, which shall then be hot applied. Care shall be taken that the working temperature of the sealant shall not exceed 155^0 to165^0 C since overheating of the sealant may lead to loss of its properties.

TABLE 15.1
PROPERTIES OF BITUMASTIC SEALANT

SI. No.	Characteristic	Unit	Characteristic Value
1.	Adhesion • To iron • To galvanized iron • To concrete (dry surface) • To concrete (hot humid surface)	MPa	 1.0 0.6 0.8 0.6
2.	Length development at breaking	%	>700
3.	Thermal stability	°C	110

All the sealant materials must be durable and retain their physical and mechanical characteristics and properties during its entire service life.

15.11 PROCEDURE

Before proceeding with the work, a detailed procedure shall be prepared by Contractor and submitted to the Engineer for approval. The materials shall be tested in approved test houses and each batch shall accompany with test certificates. Engineer may at his discretion, appoint his representative to witness these tests. Contractor shall also supply samples of materials to the Engineer for verification of specifications. No separate payment will be made for testing and supply of samples for testing/ verification.

All the sealant materials must be accompanied by following test certificates.

a) Chemical composition of the material
b) Compliance certificate
c) Fire-safety certificate
d) Certificate for health safety
e) Work instructions for usage

15.12 INSPECTION

15.12.1 All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer. Caulking material shall be tested for specified properties at no extra cost to NPCIL. No material exceeding the shelf life will be used and all such material shall be immediately removed from site.

15.12.2 All materials supplied by the Contractor and all works or construction performed by the Contractor and rejected – as not in conformity with the specifications and drawings shall be replaced at no extra cost to NPCIL.

15.12.3 Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying caulking materials and or producing finished caulking in accordance with the specifications and drawings.

15.12.4 All caulking shall be protected against damage until final acceptance by the NPCIL representative.

15.12.5 Upon completion of caulking work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

16 STRUCTURAL STEEL & EMBEDDED PARTS

16.0 SCOPE

This specification covers the technical requirements for supply of all steel items required for the work as per drawings including design of connections, preparation of fabrication drawings, fabrication, inspection, testing and painting after necessary surface preparation, transporting and erection at site at desired location of:

a) Main Structural Steelwork
b) Miscellaneous structural steelwork
c) Embedded parts (Standard/ Non-standard EPs)

The specifications given below are a general guideline and reference shall be made to PC-E-160 for detailed specifications and requirements on Embedded Parts. Additional requirements for fabrication and erection of critical and important Embedded Parts which are over and above these specifications are covered in NPCIL Specification PC-E-00034.

All the works shall be carried as per approved QA procedures.

16.1 MAIN STRUCTURAL STEEL

a) Beams, girders, monorails made of rolled section and / or rolled sections with cover plates, and/or compound girders, and/or plate girders, and / or box type sections.

b) Columns made of rolled sections with or without cover plates and / or compound sections battened / laced and / or built up sections from plates with or without grinding at ends and at splice locations,

c) Roof structure such as roof trusses, purlins, bracings, etc.

d) Base plates for columns including grinding (where specified) on top of base plates and underside of column shafts.

e) Any other item of structural steel framing, though not specifically mentioned but required for the building(s).

f) Sheet metal work of minimum 0.8mm thick.

g) Floor rails of IRST 18 grade.

h) Any other structures as shown in the drawings for fabrication

i) Rail section

16.2 MISCELLANEOUS STEELWORK

a) Platforms and walkways with chequered plates / gratings.

b) Ladders with or without cages.

c) Handrails.

d) Miscellaneous equipment supports, rails for equipment movement and their associated connections.

e) Steel enclosures for equipment or electrical instrument panels, rooms etc.

f) Any other miscellaneous structures shown in the drawings for fabrication.

16.3 EMBEDDED PARTS

16.3.1 GENERAL FUNCTION AND DESCRIPTION

Embedded Parts (EPs) are any structural member, angles, channels, plates, pipe sleeves etc. cast in the concrete and used to transmit the load from attachment to concrete structure. Eps fall into following two categories.

(i) Penetration Eps are opening through the concrete structure for the passage of process piping, ducts and cables, materials and personnel.

(ii) Non penetration Eps are used primarily as a means of supporting items such as piping, cable trays, ducts, equipment and platforms to the concrete structure or for edge preparation of concrete.

Penetration and non-penetration EPs are of different types and their descriptions are given below.

(a) Plate EPS

Plate Eps are used to support piping, cable tray, ladders and equipment. A typical plate EP consists of a plate and anchorage welded to it. Component supports can directly be welded or bolted to these EPS.

(b) Pipe Sleeves

Theses EPs are used for passage of piping, cables etc. from one side of concrete structure to other side. Pipe sleeve Eps consists of a pipe and one or more puddle flanges, provided through the length of pipe for anchorage and also for improving leak tightness. These pipes are either projecting out of the concrete surface or flush with it depending upon the requirement.

(c) Anchor bolts

Anchor bolts are used for anchoring equipment like pumps, motors, heat exchangers, tanks, pipes rails for cranes and hoists etc. The threaded portion of anchor bolt projection out of the concrete shall be suitably protected by caps/ sleeves from any possible damage to the threads till the equipment is erected.

(d) Threaded sockets/ embedded inserts

Threaded socket Eps are used for anchoring the equipment like heat exchanger, motors, pumps, tanks rails for cranes, hoists etc. The threaded portion remains below the concrete face. Suitable protective plugs shall be inserted to prevent damage to the threads during construction phase.

(e) Rectangular Box type penetration EPs

These Eps are generally used for passage of a bunch of piping or cables. It consists of a rectangular box made of plates and anchorage welded to it. The anchors help in transferring the loads from the EP to concrete structure and also improve leak tightness. These EPs are either projecting out of the concrete surface or flush to it depending upon the requirement.

(f) Expansion anchors

A post-installed anchor inserted into the concrete that transfers the loads to or from the concrete by direct bearing or friction or by both. Expansion anchors may be torque controlled where the expansion is achieved by a torque acting on the screw or bolt or displacement controlled where the expansion is achieved by impact forces acting on a sleeve or plug and the expansion is controlled by the length of travel of the sleeve of the plug. These anchors are used only if

(i) EPs are missed or misplaced from actual support location with respect to reference drawings during construction. Civil contractor shall substitute these EPs with suitable anchors meeting the design intent and cost for these shall be borne by them.

(ii) Additional requirement of anchors are arisen after concreting is done on account of design change.

Approved type of expansion anchors (for seismic/ non-seismic loads) for respective systems/ buildings/ structure from approved vendors shall be used.

(g) Grouted Anchors

Grouted anchor is an anchorage system which has the anchor rod, bolt or bar grouted or dry packed into pockets left in the hardened concrete.

(h) Embedded Piping

These are the part of the process system piping, which are embedded in the concrete and are projecting out of the concrete surface for joining with other part of the system piping while erection.

(i) Special EPs

The configuration of these EPs are different from the EPs described above and are designed to suit the particular requirement. These may have stringent tolerances depending upon the requirement of the equipment.

Different EPs used in the work and covered in these specifications are given below.

a) Anchor bolts of different sizes and Plate embedded parts (EPs)
b) Pipe sleeves with circumferential baffle plates of various diameters in carbon steel and stainless steel.
c) Electrical Canister EPs
d) Drain hubs and penetration in walls/slabs which are not joined to buried piping.
e) All Hatch frames both on the receiving hatch opening and hatch blocks/beams
f) All other embedded parts as shown on drawings released for fabrication.

16.4 APPLICABLE CODES, SPECIFICATIONS

IS : 102	Ready mixed paint, brushing, and red lead. Non-setting, priming.
IS : 800	General construction in steel- Code of Practice.
IS:801	Code of practice for use of old formed light gauge steel structural steel members in general building construction.
IS: 806	Code of practice for use of steel Tubes in General Building Construction.
IS : 808	Dimensions for Hot Rolled Steel Beams, Column Channel and Angle Sections.
IS :813	Scheme of symbols for welding

IS:819	Code of practice for resistance spot welding for light assemblies in mild steel.
IS:822	Code of practice for inspection of welds.
IS : 875	Code of practice for Design loads, For buildings & Structures (Part 1 to 5)
IS : 919	ISO systems of limits and fits. (Parts 1& 2)
IS : 1161	Steel Tubes for Structural Purposes- Specification
IS : 1200	Method of Measurement of Building and Civil Engineering Works (Part 1 to 28).
IS: 1239	Mild steel Tubes, Tubulars and other wrought steel fittings. (Parts 1 & 2)
IS :1363	Hexagon Head Bolts, Screws and Nuts of product Grade C (Part 1 to 3).
IS:1365	Slotted counter sunk head screws.
IS : 1364	Hexagon Head Bolts, Screws and Nuts of product Grade A & B.
IS : 1367	Technical supply conditions for threaded steel fasteners (Part 1 to 20)
IS : 1477	Code of practice for painting of ferrous metals in buildings. (Part 1 & 2)
IS: 1608	Metallic materials – Tensile testing at ambient temperature.
IS :1730	Dimensions for steel plate, sheets, strips and flats for structural and general engineering purposes.
IS : 1852	Rolling and cutting tolerances for hot rolled steel products.
IS : 1893	Criteria for earthquake resistant design of structures.
IS : 1977	Low tensile Structural Steels – Specification.
IS : 1978	Line Pipe
IS : 2002	Steel plates for pressure vessels for intermediate and high temperature service including boilers.
IS : 2016	Specification for Plain washers.
IS: 3502	Steel chequered Plates – specifications.
IS : 2062	Hot rolls low, medium and high tensile structural steel.
IS : 3589	Steel Pipes for water and sewage.-Specification
IS : 3757	Specification for high strength structural bolts
IS : 5372	Taper washers for channels.(ISMC)
IS : 5374	Taper washer for I beams (ISMB)
IS : 5620	Recommendation for structural design criteria for low head slide gates.
IS: 5624	Foundation Bolts – specification.
IS : 6005	Code of practice for phosphating of iron and steel.
IS: 6623	High strength structural nuts - specifications.
IS: 6533	Code of practice for design and construction of steel chimney Part 2- Structural Aspects
IS: 6639	Hexagon Bolts for steel structures – specifications.
IS :6649	Specifications for Hardened and tempered washers for high strength structural bolts and nuts.
IS : 7205	Safety code for erection of structural steel work.
IS : 7215	Tolerances for fabrication of steel structures.
IS : 8500	Structural steel - micro alloyed (medium and high strength qualities)- Specification
IS : 8629	Code of practice for protection of iron and steel structures from atmospheric corrosion (Part I-III)
IS: 9537	Conduits for electrical installations – General requirements.

IS: 10842	Evaluation procedure for Y-groove weld crack-ability test in structural steel.
IS : 11855	Guidelines for design and use of different type of rubber seals for hydraulic gates.
IS : 12843	Tolerances for erection of steel structures
SP:6(1)	ISI Hand Book for structural engineers –1, Structural Steel Section
BS : 3139	High strength friction grip bolts for structural engineering.
BS: 4395 (I)	High strength friction grip bolts and associated nuts and washers for structural engineering.
BS : 4592	Industrial type flooring and stair treads –Metal open bar gratings
BS : 4604	The use of high strength friction grip bolts in structural steel work.
AWS D1.1.	Structural Welding Code-Steel
AERB/SS/ CSE-2	Design, Fabrication and Erection of Steel Structures Important to Safety of Nuclear Facilities
ASME Sec II, Part C	Specification for Welding Rods, Electrodes and Filler Material
ASME Sec V	Non –destructive Examination.-
ASME Sec VIII, Div 1	Rules for Construction of Pressure Vessels.
ASME Sec III, Div 2	Code for concrete Reactor vessels and containments
ASME Sec IX	Qualification standard for Welding and Brazing procedure welders, brazers and welding and brazing operators
ASTM A-36	Specification for Structural Steel
ASTM A 167	Standard specification for Stainless and Heat Resisting Chromium Steel Plates, Sheet, Strip
ASTM A 262	Standard practice for Detecting Susceptibility to Intergranular attack in Austenitic Stainless Steels
ASTM A 380	Standard Practice for Cleaning and descaling Stainless Steel Plates, Equipment and Systems
ASTM A 516	Standard specification for Pressure Vessel Plates, Carbon Steel for Moderate and lower Temperature Service.
ASTM E 94	Standard Guide for Radiographic Testing
ASTM E 165	Standard test method for Liquid Penetrant Examination
ASTM E 709	Standard Guide for Magnetic Particle Examination
PC-E-160	NPCIL Specifications for Embedded parts
British Standard	EN Series carbon steel materials like EN8, EN24

The pertinent clauses and sections of the above codes, standards and specifications (latest revision), shall apply to the material, design, detailing, fabrication and inspection of the work covered by this specification as specified in the other sections of this specification.

In the event that certain requirements of this specification, applicable drawings and above standards & codes conflict with each other. The following priority shall govern in descending order.

i) Requirement given in the drawing
ii) Requirement given in specification No. PC-E-160, for EPs, PC-E-0034 for critical and important EPs and this specification for other steel structures.
iii) Requirement given in ASME/ ASTM
iv) Requirement given in Indian standard

16.5 DRAWINGS

16.5.1 ENGINEERING DESIGN DRAWINGS

Design drawings shall show all the dimensions and if necessary, clearances of the structure, typical connection details including size & length of the weld, weld arrangement, number of bolts, size of bolts and types of bolts, size of each member, definite location of openings, to various levels, and all other information necessary to prepare drawings for fabrication and erection.

16.5.2 Fabrication Drawings

16.5.2.1 Contractor shall prepare all fabrication and erection drawings in metric units for the entire work based on the design drawings. Shop detail drawings shall show all shearing, punching, drilling, bevel cutting, bending, and all welding / bolting in complete detail. All connections and splices shall be detailed by the Contractor and clearly shown on the drawings.

EPs shall not be welded to the main reinforcement. Bill of material shall show number, size, length, weight and assembly work of each erection piece. Bill of material for each drawing shall include fasteners/ bolts, nuts, washers and other accessories complete with specification, size, length and number etc. for each erection mark and proper identification for each joint.

Bill of material shall be prepared erection mark wise, showing weight of each component part and total weight of each erection mark. All revisions after initial issue of a drawing shall be clearly indicated with issue number and date of revision. Details shown in the drawings shall be clear and legible.

16.5.2.2 Contractor shall not commence shop detailing from information on Engineering design drawings unless such drawings or part of such drawings are officially released with the stamp bearing “Released for Construction”. Contractor shall be responsible for the correctness of all shop drawings. Six (6) prints of shop drawings shall be submitted to the Engineer for scrutiny and approval. The fabrication drawings shall be revised by the Contractor to reflect all revisions in design drawings as and when such revisions are made by Engineer. Six (6) prints of the revised fabrication drawings shall be submitted to the Engineer for approval.

16.5.2.3 No detailed shop drawings will be accepted for examination by the Engineer unless they are complete and checked and approved by Contractor’s qualified Structural Engineer and accompanied by an erection plan showing the location of all pieces detailed.

16.5.2.4 Contractor should check for erection clearance and ensure that detailing of connections is carefully planned to obtain ease in erection of structures including

field-welded connection and bolting. Field connections/ splices may be welded or bolted type, as specified in drawings.

16.5.2.5 Fabrication shall not be started until Contractor has received copies of such drawings upon which Engineer has endorsed his approval. Approval by Engineer of any of the drawings shall not relieve Contractor from the responsibility for correctness of engineering, workmanship, fit of parts, details, material, errors or omissions if any and all work shown thereon. Any work done prior to approval of shop drawings will be at the Contractor's risk. The Contractor shall make such changes in the design when so directed, which are considered necessary to make the structures conform to the provisions and intent of the specifications, without any additional cost to the NPCIL. Engineer's approval shall not invalidate any claim for damages of any kind for incorrectly detailed/ fabricated steel, notwithstanding any approval of such drawings by Engineer.

16.5.2.6 Contractor shall submit design calculations, for each and every connection detail proposed by him and also for any substitution for members, desired by him and approved by the Engineer. Fabrication drawings not accompanied by calculations for the connection design are liable to be rejected.

16.5.2.7 Each lot of drawings sent by Contractor for approval shall contain a limited number of drawings and shall be in an order and manner which follows erection sequence or as required by Engineer based on priorities allocated.

16.5.2.8 Engineer will return one copy of Contractor's drawing marked with Engineer's approval/ comments. Contractor shall furnish the Engineer, Six (6) prints of all approved final drawings for field use and record purpose. Contractor shall also furnish the Engineer with one reproducible of each drawing. These reproducible shall incorporate all modifications, field changes substitutions etc. affected and shall reflect the status "as built". It should be noted that so-called sepia or similar process reproducible are not acceptable. All these reproducible are not acceptable. All these reproducible shall be submitted rolled (not folded) on the outside of regular mailing tubes.

16.5.2.9 All these drawings will remain the property of the Engineer (NPCIL). Engineer reserves the right to use them in any manner whatsoever.

16.5.2.10 Two sets of soft copies of all final approved Contractor's drawings in the form of CDs shall be furnished by the Contractor for Owner's use after incorporating the as built status.

16.5.2.11 Time consumed by the Contractor in securing approval of drawings should not be added to the time allowed for completion of contract. A period of four (4) weeks from the date of receipt of drawings by the Engineer should be anticipated for this item of procedure in the schedule.

16.6 MATERIALS

16.6.1 STEEL SUPPLY

All steel shall be procured and supplied by the Contractor, from reputed sources as

approved by Engineer and shall conform to the following:

16.6.1.1 Contractor shall use materials for fabrication as specified in the approved drawings. All materials supplied by the Contractor shall be in sound condition, of recent manufacture, free from defects such as loose mill scales, slag intrusions, laminations, pitting, flaky rust etc. The lengths/sizes of steel sections and plates shall be as supplied by the steel mills and conform to the latest issue of the relevant IS /ASME specification.

16.6.1.2 All materials required for the work shall be correlated with manufactures test certificates. In the absence of test certificates, materials shall be tested by Contractor through an approved laboratory for establishing conformance to specification's requirement at Contractor's cost, and as directed by the Engineer. All tests shall be witnessed by owner's representative.

16.6.1.3 The Contractor shall supply the mill test certificate for the materials being supplied by him.

16.6.1.4 Material supplied against these Test Certificates (TCs) should have identification stamped or stenciled on them. All such identification markings shall be authenticated by the inspection agency, which has inspected and approved the material.

16.6.1.5 The Engineer shall have the right to test random samples to prove authenticity of the test certificates produced by the Contractor at the Contractor's cost. Any material found not meeting the specification requirement would be rejected. In the absence of material specification in the drawing following guidelines are given for structural steel members:

a) Rolled sections and Bars

Rolled steel sections supplied by the Contractor shall be of following quality.

Rolled Section	: IS 2062 E 250-Quality. A
Plates below 12mm	: IS 2062 E 250-Quality. A
Plates 12mm and above	: IS 2062 E 250-Quality. B0
Plates for crane girder	: IS-2062 E 250-Quality. C

Rail section:

The Y- Groove crackability test shall be performed in accordance with IS 10842 for material of Grade E 250Quality C, having thickness 12mm and above.

b) Pipes and Pipe fittings

For pipes and pipe fittings the following standards shall apply

For pipes up to 150 mm diameter IS: 1239 Part I and II,

For pipes beyond 150m to 2000mm diameter IS: 3589.

16.7 SUBSTITUTIONS

Whenever the Contractor desires to substitute structural members, shown on the drawings, due to non-availability of requisite materials, such substitutions shall be made only after authorization in writing by the Engineer.

Engineer may also direct to make substitution, when he considers such substitution is necessary.

16.8 FABRICATION OF STRUCTURAL STEEL

16.8.1 GENERAL

All workmanship and finish shall be of the best quality and shall conform to good engineering practice and the best-approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Standard fabrication clearances as detailed in American Institute of Steel Construction Manual and IS Codes shall generally be followed unless otherwise directed/ approved. For EPs specific requirements given in para titled 'EMBEDDED PARTS' and 'PAINTING' of this specification shall be followed in case found to be in variation with other clauses of this section. Materials at the shop shall be kept clean and protected from weather. In addition

a) All care should be taken to avoid undue welding distortions.
b) Complete layout shall be prepared and got approved by the Engineer before actual fabrications are started. If needed mock-ups may also be prepared.
c) All fit ups shall be got approved from the Engineer.
d) Standard tolerances as per relevant IS specifications shall be followed in case they are not provided in relevant drawings and specifications.

16.8.2 ELECTRODES

All Electrodes and welding shall be of low hydrogen type conforming to ASME Sec II Part C. Brands approved by NPCIL shall only be used. The bidders shall submit the list of venders and seek approval of NPCIL.

16.8.3 CONNECTIONS

16.8.3.1 All connections shall be designed (In case these are to be designed by the contractor) for forces indicated on the design drawings. The contractor shall be responsible for selection of standard connections from AISC, "Manual of Steel Construction" unless specified in drawings. Where standard joints are not available,

contractor shall design connections and shall get Engineer's approval prior to fabrication.

16.8.3.2 Connections shall be effected either by welding or bolting or as specified on the drawings. Type and quality of weld/bolts shall be in accordance with relevant IS Codes and as specified in the drawings.

16.8.3.3 Where necessary, tapered washers, flat washers or spring washers shall be used with bolts. The length of the bolt shall be such that at least one thread of bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be at least three times the thread pitch.

16.8.3.4 In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, even if a longer grip bolt has to be used for this purpose.

16.8.3.5 Wherever applicable, all connections and splices shall be designed for full strength of members or loads indicated unless otherwise approved. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice. Unless otherwise specified, beam end connections shall be designed for 60% of the shear capacity of rolled sections and 80% of shear capacity for built-up sections plus additional axial forces, if any.

16.8.3.6 All members likely to collect rainwater shall have drain holes provided.

16.8.3.7 Shop connections shall be generally welded. Field connections shall be made with bolts or HSFG bolts or welding as specified on the drawings.

16.8.3.8 In general, splice joints are not permitted except where standard length of the section under consideration is not sufficient to build the full length of the member. However, under exceptional condition, not more than one shop splice shall be permitted to make up the full length of a member with prior approval of Engineer at no extra cost to NPCIL. Shop splices to make the full member lengths shall be of full penetration butt-welded type and radio-graphically tested.

16.8.4 STRAIGHTENING

16.8.4.1 Rolled material, before being worked, shall be straightened, unless otherwise required/specified. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Long plates shall be straightened by passing through a mandrel or levelling rolls and structural shapes by the use of mechanical or hydraulic bar/section straightening machines. Heating or forging shall not be resorted to without the prior approval of the Engineer in writing. In case of site fabrication, the Engineer shall approve the straightening methods in writing before commencing the work.

16.8.4.2 Checking of the straightness of the structural members like angles, channels, beams etc. shall be done by using the thread. For checking of the straightness of the column sections piano wire shall be used. The sections, which are twisted beyond repairs, shall not be used for fabrication. Heating or hammering shall not be permitted. After removal of bends, structural members shall be submitted for inspection and approval of Engineer.

16.8.5 CUTTING

16.8.5.1 Cutting may be done by shearing, chopping, sawing or machine flame cutting. All re-entrant corners shall be shaped notch free to a radius of at least 12-mm. Sheared or cropped edges shall be dressed to a neat workmanlike finish and shall be free from distortion and burrs.

16.8.5.2 Hand flame cutting shall be undertaken, only if so permitted by the Engineer and shall only be carried out by an expert in such work. Hand flame cut edges shall be ground smooth and straight, for minimum 2mm in depth to remove the oxide layer.

16.8.5.3 Edges of flange cover plates and plates used to form any sections shall be ground smooth/planed.

16.8.6 PUNCHING AND DRILLING

16.8.6.1 Holes for all connections shall be drilled accurately and the burrs removed effectively. Where several parts are to be connected, such parts shall be first assembled, tightly clamped together and drilled through. Holes in secondary members such as purlins, girts, lacing bars etc. may be punched full size through material not over 12 mm thick. Holes should be clean cut, without burr or ragged edges.

16.8.6.2 ub-punching may be permitted before assemble, provided the holes are punched 3 mm smaller in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not in such cases exceed 16 mm.

16.8.6.3 When match drilling is carried out in one operation through two or more separate parts, these parts shall be separated after drilling and the burrs removed.

16.8.6.4 Holes for turned and fitted bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to HB tolerance specified in IS: 919.

16.8.6.5 Where reamed members are taken apart for transporting or handling the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. Poor matching, over drilling and ovality in holes shall be a cause for rejection. Burning holes with gas is strictly prohibited.

16.8.6.6 Holes may be required to be drilled by the Contractor at site for installing equipment or steel furnished by other agencies. The information for this will be supplied to the

Contractor by the Engineer before or after erection of the steel. Holes should be by drilling or other machining process and not by gas cutting sets.

16.8.7 ROLLING AND FORMING

Plates, channels, RSJ, etc., for circular bins, crane girders, gantry girders etc shall be accurately laid off and rolled or formed to required profile/shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field. In the case of stainless steel materials while rolling care shall be taken to avoid direct contract of MS/CS rollers with SS material in view of iron contamination to SS materials. A detailed rolling & forming procedure shall be prepared by the contractor and Engineer approval shall be obtained prior to execution.

16.8.8 GRINDING

Column ends bearing on each other, resting on base plates, compression joints designed for bearing, base plates coming in contact with column end and cap plates shall be ground smooth to ensure 90% contact with local gap not exceeding 0.10 mm (filler gauge shall be used to check this gap), unless mentioned and approved otherwise. All ground surfaces shall be protected from dirt and mechanical damages till the assembly is completed. However the underside of base plate bearing on cement grout need not be ground smooth.

16.9 GRATINGS

All gratings shown and/or listed in the drawings shall be fabricated as a complete unit as detailed or as necessary for connections to structural steel framing. The gratings shall be capable of sustaining a safe live load of 500 kg/sq. metre of plan area unless otherwise specified on the Engineer's design drawings. Treads and landings shall be suitable for the prescribed loading and be furnished complete with a one-piece standard non-slip abrasive nosing of approved type.

16.9.1 ELECTROFORGED GRATINGS

Electro forged Gratings shall be of custom fabricated/ cut to size in shapes (rectangular/ circular etc.) as required with serrated bearing bars. Gratings shall be fixed at all elevations with clamps, siddle clip & slotted clamps including drilling, providing and fixing screws. It shall be hot dip galvanized as per IS 4759 but in no case it shall be lesser than 610GSM. Wherever, due to functional requirements Galvanizing is not acceptable the grating shall be painted with high build epoxy with minimum DFT of 200 micron (excluding primer) over 75 micron zinc silicate primer etc. The gratings shall be capable of sustaining a safe live load of 500 kg/sq. meter (unless specified otherwise) of plan area. Treads and landings shall be suitable for the prescribed loading and be furnished complete with a one-piece standard non-slip abrasive nosing of approved type. The Contractor shall submit the design and fabrication drawing to NPCIL for approval prior to procurement of gratings.

16.10 HANDRAILS

Handrails shall be provided on open sides of platform, stairways and around all openings as shown in drawings. Handrails shall be of SS/mild steel pipe as specified in the drawings of flush welded construction and ground smooth. Unless specified otherwise the handrail shall be fabricated using 32mm nominal bore medium class pipe provided with double rail, top rail about 1 meter above platform / walkway level and the intermediate rail 450 mm below top rail and pipe posts spaced not more than 1.5 metres apart and 150 mm high 6mm thick toe plate. All MS handrails shall be painted as per requirement given in the drawings.

Smooth uniform curves and bends shall be provided at stair returns and also where so ever required /specified. Posts connected to curb plates shall have a neat closure at the bottom and a 6mm thick plate nearly welded to posts for attachments to curb plate/ toe guards. All necessary fittings including inner dowels at splices, brackets, bolts, bends, flanges and chains, shoes for removable type handrails where required shall be furnished by the Contractor. Open ends of all the pipe posts shall be plugged and welded. A minimum radius of 3 times the pipe diameter shall be provided at all points of direction changes in the handrail.

16.11 CHEQUERED PLATE

Chequered plates used shall be minimum 6mm thick or as indicated in the drawings and shall be capable of carrying a minimum live load of 500 kg/sq.m unless otherwise specified in the design drawings. Chequered plate shall be fixed by 8mm diameter cadmium plated M.S. screws with countersunk heads at a maximum spacing of 400mm. Members supporting the chequered plate shall have matching holes tapped in them. Chequered plates may also be required to be welded to the structural steel framing. The decision in this regard will be given by the Engineer wherever required/ specified.

Thickness of zinc coating shall be as per IS: 4759 for structural steel plates, angles, channels etc. and as per IS: 4736 for pipe sleeves.

16.12 WELDING

16.12.1GENERAL

16.12.1.1 Welding procedure specification (WPS) shall be established and Qualification of weld procedure (QWP) shall be done in accordance with the requirements of ASME Sec IX, or AWS D 1.1 as and where specified. Welders employed shall also be qualified as per above standards prior to taking up fabrication.

Following pre-qualified welding process shall be employed for fabrication, erection and repair by:

a) Submerged Arc Welding (SAW).
b) Shield Metal Arc Welding (SMAW).
c) Gas Metal Arc Welding (GMAW).

d) Gas Tungsten Arc Welding (GTAW)

16.12.1.2 All welds shall be free from defects like blowholes, lack of penetration, undercutting, cracks etc. All welds shall be cleaned of slag or flux and show sections, smoothness of weld metal, featheredges without overlap and freedom from porosity.

16.12.1.3 50mm on either side of the surfaces on which weld metal is to be deposited shall be smooth, uniform, free from fins, tears burrs cracks and absolutely free from grease, paint, loose scale, moisture or any other substance which would adversely affect quality and strength of weld.

16.12.1.4 Machining, thermal cutting or grinding may be employed for joint preparation or removal of unacceptable work or metal. The weld edges shall be smooth & regular surface free from cracks & notches. Flame cut material above 50mm thick shall be pre-heated to 100°C prior to flame cutting.

16.12.1.5 All weld fit-up shall comply with tolerances specified in the design drawing. The parts to be joined by fillet welds shall be brought into close contact as practicable. The root gap in no event shall be greater than 3 mm for SMAW process and 1.5mm for SAW process. If the separation is greater than 1.6mm the leg of the fillet weld shall be increased by the amount of root opening. This shall apply only in the case of continuous welds. Abutting parts to be butt-welded shall be carefully aligned and correct root gap shall be maintained throughout the weld operation. The fit up of joints at contact surfaces that are not completely sealed by welds shall be close enough to exclude water entry after painting. The separation between laying surfaces of lap joint and butt joints with backing plate shall not exceed 1.5mm. Abutting parts to be butt-welded shall be carefully aligned and the correct root gap maintained throughout the welding operation. Misalignments greater than 25% of the thickness of the thinner plates or 3mm, whichever is smaller, shall be corrected and in making the correction, the parts shall not be drawn into a slope sharper than 2 degrees.

16.12.1.6 All tack welds shall be made using qualified procedure and qualified welders. Any preheat requirement specified in the welding procedure shall also apply to tack welds. All tack welds shall be examined visually for defects and if found defective, shall be removed.

16.12.1.7 Welding of temporary attachment/fixtures to retain fit up is allowed in case the parts have a nominal thickness of at least 6mm. Temporary attachments are welded to at the distance of at least 30 mm from the weld seam for construction of CS and least 60mm for welding austenitic steel. Welding of temporary attachments/fixtures into the joint slot is not allowed. All temporary fixtures to be

removed after welding by grinding them to weaken the welded portion and hammering thereafter, followed by grinding the portion of any weld remaining on the base metal. A dye check at the discretion of the quality surveyor shall be done to detect any crack/defect at the point of fixture temporary weld.

16.12.1.8 It is not allowed to turn over and carry over heavy assemblies in tacking condition in order to control the geometric dimensions to the requirements of the drawings.

16.12.1.9 Non-flatness of the facing sheets being assembled into the subassemblies in the longitudinal and transverse direction is allowed within 10mm for 1m of the length.

16.12.1.10 During the installation of the structural steel members care shall be taken to prevent damage of the sheets and of the welding seams. The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided as far as possible.

16.12.1.11 In the joints of the parts with dissimilar thickness smooth transition of one part to the other must be provided by way of the gradual decreasing of the thickness of the thicker part with the slope of the surface not exceeding 15 degree.

16.12.1.12 Welding shall not be done when the surface of the members are wet or exposed to rain or high wind velocities unless the welding operator and the work are properly protected. In joints connected only by fillet welds, the minimum size of fillet weld to be used shall be as shown in the following table unless otherwise specified in the drawing.

Material thickness of Thicker part joined (mm)	Minimum size of fillet weld (leg dimension of fillet weld) (mm)
Up to 6	3
Over 6 to 12	5
Over 12 to 18	6
Over 18 to 36	8
Over 36 to 56	10
Over 56 to 150	12
Over 150	16

16.12.1.13 Fillet welds 5 mm or larger in size for SMAW and 10mm for SAW shall be made with two or more passes. Welding rods shall be 3.15 in diameter maximum for root passes, and 4mm and above in diameter for subsequent passes. Complete penetration butt weld shall be terminated at the ends of the joint in a manner that will insure their soundness. Where abutting parts are 20mm or more in thickness,

suitable run-on and run-off plates with similar edge preparation and having a width not less than the thickness of the thicker part shall be used. These extension pieces shall be removed after completion of weld and the end of the weld made smooth and flush with the abutting parts.

16.12.1.14 In case of full penetration butt welds without backing , root weld shall be back gouged to sound metal before second side welding for complete fusion throughout the entire cross section. However, in case of square butt welds done in flat position from both sides and with thickness of parts joined less than 8mm and root opening not less than half the thickness of the thinner part, gouging can be dispensed with, if approved by the engineer.

16.12.1.15 All welded shop splices in each component part of covered plate beam or built up member shall be made before the component part is welded to other parts of the member. Long girders or girder section may be made by welding sub assemblies each made in accordance as explained above. When making these sub assembly splices, whether in the shop or field, the welding sequence should be reasonably balanced between web and flange welds. Where weld reinforcement interferes with the proper fit-up between components to be assembled for welding, these welds shall be ground flush prior to assembly.

16.12.1.16 Preheating for welding of steel shall conform to ASME Section VIII Div 1

16.12.1.17 Post weld heat treatment (PWHT) shall be carried out if the weld size is more than 50mm, unless specified otherwise. The procedure for PWHT shall conform to ASME Section VIII Div 1. No stress relief using oxyacetylene flame is permitted.

16.12.1.18 In assembling & joining parts of a structure or a built-up members and in reinforcing parts to members, the procedure and sequence shall be such as to minimize distortion and shrinkage. The fabricator shall prepare a welding sequence for a member or structure which in conjunction with WPS and overall fabrication method, will produce members or structure meeting the quality requirement specified. The welding sequence and distortion control programme shall be submitted to Engineer for comments and information before start of welding such program shall include, besides other appropriate details, full particulars in regard to the following:

a) Proposed pre-bending in components such as flanges and flange cover plates and pre-setting of joints to offset expected distortion.
b) Make up of sub-assemblies proposed to be welded before incorporation in final assembly.
c) Proposed joint forms, classification of wire and flux or covered electrodes, welding process including fit up and welding sequence with directions in which freedom of movement is to be allowed.
d) Proposed number, spacing and type of storage backs and details of jigs and fixtures for maintaining proper fit up and alignment during welding.

e) Any other special features like assembling similar members back to back or stress relieving procedure.
f) If so desired by the Engineer, mock up welding shall be carried out at Contractor's cost to establish the efficiency of the proposed programme, with any modification suggested by the Engineer in limiting distortion or /and residual stress to acceptable levels.
g) For sections made of rolled sections with cover plates, the ends of the plate shall be seal welded or alternatively flange cover plate terminated 25mm short of the full length and welded across to the beam for proper end sealing and/or as directed by the Engineer.

16.12.1.19 Welds shall be defect free and surfaces shall be thoroughly cleaned to remove all visible weld defects and extra material. All welds shall be stamped/identified with System/Joint No/Welder punch etc. as per approved procedure at a distance of 30-35 mm from the weld seam.

16.12.2 WELDING CONSUMABLES

16.12.2.1 Electrodes, filler wires and flux used for welding shall be from approved manufacturers/Suppliers. When requested by the engineer, the contractor shall furnish certification that electrode or electrode flux combination will meet the requirements of classification. The classification and size of electrode, arc length, voltage & amperage shall be suited to type and thickness of material, type of groove, welding positions and other circumstances attending work.

16.12.2.2 Electrodes, filler wire and consumables shall conform to the requirements of ASME Sec. II Part C.

16.12.2.3 Only low hydrogen electrodes to AWS E7018 shall be used for welding for all Carbon Steel material. Whenever high tensile welds are required to be employed than E-8018 electrode are to be used of approved make. These electrodes shall be purchased in hermetically sealed containers or baked by the user as recommended by electrode manufacturer. Electrode flux coating shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. SMAW electrodes shall be properly stored. Before welding, the electrodes shall de dried in a holding oven as per manufacturer's recommendations. Only limited quantity shall be issued to the welders. The electrodes shall be kept in "carry ovens" and shall not be exposed to the atmosphere.

16.12.2.4 The filler wire and flux combination for submerged arc welding shall conform to the requirements of ASME Section II, Part C. The weld metal deposited by the submerged arc process shall have mechanical properties not less than that of base material specification. The flux used for SAW process shall be dry and free of contamination from dirt, mill scale or foreign material. The flux purchased in packages shall be stored in dry place. Flux shall be dried in case of damaged package at a temperature of 260° C for 1 hour prior to welding operation. Flux shall be placed in dispensing system immediately upon opening a package.

16.12.2.5 Welding plants and accessories shall be of adequate capacity and shall satisfy appropriate standards and be of the approved make and quality. Proper safety rules shall be followed and adequate means to measure the current shall be provided.

16.12.2.6 Wet magnetic particle inspection in accordance with ASME Sec. V may be performed.

16.12.2.7 For other magnetic materials dry power magnetic particle inspection in accordance with ASME Sec V.

16.12.3 WELD REPAIR

Whenever weld repair is required, Contractor shall give prior intimation to the Engineer and permission before the repairing is taken up. When a defect is detected in a weld, it shall be removed by cutting/grinding and smooth blending of the area with parent metal without sharp edges, corners. If welding is required, the same shall be done using the qualified procedure/welder and stage inspection as per the original weld. Correction of defect in the same portion of the weld shall not be allowed more than two (2) times. Portion of the welding seams, which have been subjected to repair, must be indicated in the weld inspection reports.

16.13 ERECTION

16.13.1 GENERAL

16.13.1.1 The Contractor shall supply all erection bolts, permanent bolts and electrodes as required for the job. At all times the Contractor shall be responsible for the safety and protection of fabricated material, from loss or damage of any nature until the completion of erection work.

16.13.1.2 Structural steel work will involve the erection of columns, beams, bracing, crane girders, purlins, trusses, monorails, ladders, platforms, gratings, chequered plates etc.

16.13.1.3 The Contractor shall complete all preliminary works at site, including post concrete survey wherever required well before the arrival of fabricated structural steel, such as keeping in readiness electrical winches, mobile cranes, gin poles, compressors, all tools and tackles, welding sets, torque wrenches, impact wrenches, etc., as part of this contract and any other work that may be necessary so as to start erection immediately after the arrival of fabricated steel at site.

16.13.1.4 The Contractor shall arrange for such quantum of erection equipment, supervision staff, labour and other arrangements so as to carry out the work efficiently. The equipment and services provided by Contractor shall include but not be limited to, the supply of labour, transport vehicles, crane derricks, gin poles, winches, welding equipment and tools, compressed air if required, blocking, scaffolding, locked storage for tools, welding rods, positioners, cables etc required for site fabrication assembly and erection of the structure. If found necessary the Contractor shall also provide at hisown cost arrangements for inspection and

testing of material used in erection. He shall satisfy the Engineer regarding arrangements for various types of work to be undertaken by him.

16.13.1.5 No dragging of fabricated structural steel shall be permitted.

16.13.1.6 All fabricated structural steel shall be stored 150mm above ground on suitable packing, to avoid damage during the monsoon. Steel shall be stored in the order of erection with erection/identification marks visible. Storage areas shall be prepared and maintained by the Contractor. Any steel stored near excavations shall be removed immediately to a safe distance to avoid burial under debris.

16.13.1.7 The Contractor shall protect all existing plants, embedded parts, all permanent and temporary structures, piping, conduits, equipment and facilities against damage during erection. The Contractor shall perform his work in a manner, which in no way endangers the operations of any existing plant or structures or hinders other construction activities.

16.13.1.8 The Contractor shall arrange at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after the completion of the job. The Contractor shall also provide necessary passageways, fences, safety belts, helmets, safety shoes, lights and other fittings to the satisfaction of the Engineer and for protection of his men and materials.

16.13.1.9 All structures shall be erected as shown in drawings. The Contractor shall carry out all erection work in the sequence required/ approved by the Engineer. The methods of erection and complete erection scheme shall be subject to the approval of the Engineer and shall be modified wherever required by the Engineer. This, however, will not relieve the Contractor of the responsibility for safe and expeditious completion of the work, its quality and accuracy.

16.13.1.10 Drifts should be used only for drawing the members into position and must not be used to such an extent so as to destroy the holes. Drifts of a larger size than the nominal diameter of the hole shall not be allowed. Any damaged holes or burrs must be rectified to the satisfaction of the Engineer. Correction of minor misfits and reasonable amount of reaming, if any, shall be considered as a part of erection. Any error in shop work, which prevents proper fit even after a moderate amount of reaming and slight chipping or cutting shall be immediately reported to the Engineer. The Contractor's work shall also include straightening and repairing of materials slightly damaged and drilling some holes in members where required. This is deemed to have been included in the unit rate quoted and nothing extra shall be payable for the above operations. Non Conformance Report (NCR) shall be raised and got approved for all repairs and modification required.

16.13.1.11 In case of any faulty erection, all such dismantling and re-erection required will be at the Contractor's cost. Shim stock of mild steel plates, required for erection will be set, leveled and prepared for grouting / dry packing.

16.13.1.12 Where flat bearing beams occur, bearing plates shall be set, levelled and prepared for grouting/dry packing.

16.13.1.13 Structural Steel frames shall be erected plumb and true to tolerance indicated in the relevant clause. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracing shall be introduced wherever necessary to take care of all loads to which the structures may be subjected including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety. Proper size steel cables, slings etc shall be used to avoid any damage due to accidents.

16.13.1.14 As erection progresses, the work shall be securely bolted to take care of all dead load, wind and erection stresses. No final welding or bolting shall be done until the structure has been properly aligned and approved by the Engineer.

16.13.2 CODE

Unless specified in the relevant drawing and specification, all erection work shall be carried out in accordance with the latest edition of Indian Standard Code of Practice for use of Structural Steel in General Building Construction IS-800 & AISC code wherever applicable.

16.14 ANCHOR BOLTS & FOUNDATIONS

16.14.1 The Contractor shall carefully check the location and layout of anchor bolts embedded in foundation constructed to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/foundation shall be reported to the Engineer.

16.14.2 Anchor bolts shall be provided with two nuts of approved grade of materials as per relevant IS or ASTM standard codes on upper threaded portion, one of which may be used for levelling the column base to the required elevation and one will be a lock nut. All shim stock, required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good MS plates and shall be supplied by the Contractor at his cost .Required no of washers shall also be provided by the contractor at his cost.

16.14.3 Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. The Contractor shall carry out all grouting under column base plates or beam bearing plates, unless the grouting is specifically excluded from the scope of work.

16.14.4 HIGH STRENGTH FRICTION GRIP BOLTING

16.14.4.1 High strength friction grip bolts and nuts shall conform to IS: 3757 and/or BS: 3139/ or ASTM A325.

16.14.4.2 Installation of high strength friction grip bolts in joinrs shall comply with IS : 4000 and / or BS : 3294 and or specification for structural joints using ASTM A 325 or A490 Bolts by Research council on Rivetted and Bolted Structural Joints.

16.14.4.3 The diameter of the bolt holes will not be more than 1.5 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the bolt heads, nuts and washers shall be free of scales, burs, dirt and other foreign matters tending to inhibit uniform sealing of the joint components. However, tight mill scale and the light residual oil coating on bolts, nuts and washers need not be removed.

16.14.4.4 All fasteners in a joint shall be tightened to a tension equal to greater than the specified proof load .either by the calibrated wrench method or the turn –of- nut method.

16.14.4.5 Tightening may be achieved by use of pneumatic powered impact winches , long handled manual torque wrenches with or without torque multiplier or electric wrenches . A hardened washer shall be placed under the element being turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges.

16.14.4.6 When using the calibrated wrench method, adjustable power impact wrenches and manual torque wrenches shall be calibrated to induce the bolt tension of 5% in excess of the proof load values, for each size of bolt to be used in the installation. Every wrench shall be calibrated by having it tighten a minimum three bolts of the same diameter, in a hydraulic tension measuring device. Calibration shall be repeated whenever a wrench is required to tighten a different size bolt or at least once each working day if there is no change in the bolt size. Impact wrenches shall be set so as to stall or cut at the torque effort corresponding to the prescribed fasteners tension. When manual torque wrenches are used the torque indication corresponding to the calibrating tension shall be determined and taken as the job standard. Torque measurement shall be read while the turned element is in the tightening motion. As subsequent tightening of bolts in particular assembly is liable to loosen bolts already tightened, all bolts must be ‘Touched up’.

16.14.4.7 If finger tight condition is used as a string point an extra full turn shall be taken to correspond to one half turn from the snug- tight position.

16.14.4.8 Load indicating bolts or load indicating washers may be used if so approved by the engineer in writing.

16.14.4.9 Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method and type of bolt used .

16.15 ERECTION PROCEDURES

16.15.1 The structures shall be erected by assembling in sections on the ground and hoisting successive sections into place, or they may be built up in place by individual

members at the option of the Contractor. The staging in different sections already erected shall be self-sufficient in stability for all conditions or stresses including those caused by wind. If erected by assembling in sections, not less than 50% of all bolting in place shall be done in each section before starting another section.

16.15.2 All bolts shall be drawn up tight but not to such a degree as to endanger the strength of the bolts and nuts shall be locked in place with lock nuts. Only wrenches approved by the Engineer shall be used on the work and the use of any wrench, which may deform the nut, will not be permitted. At least ten percent of the bolts in each connection as directed by Engineer shall be tested for tightness by calibrated wrenches or other approved methods free of charges. If any bolt in any connection is found to be not sufficiently tightened, all bolts in that connection shall be re-tightened and tested again without claiming any extra.

16.15.3 The Contractor shall take all precautions for the safety of labourers at the time of erection. Safety belts shall be provided to workers while working at all levels for the erection of tower. The erected structure shall be well secured and protected at the close of the day to avoid any damage to the structure and workman.

16.16 TOLERANCES

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852 for indigenous steel. The tolerances for fabrication of structural steel shall be as per IS: 7215. Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb. The tolerances specified below do not apply to steel structures where the deviations from true position are intimately linked with and directly influence technological process. In such cases, the tolerances of process technologists//suppliers which will be indicated in the drawing.

16.16.1 **Columns**

Deviation of column axes at foundation top level with respect to true axes

(a)	In longitudinal direction	:	± 5 mm
(b)	In lateral direction	:	± 5 mm

16.16.2 **Deviation in the level of bearing surface of columns at foundation top w.r.t. true level : ± 5 mm**

Out of plumbness (verticality) of column axis from true vertical axis, as measured at column top:	
(a)For columns up to and including15 meters in height:	± 1/1000 of column height inmm
(b)For columns exceeding 15 meters in height:	± 1/1000 of column height inmm or ± 20 mm whichever isless
Deviation in straightness in longitudinal and transverse planes of column at any point along the height:	± 1/1000 of column ht in mm or ± 10 mm.

Difference in erected position of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance.	± 10 mm
Deviation in any bearing or seating level with respect to true level	± 5 mm
Deviation in differences in bearing levels of a member on adjacent pair of columns both across and along the building	± 10 mm

16.16.3 **Connection of Members**

Beams up to 600 mm in depth - 1.5 mm
Beams over 600 mm in depth - 1.5mm every 600mm depth to a max. of 3mm.

Where abutting parts are to be joined by bolting through cleats or end plates, the connection requires closer tolerance.

Permissible deviation from the squareness of the end is
For Beams - 1 mm per 600 mm of depth up to a max. of 1.5 mm.

16.16.4 **Depth of Members**

Acceptable deviation from the specified overall depth is
For depth of 900 mm and under - +/- 3 mm
For depth over 900 mm and under 1800 mm- +/- 5 mm
For depth of 1800 mm and over - +8 & - 5 mm

16.16.5 **Trusses and Beams**

Shift at the centre of span of top : ± 1/250 of height of truss in mm

Chord member with respect to the : ± 15 mm whichever is less
Vertical plane passing through the centre of bottom chord.

Lateral shift of top chord of truss at the : ± 1/1500 of span of truss in mm

Centre of span from the vertical plane or : ± 15 mm whichever is less
passing through the centre of supports of the truss.

Lateral shift in location of truss from its : ± 10 mm
true vertical position

Lateral shift in location of purlin true
position : ± 5 mm

Deviation in difference of bearing : i) ±20 mm for trusses
levels of trusses or beams from ii) for beams :

the true difference	Depth < 1800 mm : ±6mm Depth > 1800 mm : ±10 mm
Deviation in sag in chords and diagonals : of truss between node points	1/1500 of length in mm or 10mm whichever is smaller
Deviation in sweep of trusses, beams etc.: in the horizontal plane	1/1000 of span in mm subject to a max. of 10 mm

16.16.6 **Crane Gantry Girders & Rails**

Shift in the centre line of crane rail with respect to centre line of web of crane gantry girder	: ± 5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	: ± 5 mm
Difference in alignment of crane rail in plan measured between any two points 2 metres apart along rail	: ± 1 mm

Deviation in crane track with respect to true gauge

(a) For track gauges upto and including 15 metres	:	± 5 mm
(b) For track gauges more than 15 metres	:	± [5 + 0.25 (S-15)] where S in metres is true gauge

Deviation in the crane rail level at any point from true level	:	1/1200 of the gauge distance or ± 10mm whichever is less
Difference in the crane rail actual levels between any two points 2 metres apart along the rail length	:	± 2 mm

Difference in levels between crane track rails at

(a) Supports of crane girders	:	± 15 mm
(b) Mid span of crane girders	:	± 20 mm

Relative shift of crane rail surfaces at a joint in plan and elevation	: 2 mm subject to grinding of surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in mm	: 1/1000 of track gauge S in mm subject to maximum of 20 mm

16.16.7 **Towers:**

Out of plumbness (verticality) from the true vertical axis	:	1/1000 of the height of the chimney or tower in mm .

16.17 MARKING OF MEMBERS

16.17.1 After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The match mark shall be punched on both sides of the member and the erection mark on the face of the member. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

16.17.2 All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

16.17.3 Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

16.17.4 In case of embedded parts, identification mark shall be visible on the exposed surface after embedding in place.

16.18 STORAGE

16.18.1 The Contractor shall have proper arrangements for storage. He shall identify the storage area where raised platform will be constructed by him. The materials will be identified area-wise and quantity-wise with proper identification marks.

16.18.2 Covered storage (Storage of fabricated materials): The Contractor shall make storage arrangements category-wise for storing fabricated materials and these materials shall be available for erection whenever called for. Fabricated materials should be stored separately according to different categories viz. embedded parts, pipe sleeves, angle frames, gratings and fabricated structural shapes. All the above materials when stacked should have proper access for inspection either by the Engineer or his authorized representatives.. The fabricated materials should be properly identified by giving identification marks. Similar precautions shall be taken to prevent the above material from rusting or any damage during the storage. Any fabricated EPs/material damaged/rusted during storage shall be rectified/repaired at Contractor's own cost.

16.19 INSPECTION, TESTING & REPORTS

16.19.1 Contractor shall give due notice to Engineer in advance of the materials or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for Engineer's approval/inspection. The fact that certain material has been accepted at Contractor's shop shall not invalidate final rejection at site by Engineer if it fails to be in proper condition or has fabrication inaccuracies which prevents proper assembly. No material shall be painted or dispatched to site without the inspection and approval by Engineer unless such inspection is waived in writing by the Engineer.

16.19.2 Shop inspection by Engineer or his authorized representative or submission of test certificates and acceptance thereof by Engineer shall not relieve Contractor from the

responsibility of furnishing material conforming to the requirements of these specifications, nor shall it invalidate any claim which the Engineer may make because of defective or unsatisfactory material or workmanship.

16.19.3 Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified. Contractor's inspection work shall be under the control of competent Chief Inspector whose primary responsibility is inspection (reporting to Management) and not to production department.

16.19.4 For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. The inspection and testing shall be conducted in a manner satisfactory to Engineer. Fit ups shall be examined by the quality surveyor as per the approved QA plan prior to welding the joint .All welds shall be inspected for flaws by the method described under the relevant Clause The inspection and testing on structural steel members shall be as set forth below:

16.20 MATERIAL TESTING

16.20.1 All materials conforming to a particular Indian/ASTM or any other standard as called for shall be tested as required by such standard. Proof in the form of certified test reports or mill certificates indicating the required tests have been carried out as per specification at the source as acceptable. In case these are not available, then the Contractor at his cost shall perform these tests.

16.20.2 Engineer has option to specify additional inspection or testing as he deems necessary and the additional cost of such testing will be borne by the Engineer.

16.20.3 The Contractor shall maintain records of all inspection and tests, which shall be made freely available to the Engineer and shall be submitted to the Engineer at completion of each stage of work.

16.20.4 If mill test reports are not available for any steel materials, the same shall be got tested by Contractor to Engineer's satisfaction to demonstrate conformity with the relevant specification at his own cost.

16.20.5 The tests are restricted to as per Indian/ASTM or any other standard for a particular material as required by such standard. If any additional tests are required to be done actual expenses shall be reimbursable.

16.21 INSPECTION OF WELDS

The following methods are used for the quality control of welded joints. All weld shall be grinded and thoroughly cleaned before taking up the inspection

16.21.1 Visual Inspection

Visual inspection shall be performed prior to and during and after non-destructive testing. The completed welds should be checked for correct size and profile. All weld surfaces shall be free from slag, creators, abrupt ridges and vallies, arc strikes. Prior to fabrication proper included angle, route opening, route face, alignment and cleanness of joint shall be checked and ensured. All weld shall be visually inspected to ensure the welding performed are within the acceptable limits.

16.21.2 Magnetic Particle Test (MPT)

Wherever specified, all MPT shall be as per ASTM- E709. Defects if found, shall be repaired and retested.

16.21.3 Dye Penetrate Inspection

MPT may be substituted by Dye Penetrate Inspection where the former is not feasible due to configuration. All surfaces of the welds to be inspected by DPT shall be free from scale, flux, ridges etc. The testing should be in accordance with ASTM-E165. Defects, if found, shall be repaired and retested. The cost of demagnetizing after testing shall also deemed to be included in the quoted rates of the Contractor.

16.21.4 Radio-graphic Examination

Wherever specified, Full penetration butt welds shall be radio-graphed or spot radiographed as shown in drawings /QA plans in accordance with ASTM: E-94 and as specified.

16.21.5 Ultrasonic Testing

Wherever built up sections for crane runways girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing as per ASME, Sec-V, Article 5.

16.21.6 Acceptance Standard

The acceptable standards for weld inspection shall be as per ASME Sec VIII - Div I.

16.22 DIMENSIONS, WORKMANSHIP AND CLEANLINESS

All the fabricated embedded parts of Structural Steel members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment and surface finish are in accordance with the requirements shown on the approved Contractor's shop drawings and/or Engineer's drawings.'

16.22.1 The dimensions of the fit ups shall be maintained as specified in the fabrication drawings.

16.22.2 Raw material with cracks, seams, laps, lamination and heavy pitting are not acceptable. Ultrasonic testing of plates above 50 mm thick or as per the material specification shall be carried out for the soundness of material.

16.22.3 The cut edges of plates more than 25 mm for fillet weld, butt welds, and the plates used for tension flanges and webs -100 % MPT / DPT shall be carried out.

16.22.4 Welding shall be carried out as per approved WPS and QWS by qualified welders.

16.22.5 Macro etch test on welds shall be carried out 1 per structures for built up girders, columns and other heavy structures for penetration.

16.22.6 For 100% weld length, MPT / DPT on root & final pass for thickness equal to or greater than 25mm for butt welds.

16.22.7 For 100% weld length, RT shall be carried out for thickness equal to greater than 32 mm butt welds.

16.22.8 For 100% weld length RT for butt welds of rolled sections having a depth greater than 600 mm shall be carried out.

16.22.9 Minimum 10% of Fillet welds length, for either plate thickness is up to and inclusive 25 mm or fillet size is less than 10 mm (inclusive 10mm), root & final pass MPT /DPT shall be carried out.

16.22.10 On 100 % weld length, MPT/DPT shall be carried out on root & final pass, for either plate thickness greater than 25mm or fillet welds is more than 10 mm size.

16.22.11 Dimensions of all the assemblies and sub-assemblies shall be as per fabrication drawings within the tolerances specified in IS 7215.

16.22.12 For full penetration welds, DPT shall be carried out after back gouging before second side welding.100% MPT shall be carried out on low alloy steel, flame cut edges for thickness greater than 12mm.

16.22.13 Wherever built up sections for crane runways girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing as per ASME, Sec-V, Article 5,

16.22.14 The contractor shall maintain records of all inspection and tests, which shall be made freely available to the Engineer or his authorized representative and shall be submitted to the Engineer at completion of each stage of work.

16.22.15 The contractor shall ascertain that materials conforming to the requirements of this specification only are used.

16.22.16 The contractor shall check that the welding procedures (including the electrodes, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

No	Type of defect	Acceptance criteria	Remarks
1	Cracks	Not acceptable (NA)	
2	Incomplete or lack of fusion	Not acceptable (NA)	
3	Misalignment of butt welds	0.25 x T maximum of 3 mm	T: Thickness of thinner plate

4	Reinforcement	Max reinforcement of 2 mm for t < 10 mm 3 mm for t > 10mm < 15 mm. 4 mm for 15 mm and greater	
5	Undercut	0.25 mm deep max	
6	Sharp edges	Min radius of 2 mm	

16.22.17 **Inspection of Test Failure**

In the event of any failure of structural, steel members to meet inspection or test requirements, the Contractor shall notify the Engineer or his authorised representative. A Non Conformance Report (NCR) has to be made and got approved from the Engineer or his representative before repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by Engineer. Contractor shall maintain records of all inspection and testing which shall be made available to the Engineer or his authorized representative, for three years from the date of completion of the contract.

16.23 EMBEDDED PARTS

16.23.1 General

The details furnished below are in addition to general requirements of material supply, fabrication, inspection, testing etc specified in the earlier clauses of this specification. In general, reference shall be made to PC-E-160 for detailed specifications and requirements on Embedded Parts.

16.23.2 Material

Contractor shall supply/ use materials for fabrication as specified in the drawings. In the absence of material specification in the drawing, following guide lines are given.

Design	Spec	Remarks
Plates for pipe sleeves of wall thickness less than 20 mm	IS-2062Grade E-250, Quality –B0	
Flanges and plate EP's and threaded fasteners of 20 mm thk/ dia and more	IS-2062, Grade E-250, Quality – B0	
C.S Pipes up to 150 mm NB	1S-1239 Heavy Grade	
C.S. Pipes of sizes 200 mm NB and above	IS-3589 Grade FE 410	
Stainless Plates	ASTM-A-240 type 304L	IGC tested
Stainless pipes	ASTM-A-312 type 304L	Seamless or seam welded by automatic or manual

		process. Inspection as per specification.

Rolled sections and Bars

Rolled steel sections supplied by the Contractor shall be of following quality.

Rolled Section	:	IS 2062 E 250-Quality. A
Plates below 12mm	:	IS 2062 E 250-Quality. A
Plates above 12mm	:	IS 2062 E 250-Quality. B

16.23.3 Electrodes

All electrodes and welding wire shall be low hydrogen type conforming to ASME Sec II Part C. Brands approved by NPCIL shall only be used.

16.23.4 Material test certificate shall be in original.

16.23.5 Material supplied against these TC's should have identification stamped or stenciled on them which can be correlated with the TC's

16.23.6 All such identification markings shall be authenticated by the inspection agency which has inspected and approved the material.

16.23.7 The contractor shall furnish to the Engineer duplicate copies of all purchase order copies covering the material ordered by him for this project and also test reports.

16.23.8 The Engineer shall have the right to test random samples to prove authenticity of the test certificates produced by the Contractor.

16.23.9 Fabrication of EPs

Fabrication of EPs shall be done as per the relevant drawings and specification to avoid any possible damage to the threading on the anchor bolts before erection of the equipment, suitable protective plugs are inserted. In some cases, internally threaded sockets are embedded with top of the socket kept flush with the concrete face.

16.23.10 Welding

All welding procedures and welder performance qualification shall be carried out as per ASME Section IX supplemented by ASME Sec. VIII Div 1 / Div 2 or ASME Sec.-III as and when specified. The welding and other fabrication requirements shall be as per PC-E-160.

16.23.11 Inspections and Testing

All fabricated EP's shall be inspected as per approved QA plan. The inspection shall cover visual examination, MPT, LPT, RT and UT such that these EP's are free from burrs, cracks, nicks and surface irregularities as per previous clauses of this specification. . The DP and Radiography examination and Air Hold Test shall be carried out as per specification No. PC-E-160.

16.23.12 Air hold test / Vacuum box test

All pipe and sleeve EPs of safety systems meant for sustaining pressure or otherwise specified shall be tested for leak tightness. The test pressure/holding time shall be as per the approved Drawings. Air pressure/vacuum shall be held minimum for 10 minutes to detect leakage and pin holes.

16.23.13 Rectification

Any rework / rectification on the EP's required due to improper placement after concreting shall be carried out by the Contractor to the satisfaction of Engineer without any extra cost. This shall also include any additional inspection requirements as decided by Engineer.

16.24 PAINTING

16.24.1 Contractor shall follow the best method of surface preparation and painting system. In order to achieve the maximum durability, one or more of the following methods of surface preparation shall be followed, depending on condition of steel surface and as instructed by Engineer. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system:
Manual or hand tool cleaning
Mechanical or power tool cleaning
Blast cleaning.

16.24.2 Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. The minimum acceptable standards in case of manual or hand tool cleaning shall be St2 or equivalent, in case of mechanical or power tool cleaning it shall be St3 or equivalent, in case of blast cleaning it shall be Sa 2 ½ or equivalent as per Swedish Standard SIS-055900 / ISO-8501-1.Where highly corrosive condition exists, then the blast cleaning shall be Sa3 as per Swedish Standard. Prior to surface preparation all other contaminants, oil, grease etc. Blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceeding 85%. Engineers reserve the right to instruct the type of surface preparation depending upon the condition of material.

16.24.3 Irrespective of the method of surface preparation, the first coat of primer must be applied on dry surface immediately and in any case within 4 hours of cleaning of surface. However at times of unfavorable weather conditions, Engineer shall have the liberty to control time period, at his sole discretion and /or to insist on recleaning, as may be required, before primer application is taken up. In general during unfavorable weather conditions, blasting and painting shall be avoided as far as possible.

16.24.4 Surfaces shall not be coated in rain, wind or in environment where injurious airborne elements exist, when the steel surface temperature is below 5^0C and the humidity is greater than 85%.

16.24.5 To the maximum extent each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spot or areas missed in the application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet & dry film thickness.

16.24.6 Paint manufacturer's instructions shall be followed strictly at all times. Particular attention shall be paid to the following.

16.24.7 Instructions for storage to avoid exposure as well as extremes of temperature.

16.24.8 Surface preparation prior to painting, Mixing and thinning, Application of paints and the recommended limit on time intervals between coats.

16.24.9 Painting shall be carried out preferably by spraying. Brushes may be used sparingly at certain locations only and the brushes used for painting shall be of a style and quality that will enable proper application of paint. Type of brush shall be chosen according to its application and there shall be a minimum of brush marks left in the applied paint. Engineer reserves to instruct type of application of paint.

16.24.10 Joints to be site welded shall have no shop paint for at least 50 mm from the welding zone. Similarly steel surfaces shall not panted in areas where connection is by use of friction grip bolts. On completion of joint the surfaces shall receive the painting as specified.

16.24.11 Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling. As such it is recommended that the primer and finish paint shall be from the same manufacturer.

16.24.12 Contractor shall furnish all the characteristics of paint material along with the test certificates. All paint material shall be of first quality.

16.24.13 All Structural steel surfaces except EPs shall be given the first coat of primer at shop and the second coat after it is erected in position. Further, any abraded surface of the first coat during transport from shop to site and during erection shall be provided with a touch-up coat of the primer. The field primer shall be compatible with the shop primer.

16.24.14 The surface of steelwork to be painted shall be thoroughly cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by grit blasting to white metal in accordance with IS 1477 –Parts I & II./ Swedish Standard SIS 05-5900. At places where grit blasting is not feasible, one coat of suitable approved anti-corrosive paint shall be applied.

16.24.15 The paint treatment specified shall be applied soon after completion of pre-cleaning or pre–treatment in order to prevent contamination of the surfaces in any way, either by brushing or by spraying on the thoroughly cleaned and dry surface as desired by the Engineer. Airless spraying shall be carried out unless specified otherwise by the Engineer.

Sl. No.	Structure	Surface preparation	Primer	Finish coat
1	All steel structure	Clean off dirt, rust, weld spatter & loose mill scale by shot blasting	1 coat of epoxy based approved zinc silicate primer to a film thickness of 75 microns	Hi-build Epoxy paint conforming to relevant specifications to a DFT of 200 microns

SS members shall be painted with the peel able paint, which shall be removed at the time of passivation.

16.24.16 Acceptance Criteria

a) All painted surfaces shall be uniform & pleasing appearance.
b) All epoxy and enamel painted surfaces wherever finish paint is specified shall be of uniform texture and high glossy finish.
c) All storms, splashes & spatters of paints shall be removed.
d) Surfaces shall meet the minimum specified DFT for their respective systems.

16.25 SPECIFICATION FOR FABRICATION OF STAINLESS STEEL EMBEDDED PARTS

16.25.1 SCOPE

This specification covers the requirements for the supply fabrication, inspection, testing and transportation of stainless steel embedded parts.

16.25.2 SPECIFICATION

Mechanical Engineering Drawing Standards - IS 696 (latest)
Assessment of surface roughness - IS: 3073 (latest)
Liquid penetrant inspection of metallic surfaces – ASME SEC V.
Ultrasonic Inspection of Metallic Surfaces – ASME sec V
ASME Boiler and Pressure Vessel Code Section IX Welding (Qualifications)

16.25.3 a) MATERIAL AND WORKMANSHIP

Materials which are not specifically covered & which are necessary for fulfillment of this specification shall be procure by the contractor. He shall be responsible for the correct procurement and performance of these materials, & shall replace at no extra cost to NPC any material failing to meet the requirements of the drawings & specifications.

b) WELDING ELECTRODES

Use of S.S. 308L or S.S.347 electrodes for welding SS 304L is recommended. Electrodes used on the work are to be approved by the Purchaser.

c) WORKMANSHIP

Workmanship shall be in accordance with high standards and adequate, to achieve accuracies and surface finish as shown on the approved drawings and this specification is to ensure satisfactory operation and service life of the liners.

16.25.4 WELDING

Weld shall be made by the weld procedure and welders qualified by tests in accordance with IS: 817 & 1181 and ASME Section IX as specified by the Purchaser. Welding procedure shall be prepared by the Contractor and submitted to the Purchaser for approval before the start of welding.

16.25.5 a) INSPECTION OF WELDS

All services and facilities related to testing and inspection to be provided by the Contractor. The inspection work shall be under the control of a competent Chief Inspector whose primary responsibility is Inspection and reporting to Management. Inspection by NPC or their authorised representative shall not relieve the Contractor of any of the inspection duties called for herein.

All welds including fillet welds shall be subjected to Liquid Penetrant Test.

b) OTHER INSPECTION

The Contractor shall conduct 100% inspection & maintain record for all components and final grids system in accordance with the Approved drawings & Specification. This shall include inspection of the following:

Dimensional accuracy, surface finish, hardness, fit and alignment, workmanship, cleanliness and lubrication, completeness.

16.25.6 TRANSPORTATION

After completion of segmented fabricated line grid, it shall be thoroughly cleaned, protected from dirt, corrosion and damage and suitably braced and packed for transportation**.**

16.26 QUALITY SURVEILLANCE FOR STRUCTURAL STEEL & EPS

16.26.1 General

The Engineer shall subject all works and materials covered by this specification to inspection.

The Contractor shall provide free access in his shop during working hours for the inspection staff, designated by the Engineer, at all phases of the work and assist them where necessary in conducting the inspection. The Contractor shall expeditiously furnish all gauges, instruments and other necessary measuring equipment required for inspection of the work in the shop. The shop inspection by the inspector is intended to ensure that the material and workmanship are in accordance with this specification, but it will be not relieve the Contractor of any of his responsibilities for the product. The inspector’s inspection will include, but not

be limited to, the following:

16.26.2 Material

The inspector will ascertain that only materials conforming to the requirements of this specification are used.

16.26.3 Dimension and Tolerances

The Engineer will ensure and check that the structural members conform to the dimensions and tolerances as set out on the drawings and as required by the specification.

16.26.4 Welding Procedure

The Engineer will witness the welding and testing of any procedure qualification tests that are required by this specification. The Engineer will also check that welding procedure (including the electrode, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

16.26.5 Welding Equipment

The Engineer will check the welding equipment to be used for the work to ensure that it is in such condition as to enable qualified welders to follow the procedures.

16.26.6 Welder & Welding Operator Qualifications

The Engineer will permit welding to be performed only by welders and welding operators who are qualified by tests in accordance with ASME – Section IX.

When the quality of a welder or welding operators' work, appears to be below the requirements, the Engineer may require testing of his qualifications by necessary tests.

16.26.7 Welds

The Engineer will ascertain that the sizes, length and the location of all welds conform to the requirements of this specification and the approved fabrication drawings. Temporary welds used for the works shall be removed and ground flush with the original surface.

The Engineer will identify with a distinguishing mark of all parts of the joints that has been inspected and accepted.

The Contractor shall comply with all the demands of the Engineer to correct improper workmanship and to remove and replace, or correct as instructed, all welds found defective or deficient.

In the event of faulty welding or its removal for rewelding results in damage to the base metal in the judgement of the Engineer, or its retention is not in accordance with the intent of the plans and specification, the Contractor shall remove and replace the damaged materials at his own cost.

17 FIRE PROOFING OF STRUCTURAL STEEL MEMBERS USING INTUMESCENT PAINTING

17.0 SCOPE

This specification covers the requirements in general that needs to be followed for thin Intumescent Coatings used as Passive Fire Protection measure on Steel Structures of defined fire ratings, wherever applicable. The specification in general covers the requirements for selection of coating, testing, application & quality control measures which shall be followed to use the Thin Intumescent Coatings. Wherever Intumescent Paint is proposed to be used in radiation area, the adequacy of same shall be established prior to its use.

17.1 INTUMESCENT COATING SYSTEM

The system shall comprise the 3 layers i.e primer, basecoat and seal top or decorative coat. The Primer & Seal/Top coat shall be compatible with base coat. The product proposed for use shall be manufactured by a reputed & experienced company having In-house R&D & fire test facility, unless approved otherwise.

The Coating shall be certified from reputed agencies like UL (USA) & Warrington (UK) etc. The certifying agency shall be well recognized and acceptable to NPCIL.

Unless approved otherwise, the Primer, Intumescent base coat , seal coat or decorative top coat should be sourced from the same manufacturer, to assure their compatibility.

The coating system should be such, where recoating of the coating shall be feasible if required, with approved top / seal coat for asthetic reason. It shall also be feasible to repair the same as per approved procedure from Manufacturer in case of damage to Intumescent coating.

17.1.1 PRIMER

A protective coating, usually anti-corrosive, is applied to the substrate prior to application of the basecoat. It shall also provide adequate adhesion to base coat in case of fire.

For site applied Intumescent coatings, the primer is the only part of the total system that would normally be applied in shop and balance base coat & Seal Coats are applied a site.

17.1.1.1 PRIMER SELECTION

The choice and thickness of primer shall depend on

- the In-service environment, which affect the degree of anti-corrosive protection required.
- where the primer is to be applied, and subsequent Intumescent basecoat application requires a significant delay between steel preparation in shop and final erection and completion of coating at site, the primer needs to have suitable weathering properties and durability, it must be suitable for over-coating with the intumescent coating after the appropriate time interval, and it should be sufficiently tough to be transported with minimum mechanical damage. In such cases the primer may be applied in 2 stages, if recommended, by coating manufacturer.
- the primers having poor heat resistance, and likely to have a detrimental effect on the performance of the intumescent in a fire shall not be used.
- primers based on weaker solvents than the (solvent based) intumescent, may exhibit defects such as rivelling and/or wrinkling when over-coated, and therefore shall be avoided.
- the primer shall be compatible with base coat and generally manufactured by same manufacturer, In case primer from different producer, if used with prior approval, before application of the Intumescent basecoat, the confirmation from the Intumescent manufacturer shall be obtained in writing, such that the primer and Intumescent basecoat are compatible in both ambient and fire conditions. In such case the technical data sheet for the primer, the actual primer thickness and information regarding the length of time the primer has been applied should be shared with base coat material supplier, who should then be able either to give approval for use of the primer, or to provide alternative advice.

17.1.1.1.1 COMPATIBILITY OF INTUMESCENT COATINGS WITH ZINC RICH PRIMERS

Wherever Zinc rich primers, are used to avoid problems of inter-coat adhesion. It is essential that the zinc salts, if exist due to prolonged exposure prior to application of base coat, are completely removed by washing down with clean fresh water. Where full removal of zinc salts cannot be guaranteed, the option to remove the zinc coating and re-prime the steelwork shall be followed.

Formation of Zinc salts can be prevented by applying a tie-coat over the primer at the fabrication stage. The Intumescent coating can then be applied to the tie-coat.

The application of water based intumescent coatings(if approved to use) directly over zinc rich primers is not recommended.

In all cases, the intumescent coating manufacturer should be consulted to confirm the compatibility of the priming system with the intumescent system and, where applicable, the tie coat.

17.1.1.1.2 COMPATIBILITY OF INTUMESCENT COATINGS WITH EXISTING PAINT LAYERS

Steelwork requiring refurbishment will usually be treated with an existing coating system. The existing paint coatings are likely to be old and their adhesion to the substrate, or between layers of the system, may be poor.

In such cases earlier coating shall be completely removed and the application of a primer/primer system compatible with the new Intumescent system shall be applied. The old paint shall be preferably blast cleaned to Sa 2½ standard as defined in BS EN ISO 8501-1. The blasted surface provides a suitable base for the application of the new priming system.

In situations where site conditions may make abrasive blast cleaning impractical or unacceptable, the use of manual cleaning methods may be considered. Impact tools such as chipping hammers, needle guns are reasonably effective in removing old paint coatings . Power rotary wire brushes may also be used to remove the existing paint, where a compatible surface tolerant primer is used. When using power tools care should be taken to avoid polishing the surface, and to achieve an acceptable profile or anchor pattern.

The Intumescent system manufacturer should be consulted to provide advice about surface preparation standard, with appropriate supporting evidence.

Where a manufacturer wishes to demonstrate that compliance can be achieved by the application of an Intumescent system over existing painted surfaces of known generic type and thickness, fire test evidence should be available to provide a technical justification. Agreement should be reached with NPCIL about the applicability of the test data to the circumstances which prevail on the specific site.

17.1.2 BASE COAT

The base coat shall be Solvent based Intumescent Coating of approved Dry Film Thickness, unless approved otherwise.

The Intumescent coating (Base Coat) shall be fit for use for given "In service environment exposure condition". The coatings proposed to be used in exterior condition shall be specifically certified for its suitability for exterior use. Wherever, coatings of interior members needs to be left exposed, while erection for a reasonable period of time prior to completion of enclosure, the same shall be adequately protected with suitable seal coat to avoid any damage to base coat from moisture etc.

Wherever unusual conditions given below are likely to arise, the advice of the coating manufacturer about suitability of coating, should be sought:

- If environment change in the foreseeable future.
- If some form of local pollution present. For example, high levels of sulphur dioxide could produce acidic conditions and this in turn may influence the type of seal coat required.

- If conditions vary within the building. For example, roof spaces (of an air conditioned building) subjected to periodic condensation.
- If some elements of the construction particularly vulnerable to impact damage.
- If any unusual processes likely to cause localised special conditions, such as splashing, water pooling, localised high temperatures etc.

17.1.3 SEAL COAT OR TOP COAT

A Polyurethane coating of specified thickness shall be applied over the basecoat to prevent the basecoat from environmental degradation and abrasive damage as seal coat.

17.1.4 FIRE TESTING OF COATING

Fire protection systems for steel structures are tested for their ability to retard the rate at which the steelwork heats up in a fire.

If desired by NPCIL, the coating system (Inclusive of all 3 coats, as proposed to be used) shall be independently evaluated by performing the fire testing in independent approved laboratory, before acceptance of product. The number of test samples shall be decided based on variability of coating thickness proposed to be used in the project and with mutual consent of NPCIL & Contractor. Generally, for a given fire rating and coating thickness the member having highest Hp/ A (Heated Perimeter/ Cross-sectional Area) shall be most critical and selected for testing. The cost of testing upto 2 samples are deemed to be included in the coated rate . In case if it is decided to test more than 2 samples, the cost of such additional tests (Beyond 2 Samples) including materials & labour shall be reimbursable to the contractor on actual expenditure, If the product is successfully tested and qualified. However, in case of failure of coating on testing, the cost of testing shall be compulsorily borne by the contractor.

17.2 FIRE RATING

It is defined as the ability of an element of building construction/ component for structure to fulfill, for a stated period of time, the required stability, fire integrity and or thermal insulation and/ or other expected duty in a standard fire resistance test.
The fire resistance requirement for a building is defined in terms of the fire resistance period and stated in terms of minutes (15, 30, 45, 60, 75, 90 or 120 minutes) based on standard time temperature curve as per ISO 834 / IS 3809.
The fire rating of the members shall be derived, based on relevant codal provisions or from Fire Hazard Analysis. The fire rating for each member shall be as specified and approved by NPCIL.
Wherever specified, the ability of a component or material to achieve the required fire resistance period is demonstrated by subjecting it to a standard fire test as defined in BS 476-20 /21 or BS EN 1363-1 or ASTM E119 as approved from NPCIL.

In case of Intumescent Coating the adequacy of the system under test, shall be decided based on the fulfillment of requirement, that the substrate temperature does exceed the critical temperature when heated for rated duration as per standard time temperature curve given in IS 3809.

17.3 CRITICAL TEMPERATURE

Unless specified otherwise, the critical temperature for member with 4 side exposure & 3 side exposure shall be 550 deg C and 620 deg C respectively.

17.4 FILM THICKNESS OF INTUMESCENT SYSTEMS

Primer, Base Coat and seal coat / decorative top coat thicknesses shall be as specified and approved by NPCIL.

Unless specified otherwise, the thickness of primer & seal coat shall not vary with size of member, for a given fire rating. However, the thickness of base coat may vary as per its Section Factor, fire rating, critical temperature & exposure condition etc.

17.4.1 PRIMER FILM THICKNESS

The thickness of primer shall be as specified and approved by NPCIL. In no case, the primer thickness shall exceed the upper limit, if any, specified by the coating certifiying agency or by the coating manufacturer, above which the performance of the intumescent may be impaired in a fire situation.

Wherever, steelwork delivered to site is treated with a primer applied elsewhere in shop, the compatibility of the primer applied shall be ensured with Intumesecent coating by the coating manufacturer. The correct thickness of the primer applied in shop shall be properly documented and informed to Base coat applicator, to work out the thickness of base coat from combined thickness measured after application of base coat. In case, such records are not available, the site applicator must conduct a primer thickness survey prior to commencement of intumescent application to the satisfaction of NPCIL.

17.4.2 BASE COAT THICKNESS

Unless specified otherwise, the DFT of base coat shall be derived based on charts of proposed coating material, certified from the reputed agencies like UL (Under Writer Laboratories, USA) & Warrington, UK etc. The base coat thickness shall be derived based on critical temperature of the member, its desired fire rating, its section factor , no of sides exposed to fire etc. using above certified charts. The correct film thickness must be determined for each section, in order to produce a list of section sizes with their associated film thicknesses for the entire project.

The contractor shall prepare a painting schedule of primer, intumescent coating & seal coat thicknesses required to provide fire protection to each of the steel sections to achieve the specified fire resistance periods. This schedule shall be submitted to the NPCIL for review and approval, prior to commencing the works. The schedule must include, but not be limited to, the following.

(i) Fire resistance period(s) required.
(ii) Steelwork references as noted on general drawings.
(iii) Steelwork section sizes and section factors.
(iv) Details of any partial fire protection, if provided by concrete floor slabs etc.
(v) Name of intumescent product(s) specified / selected.
(vi) Method used to determine required coating thicknesses.

The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

17.4.3 SEAL COAT FILM THICKNESS

The coat thickness shall be as specified and approved by NPCIL.

17.4.4 PAINT THICKNESS ON BOLT HEADS AND STEEL TO STEEL CONNECTIONS

Where structural steelwork is treated with intumescent in shop and erected in finished condition, special provision has to be made for the coating on site of bolt heads and other surfaces not previously fire protected. As per recommendations of BS 5950 Part 8, the protection coating thickness on bolt heads and connections should be the same as that on adjacent steel sections.

Where the coating operation is delayed for any reason or where the bolts/ connections are made of a special material proper cleaning prior to coating shall be carried out. In such case a special adhesion primer may be required before application of the intumescent in consultation with coating manufacturer and approval of NPCIL.

17.4.5 FILM THICKNESS DETERMINATION

The correct thickness of intumescent coating system applied on the members shall be confirmed before proceeding to application of the decorative topcoat, as any deficiency in intumescent thickness can be best corrected at this stage.

The average DFT of the primer coat shall be properly recorded and verified in the shop. If same is not available it shall be measured physically at site. prior to application of Base Coat. After application of the intumescent basecoat, the average primer thickness should be subtracted from measurements taken on the basecoat, to establish the true intumescent thickness.

The thickness of topcoat must be confirmed in the same way as for the intumescent basecoat above.

Where decorative appearance is important and requires additional coats of finish, or where additional topcoat thickness is required to protect from severe environmental

conditions, the intumescent manufacturer should be consulted to confirm that the additional thickness will not inhibit the fire resistance of the system.

17.5 IN-SERVICE ENVIRONMENT

The nature of the environment to which the coatings will be exposed may affect their durability or their performance in a fire situation, and must therefore have a major influence on the properties required of them. Environment may have a significant bearing not only on the choice of intumescent basecoat, but also on the type and thickness of anticorrosive primer and on the type and thickness of seal coat.
For steel protection generally, BS EN ISO12944-2:1998(7) defines a number of environments in terms of 'corrosivity', based on relative corrosion rates of carbon steel, as follows:
Category C1 Very low
Category C2 Low
Category C3 Medium
Category C4 High
Category C5-I Very high (Industrial)
Category C5-M Very high (Marine)

ISO 12944 relates these categories to the composition and thickness of different protective coating systems required to provide short, medium or long term protection against corrosion, but only categories C1 and C2 would be considered typical of most thin film applications.

Examples of typical environments for each category are given in Table 17.1 below.

For C1 environments (the most common for fire protection) corrosion protection may not be strictly necessary but for site-applied intumescent coatings an anticorrosive primer may still be specified to provide temporary protection .

For all other environment categories some degree of corrosion protection would normally be included, but the specifier must also consider the type and thickness of seal coat that may be necessary to prevent degradation of the intumescent by moisture from humid atmospheres, condensation etc.

TABLE 17.1: CLASSIFICATION OF ENVIRONMENT TYPES

Corrosivity Category	Corrosion/ Exposure Rating	Examples of typical environments in a temperate climate (information only)	
		Exterior	Interior
C1	Very low	N/A	Inside heated or air-conditioned buildings with clean atmospheres. Low relative humidity and no likelihood of damp or condensation e.g. offices, schools, shops, hotels.
C2	Low	Atmospheres with low level of pollution and fairly dry climate. Mostly rural areas. Intumescent use mainly in sheltered locations e.g. under canopies.	Occasional damp or wet conditions. Unheated buildings where water leakage or condensation may occur, e.g. unheated warehousing, sports halls, plant rooms etc and in roof voids.
C3	Medium	Urban and industrial atmospheres, moderate sulphur dioxide pollution. Coastal areas with low salinity. Examples would include exposed car parks.	Constant damp atmosphere, but may be warm and well ventilated. Production rooms with high humidity and some air pollution, e.g. food processing plants, kitchens, laundries, breweries, dairies.
C4	High	Industrial areas with high sulphur dioxide pollution and coastal areas with moderate salinity. Typical areas include tank farms, petrochemical installations etc or exposed exterior surfaces of any structure in a polluted environment.	Interior of chemical plants subject to continual injection of chemical vapours or steam in the atmosphere. Constant warm and high humidity conditions such as in swimming pools. Coastal ship and boat yards.
C5-I	Very high	Industrial areas with high humidity and aggressive atmosphere. Thin film intumescents should only be used with manufacturer advice.	N/A
C5-M	Very high	Coastal and offshore areas with high salinity. Thin film intumescents should only be used with manufacturer advice.	N/A

17.6 STORAGE

The storage of all material(s) should be strctly in accordance with the manufacturer's recommendations . As a general guide, the storage temperature for all material(s) will be within the range of 5 -30°C, and any water based materials in particular should always be protected from frost. Material containers should remain unopened until needed and should be used in date order (FIFO).

All materials delivered to site must be used within the manufacturer's stated shelf life, or otherwise be approved in writing by NPCIL, if declared suitable for use by the original manufacturer.

17.7 APPLICATION OF COATING SYSTEM

17.7.1 PREREQUISITES

Application must not proceed, if the prevailing environmental conditions are outside the limits set out in the manufacturer's technical data sheets.

As a general rule, environmental conditions – air and steel temperatures, humidity and dew point – should be determined before commencement of work in the morning, afternoon and evening (if appropriate), and at other times if conditions show a noticeable change (e.g. if it starts raining). All measurements should be logged and be available for inspection at all times.

Prior to site application, all surfaces to be coated should be in a clean, dry condition and any areas not requiring fire protection or which may be exposed to overspray should be appropriately protected by masking.

The applicator should ensure that all equipment required to carry out the surface preparation and application of all components of the intumescent coating system, according to technical specification, are available and in good working order.

The applicator must ensure that all relevant Health and Safety data sheets, application instructions and method statements are available and are fully understood.

Where required, mixing should be carried out in accordance with the manufacturers' instructions. Materials taken from store should attain the temperature recommended for use before being applied.

The scheduling of the works should be such that sufficient areas are made available, allowing free access for the applicator of the intumescent coating system to apply the material to the required specification.

All work should be scheduled to ensure that the conditions required by the manufacturer (temperatures and humidity, over-coating times etc) can be met.

It is particularly important that where application is to be carried out in a partially clad building (i.e. not theoretically open to the elements), the contractor ensures that the building is water-tight and that areas where coatings are to be applied are not directly exposed to external weather conditions at any time.

17.7.2 MONITORING OF ENVIRONMENT CONDITIONS

No application should take place on site when environmental conditions – air and steel temperatures, relative humidity, dew point – are outside the limits laid down by the coating supplier, to avoid any detrimental effects on both film formation and integrity of the coating (especially water based systems) as well as on long term performance.

Typically, steel temperatures should be more than 30 C above the dew point to ensure that no (visible or invisible) moisture or condensation is present on the surface during application.

The applicator's shall monitor these conditions in accordance with the specification, and to maintain auditable records to demonstrate compliance.

17.7.3 SURFACE PREPARATION

Steel surfaces should be prepared by removing scale and rust using abrasive shot blasting to a minimum standard of Sa2½ as defined in BS EN ISO 8501-1: 2001 "Preparation of steel substrates before application of paints and related products"

Prior to the commencement of blast cleaning all steel surfaces should be clean and dry. Oil and grease contaminants, if present, should be removed by the use of suitable emulsifying degreasers, suitable clean organic solvents or steam cleaning before the commencement of blasting.

A surface profile shall be within the range of 35 – 75 micron in general suiting to primer and as specified by the Coating Supplier and shall not exceed 100 microns.

All dust and spent abrasive must be removed from the prepared steelwork by blowing down with clean dry compressed air.

17.7.4 APPLICATION OF PRIMER

The primer of specified thickness should be applied before the blast cleaned surface deteriorates.

Where the steel sections are (more normally) blasted and primed in shop, the same surface preparation standards as above would be specified, but after transportation and site storage further measures need to be included to ensure cleanliness of the primer prior to over-coating with the Intumescent basecoat. In such case the primer may be applied in 2 stages, if recommended, by coating manufacturer. The first stage primer shall be applied in shop to protect the shot blasted surface till final painting, and second coat of primer shall be applied prior to application of

Intumescent Coating in consultation with coating manufacturer. The necessary surface preparation at each stage shall be carried out in line with coating manufacturer recommendations. The next stage of coat shall be applied after minimum curing time of previous coat and shall also be completed before the end date if specified by the coating manufacture.

The coating manufacturer shall ensure and certify that the primer & process followed in such a way shall not adversely affect the performance of the coating.

The primer should be applied to the specified dry film thickness and the thickness measured in accordance with the approved procedure.

When thicknesses are found to be outside the specification, the advice of the designer and/or primer and intumescent coating manufacturer should be sought and remedial action carried out as necessary.

Because different structural steel sections may require different intumescent basecoat thicknesses, it is important to ensure that all sections are correctly marked or otherwise identified for application and record purposes. Marking is best carried out after completion of priming and should not interfere with the application or operation of the intumescent coating system.

Where unprotected elements meet fire protected elements in a structure, it is normally considered good practice to overlap the fire protection onto the adjoining 500mm of 'unprotected' structural steel to limit heat transfer into the protected substrate.

17.8 QUALIFICATION OF APPLICATOR

The fire performance of a product, component or structure is dependent on satisfactory site application and maintenance. Competence in application requires an understanding of the importance of such factors as surface preparation, data sheet limitations for conditions during applications, achievement of film thickness etc. Such competence is important for any coating operation, but for intumescent paints the potential consequences of coating failure make the standard and control of application quality even more critical. Therefore, these coating shall be applied by experienced persons who know and understand not only the practicalities of coating application, but also the importance of attention to detail in the installation process. The applicator shall be certified by the Intumescent Coating Manufacturer, which shall provide confidence in the appropriate standard of workmanship being provided.

17.9 APPLICATION METHODS

The application of all coatings should be carried out fully in accordance with manufacturers' technical data sheet requirements and the applicator's method statement approved by NPCIL. These in turn must reflect fire test and assessment conditions.

While airless spray is generally the preferred method of application for most coatings, the use of this method on site may be restricted, in such cases either provision to protect adjacent buildings and the surrounding environment from

overspray shall be made, or brush/ roller application may be followed if permitted as per coating manufacturer recommendations.

Where spray is not possible, a larger number of coats by brush or roller may be required, and minimum and maximum over- coating times must be observed. In such case he recommended thicknesses provided on manufacturer's data sheets, along with the maximum achievable thickness per coat by the different methods may be used as basis of application.

17.10 THINNING AND EQUIPMENT CLEANING

Thinning of Intumescent product may be permissible to aid application characteristics with prior approval of NPCIL, particularly where ambient temperatures affect product viscosity and make a good quality finish difficult to achieve. However, excessive thinning can create sagging, drying and film formation problems, particularly where high film thicknesses are involved, so all thinning is subject to approval by the manufacturer in writing. Only thinners approved by the manufacturer may be used, if approved.

Wherever, solvent is used for equipment cleaning, the same should be approved by the coating manufacturer as being compatible with the coating system, as incompatible gun-washes left in equipment overnight can give rise to film formation defects if mixed in with the coating.

It should be noted that thinning with solvent will invalidate the wet to dry ratio given on the product data sheet and may significantly affect the VOC (Volatile Organic Compound) content of the coating, and hence its use should be limited so that it does not adversely affect compliance with environmental legislation and does not causes any health hazard to the applicator and surroundings.

17.11 HANDLING, TRANSPORTATION AND STORAGE OF SHOP-PRIMED STEELWORK

The primers used for the shop priming of structural steelwork shall be fairly tough ,resilient, and shall be resistant to mechanical damage . Further, the contractor is required to implement protective measures and appropriate care during the transport, storage and erection of steel structures.

Coatings should be sufficiently dry before handling and members should be lifted at designated lifting points or by using lifting brackets where available. The use of lifting chains in contact with coated steel is preferred to strops/webbing slings as the former cause only minimal damage that is normally easy to rectify. Member shall be preferable lifted in single lift.

The loading of trailers should be carefully planned, with timber supports positioned, where possible, in uncoated contact areas (e.g. areas to receive bolted connections). Where contact of supports with coated areas is unavoidable, members should be supported on their toes to minimise the contact area. Where thin-film prefabrication primer only has been applied in shop, members which may fill with water should be

prevented from doing so by the use of covers to avoid premature breakdown under immersion. Loads are best secured with the careful use of clean chains and it is advised that the loaders wear overshoes and where possible avoid walking on coated surfaces in order to minimise contamination.

Where site storage is unavoidable, similar care should be taken in the handling and support of the coated steel using the same lifting and support points as those used in transportation. Where possible members should not be stacked and water ponding should again be avoided using localised protection where necessary. The contractor should be made fully aware of the importance of good handling practice and storage areas should be roped off with signage clearly explaining the need to avoid contamination and mechanical damage to the coating finishes.

Similar care should be taken during the erection phase, with any lifting activities making use of strategically positioned holes, lifting lugs and brackets etc to minimise damage to the body of the paintwork.

17.12 TREATMENT OF SHOP-PRIMED STEELWORK AT SITE

17.12.1 REPAIR OF TRANSIT DAMAGE

Despite the contractor's efforts to be careful, some damage to the coating will inevitably occur during handling and transportation. Further damage may occur as a result of site modifications, welding etc prior to the application of the intumescent basecoat.

The nature and extent of primer repair required will vary, dependent on

- The scale of damage incurred.
- The degree of deterioration of the damaged surface.
- The type of exposure – i.e. the service environment and the importance of the primer in providing long-term anticorrosive protection.

Even where damage to the primer is extensive, provided that the exposed steel surface has not badly corroded it may be sufficient to re-prepare the surface to an acceptable standard prior to application of the intumescent basecoat overall i.e. without reinstating the primer. This might be acceptable, for example, where conditions during application are acceptable and subsequent exposure is to an environment of corrosivity category C1, provided the intumescent coating manufacturer agrees.

17.12.2 Repair of weld damage area

In cases where on-site welding, cutting or grinding has been necessary, all affected areas must be re- prepared to a standard agreed with the intumescent manufacturer, and cleaned down to remove any resultant contamination.

In general, site welding would be carried out prior to application of the intumescent basecoat, and the welds and heat-damaged areas then re-prepared by suitable mechanical means such as power discing and/or grinding prior to reinstatement of the

primer. Where welding is carried out after application of the intumescent basecoat, any heat-damaged coating should be cut back to a sound coating (distance) prior to re-preparation and reinstatement of all coats in the area of repair.

Where subsequent service is to be in an environment subject to damp or wet conditions – e.g. humid buildings without air conditioning, swimming pools etc – the anticorrosive coating may be important to the long term performance of the system and a good standard of surface preparation and reinstatement of the full anticorrosive primer thickness may be necessary. In all cases, the advice of the intumescent manufacturer should be followed.

17.12.3 Contaminated and corroded primer

Where a thin coat of primer is specified to provide protection of the blast cleaned steel during the transport and erection stages only, any delays in the build programme may result in some breakdown of the coating and consequent corrosion (rust rashing) of any exposed steelwork. In such cases if decided by the Engineer, re-preparation shall carried out by the contractor. Depending on the extent of corrosion and the nature of the intended service environment, the decision may range from no re-preparation to manual re-preparation of affected areas followed by immediate application of the intumescent basecoat overall, or manual preparation to BS EN ISO 8501-1 St3 standard, followed by re-application of primer prior to completion of intumescent coating. Wherever, the primer forms a functional part of the long term protective system and to be used under severe exposure environment re-preparation at site shall be required.

Where the primer is in good condition but in a contaminated state, it be cleaned using suitable methods such as washing using detergent and/or fresh water pressure washing and allowed to dry before application of the intumescent basecoat. The decision of NPCIL in this regard shall be final.

17.13 SEALING OF INACCESSIBLE AREAS

If some gaps are present in structures, where moisture ingress may occur and if not sealed may cause problems such as blistering or degradation of the intumescent coating after application. Such areas need to be sealed prior to application of the intumescent basecoat, with a moisture resistant intumescent mastic or equivalent, prior to the application of intumescent basecoat.

Areas like interface between the top flange and concrete decking, may allow moisture to penetrate and this will take a long time to dry out, even if environmental conditions are satisfactory for paint application.

17.14 REPAIR PROCEDURE

During the application process and after completion of the work, repairs may be necessary to ensure that the standard of fire protection, surface integrity and finish is in accordance with the original specification. The cause of the damage or degradation should be addressed prior to carrying out the repairs, to avoid any repetition.

Before carrying out on-site remedial works, a written Method Statement for repair procedures shall be prepared by the contractor and submitted to the NPCIL for review and approval.

The contractor shall be responsible for identifying all areas requiring remedial works and for rectification in accordance with the coating manufacturer's recommendations. Issues such as compatibility, effectiveness and adhesion of combined thicknesses etc shall be considered while taking the decision.

In case, where the intumescent coating has detached due to mechanical damage, or suffered localised degradation due to water ingress, the normal repair procedure of mechanical removal of the damaged or denatured coating to a firm (unaffected) edge, followed by reinstatement of the system to the original, specified thickness shall be followed.

17.14.1 Repair of film thickness deficiencies

If the dry film thickness of the intumescent basecoat or topcoat, does not comply with the nominal dry film thickness stated in the schedule of thickness, work shall be undertaken to bring the affected area up to the required thickness.

Where a decorative finish has been specified, the contractor shall make provision for the removal of all visible dirt from the surface of the coating, following erection of the steelwork.

17.14.2 Repair of damage to completed Intumescent coating systems

Remedial work on complete fire protection systems will depend on both the extent of the damage and whether or not a seal coat was applied to the original coating.

Minor damage, such as chips and scrapes, will not normally affect the performance of the material unless the service environment is wet or exposed, in such case damage may allow moisture ingress and lead to degradation of the intumescent. It is therefore recommended that minor damage should be repaired with the approval of NPCIL at the earliest opportunity, following the procedure given below:

a) In cases of damage to the basecoat, the damaged area should be cut back to a firm edge. If the primer coat is damaged, any corrosion products which may have formed should be removed and the steelwork "patch primed" using a suitable compatible primer.

b) If only the basecoat is damaged, fresh basecoat or approved repair material should be applied to match the existing thickness, taking care not to excessively overlap onto the surrounding intact seal. When the dried intumescent material matches the surrounding thickness, the recommended seal coat (if any) should be applied either to the patch repair or overall.

c) If only the seal coat is damaged, fresh seal coat should be applied, either to the localised area, or over the whole section.

In the unlikely event that major repairs are required (i.e. due to water or chemical attack), the intumescent coating manufacturer should be consulted for expert advice and repair shall be carried out as per approval of NPCIL.

17.15 HEALTH AND SAFETY PROVISIONS

Products used on site shall comply with the recommendations of manufacturers' health and safety data sheets, and that the safety of all personnel in the vicinity of the application is protected. During and throughout the application process, full compliance with all relevant Health and Safety and Environmental legislation must be demonstrated. As a minimum this includes

- Observance of all precautions and conditions for use of the coating system, as defined in the manufacturer's Product Safety Data Sheets.
- Compliance with relevant Site Storage Regulations.
- Compliance with all applicable relevant Waste Disposal Regulations, in particular for the Hazardous Waste.

17.16 DESIGN LIFE AND LIFE TO FIRST MAINTENANCE

In general the intumescent systems along with seal coat should not require maintenance before 15 years, other than for decorative purposes or where mechanical damage has occurred and shall be guaranteed for same. The thickness of the seal coat shall be decided according to above requirements.

The Coating shall be regularly and frequently inspected of the condition of the fire protection. A schedule of regular maintenance shall be prepared in service. Wherever, there is any doubt about the capability of a thin film intumescent system to provide the required long term durability, a thick film system may be advised.

17.17 QUALITY PLAN, INSPECTION CRITERIA AND METHODOLOGY

17.17.1 QUALITY PLAN

Competent contractors and applicators shall have in-house systems in place to control site work and to demonstrate compliance with specification requirements. The quality plan shall cover the sequence of activities required to deliver the specified quality of finish. This plan shall also identify the inspection stages and hold point in the process, and shall be submitted to NPCIL for approval prior to commencement of the work.

17.17.2 Measuring Equipment

The following fully calibrated and certificated measurement equipment to be available on site

- Where steel surface preparation is to be carried out at site, pictorial standards for blast cleaning and for manual / mechanical surface preparation as supplied with EN ISO 8501-1:1988 should be available to ensure the correct standard is being achieved.
- Comparator plates or Testex tape and micrometer are required to determine the blast profile, where relevant. EN ISO 8503-1:1988 and EN ISO 8503-5:2004 apply.
- Ambient temperature thermometer.

- Minimum – maximum thermometer.
- Steel temperature gauge, preferably electronic.
- Whirling hygrometer, together with a relative humidity and dew point calculator as included in EN ISO 8502-4:1999, or electronic equivalent.
- Instruments which provide ambient and substrate temperatures, relative humidity and dew point calculations automatically.
- Tape measure to check steel section sizes, if necessary.
- Wet film thickness gauges.
- Dry film thickness gauges having a measurement range appropriate to the specified dry film thickness. Ideally the instruments used should have the capability to record thickness readings in batches, and it would aid the completeness of records if the readings were also downloadable to computer.

17.17.3 Site inspection criteria

Typically, the inspection criteria shall include the following

1. Surface preparation

- Surface preparation standard – as specified, usually against EN ISO 8501-1 or equivalent
- Surface profile minimum and maximum – as specified (EN ISO 8503-2) or equivalent
- Dust or other contamination – visual or EN ISO 8502-3

2. Application

- Air temperature, substrate temperature, relative humidity and dew point (throughout the application process) – as specified or as manufacturer's data sheet.
- Batch numbers of all products used
- Dates and times of application and compliance with recommended over-coating times from manufacturer's data sheets
- Wet film thickness checks

3. Dry film checks

- Dry film thickness survey and records
  (i) at primer stage
  (ii) after application of intumescent basecoat and
  (iii) on completion of coating

  Thicknesses at each stage should be in accordance with the specification.
- Visual appearance – as specified or in accordance with agreed standard.

  NB: Dry film thicknesses should always be checked against the approved film thickness schedule, which defines the required thickness for each individual steel

member. Drawings or tables showing the correct thickness for each member must therefore be available to the inspector (contractor's QA representative or NPCIL representatives) prior to a dry film thickness survey.

17.18 INSPECTION METHODOLOGY

17.18.1 WET FILM THICKNESS

Wet film thickness measurements should be taken during application using a wet film gauge. These readings will provide a guide for the applicator to ensure that the required dry film thickness of the primer/basecoat/seal coat will be achieved. Wet film thickness measurements indicate the thickness of an individual coat. Care should be taken when applying subsequent coats, as readings may be misleading due to the gauge sinking into a softened previous coat.

Information on the wet film thickness necessary to give a specified dry film thickness should be obtained from the relevant intumescent manufacturers' technical data sheet(s).

17.18.2 Dry Film Thickness (DFT)

17.18.2.1 MEASURING GAUGES

The method of Dry Film thickness determination shall use a gauge employing the electro-magnetic induction principle. Such instruments shall have a range appropriate to the specified dry film thickness and shall be calibrated on a smooth plate prior to use. Calibration should use shims appropriate to the specified film thickness.

If feasible, the instruments should be capable of storing data. Ability to print and/or download to computer.

17.18.2.2 Thickness measurement

Primer thickness may be determined either after application in shop, or on site prior to commencement of application of the intumescent basecoat.

Allowing for the thickness of primer applied, the total dry film coating thickness of the intumescent basecoat should be determined prior to the application of any specified protective/decorative topcoat(s). Measurement at this stage will more easily facilitate any subsequent corrections which may prove necessary.

If the total intumescent dry film coating thickness, allowing for the underlying primer, is found to be within specified tolerances, application of the next coat (usually a decorative and/or protective coat) can proceed.

If the total intumescent dry film coating thickness is found to be outside the specified tolerances, the procedure outlined in section 19.4 should be followed.

Indentation of the coating by the measuring instrument probe indicates insufficient hardness of the coating and measurements should be deferred. However, if programming requires coating to precede urgently, with prior approval of NPCIL,

a shim of known thickness can be used to spread the load of the probe tip on the coated surface, allowing measurement to proceed before the coating has fully hardened. The dry film thickness of coating and shim together can then be measured and the shim value deducted to give the coating thickness.

Application within the specified tolerances shall also be ensured by careful monitoring of material usage and the elimination of surface defect prior to application.

When taking dry film thickness readings, it is recommended that no readings are taken within 25mm of the edge of an I section or within 25mm of the join of flange to web of an I section.

Taking the above into account, readings should be taken randomly over the remaining areas of the section with a frequency as described in clause 19.3 below.

17.18.3 Frequency of measurement

Sections should be measured in accordance with the following guidelines

A) For first 10% members or till consistent performance to the satisfaction of NPCIL is achieved, whichever is later, the thickness measurement shall done as per following frequency.

(i) I Sections, Tee Sections and Channels
Webs: Two readings per metre length on each face of web
Flanges: Two readings per metre length on the outer face of each flange
One reading per metre length on the inner face of each flange.

(ii) Square and Rectangular Hollow Sections and
Angles: Two readings per metre length on each face.

(iii) Circular Hollow Sections
Eight readings per metre length evenly spread around the section

Where members are less than 2m in length, three sets of readings shall be taken, one at each end and at the centre of the member. Each set shall comprise the number of readings on each face given by (i), (ii) or (iii) above, as appropriate.

Following guidelines for setting out a film thickness survey shall be followed.

- The contractor must provide suitable and adequate means of access, including to difficult and / or partially inaccessible areas. It is therefore important that surveys are scheduled when the fullest possible access is still available on site.
- All equipment used must be correctly calibrated, and if more than one party is carrying out thickness checks, agreement regarding calibration of all instruments must be reached before commencing.
- At least 10% of steel sections should be measured in accordance with the frequency set out in 19.3 A) above. These should include a representative mix of section sizes, and difficult access sections as well as those that are easiest to access.

- All other sections should be measured with reduced frequency with prior approval of NPCIL, unless the detailed survey (of 10% of sections) identifies a recurrent problem of thickness.
- If the detailed survey reveals a trend of unacceptable thickness, this should be taken into account when planning the remainder of the survey.
- In the worst case scenario, a full and detailed survey according to 18.3 A) above may be adopted.
- If certain faces of the sections are repeatedly found to be unacceptable (e.g. top flange or one face known to be difficult to access), the remainder of the survey should include detailed measurements of that face as well as random measurements of other faces.
- Where no unacceptable trends are identified, the remainder of the survey should consist of random readings taken at a frequency of 4-5 readings per metre length.
- Unacceptable low areas should be marked up for remedial coating by the inspector.

17.18.4 Acceptance criteria

The coating thickness acceptance criteria shall be as follows, assuming that the specified thickness is a nominal value:

(i) The average dry film thickness applied to each element shall be greater than or equal to the specified nominal value.

(ii) The average measured dry film thickness on any face of any member shall not be less than 100% of the specified nominal value.

(iii) Dry film thickness values less than 80% of the specified nominal value are acceptable, provided that such values are isolated and that no more than 10% of the readings on a member are less than 80% of the specified nominal value.

Where any single thickness reading is found to be less than 80% of the specified nominal value, a further two, or where possible three, readings shall be taken within 150 to 300 mm of the low reading. The initial reading may be considered isolated if all the additional readings are at least 80% of the specified nominal value. If one or more of the additional readings are less than 80% of the specified nominal value, further readings shall be made to determine the extent of the area of under thickness. In such cases, low thickness areas identified should be brought up to the required thickness before proceeding to the next application stage.

(iv) The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

17.19 CORRECTION OF DEFECTIVE OR INADEQUATE COATINGS

17.19.1 THICKNESS CORRECTION

Wherever inadequate thickness is identified, the deficient area shall be identified and further coat(s) of intumescent product to bring the overall thickness up to acceptable standards shall be applied, prior to application of the final seal coat / decorative top coat.

However, if low thickness is not detected until after the seal coat / decorative top coat has been applied, detailed guidance must be sought from the intumescent coating manufacturer. In some circumstances – and with supporting test evidence – it may be possible to remedy the situation by the application of further coats of intumescent paint, but in the other extreme it may be necessary to remove previous coatings in order to build up the necessary fire protection from scratch.

Wherever the intumescent coating thickness exceeds the limits stated in the manufacturer's recommendations, guidance should be obtained from the manufacturer.

17.20 RECORDS AND REPORTS

Where appropriate, site records should contain the following information

17.20.1 VERIFICATION OF PRODUCT AND SPECIFICATION

Confirmation of product testing and certification, preferably in accordance with a third party certification scheme.
In addition, any contract specific requirements regarding product or specification should form part of the site records. For example, where appearance of the finish is important, and where sample paints or panels have been approved by the NPCIL, these should form part of the product dossier.

17.20.2 Contract documentation covering the fire protection product and its installation

- Substrate type (i.e. section sizes and shape, orientation, Hp/A value, etc.)
- Substrate location
- Surface preparation (i.e. degreasing, blast cleaning, etc. and standard)
- Identification of any primer and information concerning compatibility with intumescent coating.
- Evidence of third party product certification, including proof of specific testing for cellular beams and fire-engineered situations, giving relevant report reference etc.
- Declarations of Supply covering the fire protection products used.
- Batch numbers of products supplied.
- Thickness of intumescent coating required for the specified fire resistance period.
- Any variations or concessions agreed during the course of the contract.

- Design review to confirm any design changes and their effect on the specification, prior to commencement of application.

17.20.3 Quality Control Records

- All records should identify the areas inspected with reference to the relevant drawings, and should include
- Environmental conditions – air and substrate temperature, relative humidity and dew point.
- Dry film thicknesses per coat and for the full fire protection system, for each element of the structure. Measurements should include

- the member identification mark
- the number of readings taken
- maximum coating thickness recorded
- minimum coating thickness recorded
- average coating thickness
- any supplementary readings taken to establish if low readings (below 80% of specification) are limited and isolated areas.

- Variations, corrective actions or concessions carried out in relation to environmental conditions or dry film thicknesses.

17.20.4 Site Remedial Work

Where dry film thicknesses are checked after application of each coat, it is a fairly simple procedure to correct low thickness as this can be achieved by simply applying an additional coat (or part coat) before proceeding to the next stage of the specification.

If film thicknesses are not carried out with the required regularity, or if low thicknesses are not detected until the application process has been completed, it will be necessary to seek the manufacturer's advice regarding the best method of bringing the coating up to the required level of protection.

Advice may vary from complete removal of applied coatings, to selective removal of seal coat or, if supporting test evidence is available, to building up the thickness of the intumescent base coat (on top of the seal coat) followed by re-application of further seal coat.

In all cases, records must show the nature of defect, source of remedial advice and the full extent of remedial work carried out at site.

18 PRECAST CONCRETE

18.0 GENERAL

All concrete for precast concrete work shall comply with specifications for general concrete work and with the following additional requirements.

18.1 TOLERANCES

All units shall be cast as per detailed drawings furnished by the Engineer and to the tolerances indicated thereon. In the absence of any such indication, the dimensions shall not vary by more than ± 3 mm.

18.2 PLATFORM

All precast units shall be cast on a suitable yard, bed or platform with firm foundation and free from wind. The platform shall be fenced and shall have a curing tank of adequate size. The Contractor shall be responsible for the accuracy of the level or shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or printed on each unit. Each unit shall be concreted in one operation.

18.3 FORMS

The forms shall be steel forms with rigid steel frames or plywood forms if specifically approved by the Engineer. All component parts of formwork shall be so held that during concreting, there is no deformation of the form resulting in the concrete units not conforming to dimensions indicated on the drawings.

18.4 STRIKING FORMS

Side shutters shall not be struck in less than 24 hours for ordinary Portland cement after depositing concrete or as specified by the Engineer.

18.5 IDENTIFICATION MARKS

The surface of the underside or upper side, which is reinforced, shall be distinctly marked.

18.6 CURING

The blocks shall be kept at not less than 90% humidity immediately after manufacture for 24 hours and thereafter wet cured for a period of 10 days at a temperature of not less than 16°C. Rapid drying at the end of curing period shall not be permitted. Therefore they shall be stored under a safe and shaded enclosure/area. During this period, the blocks shall be handled carefully without causing any damage to corners, edges, surfaces etc.

18.7 HOISTING

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal

takes place, the Contractor shall satisfy the Engineer or his representative that the methods he proposes to adopt for these operations will not overstress or otherwise affect seriously the strength of the precast units. Lifting hooks shall be embedded in correct position of the unit as shown in the drawings to facilitate erection. These shall be burnt off and finished after erection if directed so, by the Engineer. The units shall be incorporated in the work in accordance with details shown on drawings or as directed by the Engineer. Cracked or damaged precast pieces during, before or after erection shall be removed and replaced with good ones at the Contractor's expense.

18.8 JOINTING

The joints shall be filled in with cement mortar 1:3 unless otherwise specified on the drawings. After jointing, the joint shall be cured for a minimum period of 10 days. All sharp and abrupt ridges and marked depressions shall be removed by grinding or filling with cement mortar properly bonded to the concrete.

18.9 PRECAST CONCRETE HATCH COVERS

All concrete for hatch covers shall comply with specifications for general concrete work and with following additional requirements.

18.9.1 All Hatch covers shall be cast as per detailed drawings furnished by the Engineer and to suit the openings as built. The tolerances in dimensions shall be + 0 or – 3 mm unless otherwise noted on drawings. No two adjacent hatch covers shall differ by 2 mm in elevation. However, before concreting hatch covers, site measurements of actual openings at the final location of hatches shall be taken. Clearance around hatch covers shall be maintained, if required, by adjusting their overall dimensions to suit actual size of opening.

18.9.2 As far as possible these hatch covers shall be cast very near to their final locations to minimize handling of these hatch covers.

18.9.3 Each Hatch cover cast for a particular location/opening shall be properly identified by use of metal plates as indicated in drawings.

18.9.4 Each Hatch cover shall have MS edge protection angle frame along its perimeter, and vertical connecting angles, as given in detailed drawings. The frame shall be fabricated taking into consideration, the actual size of opening at its final location.

18.9.5 Care shall be taken while concreting to ensure that this framework does not get distorted during/after concreting.

18.9.6 All Formed surfaces of the hatch cover shall have F3 finish and unformed surfaces shall have U3 finish.

18.9.7 The Hatch covers/blocks will have to be transported and placed in final location by the Contractor. Rectification of hatch covers or blocks will have to be carried out by the Contractor if tolerances as specified are not achieved. The unit rate for this item

shall include casting, curing, transporting to final location, erection, rectification and re-erection after painting at final location. Hoisting shall be done as per relevant clause for precast concrete given above.

18.10 SAMPLING, TESTING AND STRENGTH

Prior to manufacture trial mixes shall be prepared. When suitable mixes have been established, a sufficient number of blocks shall be cast to permit the Engineer to check the density and surface finish. If accepted these shall be standardized for all blocks to be manufactured. Provisions of IS: 1199 (Method of sampling and analysis of concrete) shall apply in addition to the requirement of this specification. The compressive cube strength of cured concrete blocks shall not be less than the specified strength at 28 days after casting.

19 MASONRY AND ALLIED WORKS

19.0 SCOPE

This chapter includes concrete block masonry, brick masonry, stone masonry, plastering, rubble soling for floors on grade, expansion and separation joints, sealing of joints, PVC/ GI water stops, flooring, skirting and dado, general area painting, steel doors, fire doors, sewer and plant drains, sanitary and plumbing items and other finishing works of the main plant structures.

19.1 APPLICABLE CODES

19.1.1 INDIAN STANDARD CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

IS: 277 Galvanized steel sheets (plain and corrugated)-specification

IS: 383 Specification for coarse and fine aggregates from natural sources for concrete

IS: 513 Cold reduced low carbon steel sheet & strip

IS: 702 Specification for Industrial bitumen

IS: 712 Specification for Building Limes

IS: 777 Glazed earthenware wall tiles

IS: 782 Specification for Caulking Lead

I.S: 1038 Specifications for Steel Doors, Windows and Ventilators

I.S: 1200 Methods of measurement of building and civil engineering works

IS: 1081 Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators

IS: 1443 Code of practice for laying and finishing of cement concrete flooring tiles

IS: 1834 Specification for hot applied sealing compounds for joints in concrete

IS: 1838 Specifications for Preformed Fillers for Expansion Joint in Concrete Pavement and Structures(Non-Extruding and Resilient Type)

Part I Bitumen Impregnated Fiber

IS: 2116 Specifications for Sand for Masonry Mortars

IS: 2185 (part-1) Concrete masonry units — specification; part 1 hollow and solid concrete block

IS: 2212 Brick Works - Code of Practice.

IS: 2508 Specification for low-density polyethylene films

IS: 2645 Integral waterproofing compounds forcement mortar and concrete— specification

IS: 2932 Enamel, synthetic, exterior a) Undercoating b) Finishing - Specification

IS: 2933 Specification for Enamel exterior a) Undercoating b) Finishing

IS: 3462 Specification for Unbacked flexible PVC flooring

IS 3495 Methods of tests of burnt clay building bricks

IS: 3614 (Part-1)Fire-check Doors, Part I: Plate, Metal Covered and Rolling type

IS: 4351 Steel door frames - Specification

IS: 4671 Specification for expanded polystyrene for thermal insulation purposes

IS: 6248 Specification for Metal rolling shutters and rolling grills.

IS: 9862 Specification for ready mixed paint, brushing, bituminous black, lead-free, acid alkali, water and chlorine resisting.

IS: 12894 Pulverized Fuel Ash-Lime Bricks - specifications

IS: 14811Rolled copper plate, sheet, strip and foils for general engineering purposes - specification

19.2 CONCRETE BLOCK MASONRY

In general, concrete block masonry shall be used in the work. Concrete block masonry shall be of solid concrete blocks having minimum average compressive strength of 5 $N/MM^2$and density shall not be less than 1800 kg/m^3.Precast concrete block masonry shall be constructed in various sizes in cement mortar 1:4 by volume with blocks manufactured as per IS: 2185 (part-1) and as per drawings and direction of engineer using standard equipment.

If Contractor proposes to cast concrete blocks at plant site, they shall submit a detailed procedure for casting of concrete blocks and submit it for the approval of the Engineer. Work shall start only after approval of the procedure. Concrete blocks shall be tested in accordance with the provisions given in IS: 2185. Contractor shall submit inspection and test plan for approval of the Engineer. Contractor shall develop proper casting yard with curing facilities for casting concrete blocks as per direction of the Engineer.

For construction of concrete block masonry, code of practice for brick works i.e. IS 2212 shall apply.

19.2.1 MATERIAL

The following are the materials to be used in the concrete block masonry work.

19.2.1.1 CEMENT

Cement shall be as covered in per specification titled ‘Plain and Reinforced Concrete’.

19.2.1.2 SAND

The sand shall consist of natural sand from an approved source. The sand shall be hard, durable, clean and free from adherent coatings, mica, shale organic matter and appreciable amount of clay. The sand shall not have deleterious impurities such as iron pyrites, alkalis, salts, coal, mica, shell etc. Sand for masonry mortars shall have particle size grading conforming to IS: 2116 – latest edition. The grading of sand for use in mortar for unreinforced and reinforced brickwork shall be within the specified limits for respective works. The fineness modulus of sand for mortar used in brickwork shall be between 2.9 and 2.1. Where grading of the sand falls outside the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening and or blending.

19.2.1.3 WATER

Requirement of water shall be as covered in the specification for 'Plain and Reinforced Concrete'.

19.2.2 STORAGE, HANDLING OF MATERIALS, CONCRETE BLOCKS, CEMENT, SAND, ETC.

Concrete blocks shall not be dumped at site & they shall be stacked in regularities, even as they are unloaded to minimise breakages and defacement of blocks. The supply/ manufacture of blocks shall be so arranged that at least fifteen days requirements of blocks are available at site at any time. Blocks selected for different situation of use in the work shall be stocked separately.

Cement, sand etc. shall be stored as stated in specification for 'Plain and Reinforced Concrete'.

Concrete shall be as per the specification for 'Plain and Reinforced Concrete'.

19.2.3 MORTAR

Mix for mortar shall be as specified in Schedule of Quantities. The cement and sand shall be mixed dry in specified proportion and then thoroughly mixed to proper consistency. No mortar that has stood for more than half an hour shall be used.

19.2.4 LAYING AND WORKMANSHIP

a) Blocks of same dimensions will be used on the same work except otherwise specially permitted by the Engineer. All blocks shall be sufficiently soaked but not excessively wet before laying. All blocks shall be soaked in water for a period of two hours before use and no blocks shall be used until there is complete cessation of bubbles when immersed in water. Concrete surfaces in contact with block masonry shall be hacked to remove the laitance and the surface roughened to the satisfaction of the Engineer for proper bonding.

b) All dirt and dust shall be removed from the block and the surfaces shall be moist at the time of laying.

c) No bats or cut blocks shall be used in the work unless absolutely necessary around irregular openings for adjusting the dimensions of different courses and for closers, in which case full block shall be laid at corners, the bats being placed in the middle of the courses.

d) The blocks shall be laid on a full bed of mortar and to line, level and shapes shown on the drawings. When laying, the blocks shall be slightly pressed so that mortar can get into all the pores of the brick surface to ensure proper adhesion. Cross-joints and wall joints shall be properly flushed in packed with mortar so that no hollow spaces are

left. Blocks shall be handled carefully so as not to damage their edges. They should also not be thrown from any height to the ground but should be put down gently.

e) All courses shall be laid truly horizontal and all vertical joints made truly vertical. Vertical joints in one course and the next below shall not come over another and shall not normally be nearer than 1/4 of block length. Fixture, plugs, frames etc. if any, shall be built in at places shown in the drawing while laying courses only and not later by removal of the blocks already laid.

f) Care shall be taken during construction to see that edges of blocks at quoins, sills, heads etc. are not damaged. All block work shall be tightly built against columns, floor slabs, or other structural members around door and window frames with proper distance to permit caulked joints. In case of very dry weather, the surface of the block shall be kept wet to prevent drying of mortar. At the end of days work, provision shall be made to keep the surface of block work wet with water. Block work shall be added uniformly throughout so that no portion of the work shall be left more than 900 mm lower than other. Verticality of walls and horizontality of the courses shall be checked very often with plumb bob and spirit level respectively.

g) Block work shall be laid out and arranged such that a minimum of cutting and shaping is required. Where necessary to trim block work units, they shall be cut, trimmed or broken at kerbs, or where required to a neat true line without chips on exposed faces.

h) Block work one and half blocks thick or more shall have both faces in true plane. Block work of lesser thickness shall have one selected face, in true plane.

i) Bond used shall be English bond and shall be carried throughout the work. At all corners alternate courses of brickwork shall be laid header and stretcher-wise as seen in the face so as to secure good bonds. The arrangement of bonds at quoins shall be symmetrical.

j) Blocks shall be laid in joints not exceeding 10 mm in thickness and this thickness shall be uniform throughout. Joints shall be struck flush with the face at the time of laying.

k) All joints on face shall be raked to minimum 10 mm depth while the mortar is still green to provide bond for plaster or pointing.

l) The rate of laying masonry may be up to a height of 1000 mm per day or as approved by the Engineer.

19.2.5 ENCASING OF STRUCTURAL MEMBERS

Where drawings show that structural steel columns and spandrel beams are to be partly or wholly covered with block work, the blocks shall be built tightly against all flanges and webs with all spaces between the steel and the block work filled solid with setting mortar and this mortar shall not be less than 12 mm thick.

19.2.6 REINFORCEMENT AND ANCHORAGE

a) For the walls, anchors in the form of M.S. flats or rods from columns and/or beams and embedment and any other anchoring and reinforcements, shown on drawings, shall be adequately embedded in the block work.

b) For reinforced blockwork, the reinforcements shall be as specified in the schedule of quantities. All reinforcements shall be thoroughly cleaned and fully embedded in the mortar. The thickness of the joints in blockwork containing steel bars shall be increased so as to have a minimum mortar cover of 6 mm around the bar interposed between the block and the reinforcement. Overlap in the reinforcement, if any, shall not be less than 50 times the diameter of the bar. The reinforcements shall be lapped with dowels left in R.C. columns or welded to steel stanchions. Where reinforced concrete bands are provided in the block walls, such bands shall be to the full width of the wall and the concrete of grade not lesser than M-25 shall be used. Such band will be measured separately under respective items of concrete in the Schedule of Quantities.

c) All half-block partition walls shall have M.S. reinforcing bars at every fourth course of the block work and they shall be securely anchored at their ends where the partitions bond.

d) All sash and door frames, louvers and other connections requiring weather proofing, shall be built in and the outside frames shall be cleaned out to uniform 20 mm depth and filled solidly with an approved elastic caulking compound applied with a caulking gun.

e) Scaffolding will generally be double but may be single if warranted for the particular work as approved by the Engineer. Scaffolding shall generally be erected with steel pipes. The Contractor shall take all measures to ensure safety of work and the working people.

f) Contractor shall be entirely responsible for any damage to property or injury to persons resulting from defective scaffolding, ladders and materials or otherwise arising out of default in this respect. Proper scaffolding shall be provided to allow, easy approach to every part of the work. Overhead work shall not be allowed.

19.2.7 CURING

All block work shall be kept constantly wet for at least 7 days from the date of laying of block work.

19.2.8 CLEANING

Upon completion of the masonry installation, all exposed block shall be cleaned of all mortar and cement grout incrustations and concrete stains. Protruding mortar joints shall be chipped off. As the cleaning progresses, all masonry work shall be examined

and all imperfect jointing, nail holes, cracks, etc. shall be carefully pointed up and filled with mortar where required and the horizontal rakings left tooled and clean.

19.3 PLASTERING

19.3.1 WATER AND CEMENT

Water and Portland cement shall be as specified for masonry work.

19.3.2 SAND

Sand shall consist of natural sand, crushed stone sand or crushed gravel sand, from an approved source. The sand shall be hard, durable, clean and free from adherent coatings and organic matter, and shall not contain any appreciable amount of clay balls or pellets. The sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal, mica, shale or similar laminated or other in such form or in such quantities as to affect adversely the hardening, the strength, the durability, or the appearance of the plaster or applied decoration, or to cause corrosion of any metal in contact with the plaster. Total of all deleterious substances shall not exceed 5% by weight. The sand shall be properly graded and of medium size with a fineness modulus of 2.0 to 2.2.

19.3.3 STORAGE OF MATERIALS

Cement and sand shall be stored as specified in specification for 'Plain and Reinforced Concrete'

19.3.4 MIX

The Mortar for plastering shall be mixed in suitable mechanical mixer in the proportion as indicated in the schedule of quantities. Water proofing compound conforming to IS: 2645 of approved manufacturer shall be added to the mortar mix for external plastering and finishes in the proportion as specified in the specification or in accordance with the manufacturer's instructions. Cement and sand shall be mixed in a dry state and then wetted and mixed thoroughly to obtain the required consistency, including machine mixing if desired by the Engineer. The mortar shall be consumed within half an hour of mixing. Any mortar for plaster, which is partially set, shall be rejected and removed from the site. Machine mixed mortar shall be prepared in an approved mixer as approved by Engineer-in-charge. Mixing for 1-1/2 to 2 minutes is normally sufficient. Only cement sand mortar shall be used in the plastering works. Cement mortar for plastering shall have a mix in the proportion of 1 part of cement and 3 parts of sand by volume unless otherwise specified in the schedule of quantities.

19.3.5 PREPARATION OF SURFACE

All joints in the masonry shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Surface on which plastering is to be applied shall be clean and free from all dust, loose materials, grease etc. and be well wetted for at least 6 hours before plastering. Brick/ block work shall be brushed down with a steel wire brush to remove all loose dust from the joints and thoroughly washed with water. All laitance shall be removed by chipping and roughening from concrete surfaces, which are to be plastered.

19.3.6 APPLICATION OF PLASTER

In all plaster work, mortar shall be applied with somewhat more than the required thickness and well pressed into the joint and on the surface and rubbed and levelled with a flat wooden rule to give required thickness. Plaster, when more than 15 mm thick, shall be applied in two coats, a base coat followed by the finishing coat. Thickness of the base coat shall be just sufficient to fill up all unevenness in the surface. No single coat, however, shall exceed 12 mm in thickness except in foundation / plinth work. The lower coat shall be thicker than the upper coat. The overall thickness of the coats shall not be less than the minimum thickness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat of plaster. The under-coat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be “thrown on” rather than “applied by trowel”.

To ensure even thickness and true surface, patches of plaster about 100 mm to 150mm square or wooden screed 15 mm wide and of the thickness of the plaster shall be fixed vertically about 2000 mm to 3000 mm apart, to act as gauges. The finished wall surface shall be true to plumb, and the contractor shall, without any extra cost to NPC, make up any irregularity in the brickwork with plaster. All vertical edges of brick, pillars, door jamb etc. shall be chamfered or rounded off at no extra cost to NPCIL as directed by the Engineer. After the plastering work is completed all debris shall be removed and the area left clean. All corners must be finished to their true angles or rounded. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

19.3.7 CURING

All plastered surfaces after laying shall be cured for a minimum period of seven days, by an approved method, and shall be protected from excessive heat and sunlight by suitable approved means. Moistening shall be commenced as soon as the plaster has hardened sufficiently and is not susceptible to damage. Each individual coat of plaster shall be kept damp continuously, for at least two days, and then dried thoroughly, before applying the next coat.

19.3.8 FINISH

In any continuous face of a wall, finishing treatment of any type should be carried out continuously and day break made to coincide with architectural break in order to avoid unsightly patches at junctions.

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

19.3.8.1 STANDARD FINISH

Where punning is not indicated, the interior plaster shall be finished rough, otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

19.3.8.2 NEAT CEMENT FINISH

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg per sq.m and rubbed smooth with a trowel.

19.4 RUBBLE SOLING FOR FLOORS ON GRADE

The rubble shall be of approved quality. Thickness of soling shall be as shown on the drawings/schedule of quantities. The rubble soling shall be carefully hand packed as close as possible and bedded firmly with their largest side placed vertical, the broader faces downward, the smaller surface at top and voids and interstices filled in solidly by wedging with hard chips and small stones but of largest size possible to fit interstices finished with cement sand mortar 1:10 min. and thickness as indicated on drawing.

No stone shall be less than 80 mm in thickness or less than 2.8 kg in weight or more than the depth of soling in thickness and not to exceed in length or breadth twice its thickness.

When a sufficient length of soling has been laid, this shall be compacted with a three wheeler power roller and the surface shall be evened by blinding uniformly with sand not exceeding 10% silt during rolling. Places inaccessible to the roller may be compacted by hand with log hammer or mechanical tampers or by hand rollers subject to the approval of the Engineer.

19.5 EXPANSION JOINT FILLER

Standard heavy density expanded polystyrene of minimum density 35 kg/cu.m and conforming to IS:4671 shall be supplied in sizes and used in accordance with drawings. The thickness of the material shall be as indicated on drawing. Adhesive if any required to fix expansion joint filler to all forms of structure shall be supplied by

the Contractor. A sample of material shall be approved by the Engineer before it is used on site. Installation shall be carried out as directed by the Engineer. The polythene sheet used for wrapping shall be minimum 250 micron thick and shall be got approved by the Engineer.

19.6 EXPANSION JOINT SEALING

Expansion joint shall be provided with PVC water stop / hot dip galvanised strips with class 2 zinc coating of width and thickness as stated in the schedule of quantities/ as shown on drawings or as approved by the Engineer. The strips shall be bent to shape indicated on the drawings and connected properly to the structure. Expansion joints shall be continuous and where two or more strips meet they shall be lapped 75 mm and brazed or welded as the case may be. Welding shall be carried out by qualified welders and shall be subject to non-destructive testing as directed by the Engineer. For the purpose of measurement, the laps provided shall be neglected.

19.6.1 G.I WATERSTOPS

The work to be done under this specification comprises the supply and delivery of Galvanized Iron water stops and accessories for the Main Plant Civil Works, all in accordance with the requirements of this specification. The Intent of this specification is to provide water stops completely in accordance with this specification ready for installation. Installation of material will be done by the contractor.

APPLICABLE CODES

IS: 277: 2003 Specification for Galvanized Steel Sheets (Plain and Corrugated)

DESCRIPTION

The GI Water stops shall be of 3.15 mm thick fabricated in accordance with IS: 277 (latest edition) and galvanized for dry film thickness of 60-100 micron

19.7 BITUMASTIC JOINT SEALING COMPOUND

Bitumastic joint sealing compound conforming to Grade A (normal) of IS: 1834 (latest Edition) shall be supplied and used in accordance with drawings. The size of groove to be sealed shall be in accordance with drawings/schedule of quantities. A sample of material shall be approved by the Engineer before its use on site. Work shall be carried out as per manufacturer’s instructions or/and as directed by the Engineer.

19.8 BITUMASTIC PAINT FOR ISOLATION JOINTS

Bitumastic Paint Conforming to IS: 9862 shall be supplied and applied by the Contractor. Two coats of paint shall be applied over surfaces to form isolation joints.

Painting shall be performed in accordance with the manufacturer's instructions or /and as directed by the Engineer. A sample of material shall be approved by the Engineer before it is used on site.

19.9 NEOPRENE & COPPER SHEET

Neoprene & copper sheet shall conform to the following specifications and a sample of material shall be approved by the Engineer.

19.9.1 NEOPRENE PAD

The pads shall be 100 percent Chloroprene compound known as "Neoprene" and shall be cast in moulds under pressure and heat. Compositions for pads shall meet the requirements listed below.

The pads shall meet the following physical test requirements:

PROPERTY	**REQUIREMENT**	**ASTM TEST METHOD**
Durometer (Type A), Hardness	60±5	D 2240
Ultimate Tensile PSI Min.	2500	D 412
Ultimate elongation at Break Min. %	350	D 412
HEAT RESISTANCE: 70 HRS. @ 212° F in AIR Change in Durometer Hardness , %Max Change in Tensile, %Max. Change in Elongation, % Max.	 +15 -15 -40	D 573
COMPRESSION SET 22 HRS. @ 212° F,% Max	35	D 395 Method B
Compression set induced in vulcanized Rubber During Exposure to high energy Nuclear Radiation, % Max.	25	ASTM D-2309
OZONE RESISTANCE 100 pphm ozone in air by volume, 20 % strain 100 ± 2 ° F, 100 hrs, mounting procedure ASTM D 518 Procedure A	No Cracks	D 1149
TEAR RESISTANCE, (kgf/cm), Min.	45	D 624
LOW TEMPERATURE TEST Brittleness at - 40° F	Pass	D 746 Procedure B

Neoprene sheet shall be placed and cut suitably to shapes and sizes as mentioned in the drawings. Brazing shall be carried out as per manufacturer's specifications and by qualified persons, subject to testing as directed by Engineer.

19.9.2 COPPER SHEET

Copper strips of material type-"O" (annealed) conforming to IS: 14811 shall be used.

19.10 POLYETHYLENE SHEET

Polyethylene sheets 250 micron thick conforming to the IS 2508 shall be supplied and used to form separation joints. A sample material shall be approved by Engineer before its use at site.

19.11 SLIDING COVER STRIP

At the expansion joints, members like columns and beams have been duplicated on either side of the separation and provided with embedded parts for installing the sliding type cover strip to accommodate any building block movement. The cover strip shall be provided both at vertical and horizontal points in accordance with details shown on drawings. The strip element shall be of mild steel, plain or chequered as indicated, and of size and thickness shown on drawings and schedule of quantities and rates. The fixed edge shall be suitably attached to the embedded bearing plate, as provided, by plug weld or tap screw as shown or as instructed by the Engineer. At the sliding edge, the sliding surfaces of the embedded plate provided and underside of the cover strip shall be machined smooth. Adequate care shall be taken not to cause any damage to the strip.

19.12 Aluminium Door, Windows and Partitions

The type and construction of Aluminium Doors shall be similar to steel doors.

These (doors, windows and partitions) shall be of sections extruded from aluminium alloy conforming to IS: 733 . Door skin plates and stiffeners shall have a minimum 3 mm thickness. All sections shall be manufactured by Indian Aluminium Co. Ltd., All doors shall be insulated with spun mineral wool insulation for sound deadening. Doors, frames, mullions, transoms and all other exposed aluminum sections shall be alumilited, 0.015mm thickness, satin finished in natural aluminium colour. A protective transparent coating shall be applied to the sections before shipment from the factory.

Aluminium frame work for glazed partitions with aluminium glazed access doors shall be as shown in drawings, excluding supply of glass and glazing. All sections shall have a minimum 3 mm thickness and alumilited as specified above.

Aluminium door shutters, windows and partitions shall have mechanical joints with necessary fasteners.

Portions of aluminium frames which come in contact with masonry construction shall, before shipment from the factory, be protected with a heavy coat of alkali resistant, bituminous paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer.

All work shall be fitted and shop assembled to a first class job and ready for erection. Shop joints shall be made to hairlines. Work on the above, other than described, shall be carefully fitted and assembled with name joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. All drilling of structural supports to install aluminium doors and frames shall be done and included in the work. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

All work shall be erected in plumb and true to line and ready for building into masonry or other types of wall construction. Doors and frames, not properly installed or being out of line or distorted shall be reset and corrected by the contractor at his expense.

Hardware and fixtures shall be as specified under "Door/Window Schedule". All hardware shall be heavy duty and the door closers of extra heavy duty type. All exposed metal shall be satin finished aluminium. All locks shall be cylinder type. All hardware shall be approved by the Engineer before installation.

19.12.1 **Fabrication Drawings**

Before starting fabrication of all metal doors windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. Only after approval of drawings, the fabrication shall be started.

19.12.2 **Workmanship**

Workmanship shall be of best quality, free from any flaws and defects. Samples of each type shall be submitted and approval of the Engineer taken by the Contractor, before starting bulk manufacture.

19.12.3 **Transporting**

All metal doors, windows, etc., shall be packed and crated properly before dispatch, to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in undamaged condition.

19.12.4 **Sliding Door (Supply and Installation)**

19.12.4.1 Scope

This specification covers the design, supply of materials, fabrication, delivery and

erection of MS sliding doors including all accessories as herein after specified.

19.12.4.2 General Description and Construction Details

The M.S. sliding doors shall be best quality adhering to the dimensions and details shown on drawings and schedule and as directed by the Engineer.

The sliding shutter shall be made of MS sheet steel panel of 16 gauge with siffeners made of 14 gauge MS, bent sheets of sizes & shapes as shown in the drawing.

The Heavy duty CI bracket shall be fixed to the lintel by means of coach screws of proper strength but of size not less 6mm diameter with length and spacing as given in the drawing.

The Standard Track/roller guide at top shall be supported on CI bracket at spacing not more than 1500 mm. The guide shall consist of Heavy duty 4 roller trolley fixed to the shutter by standard nut and bolt assembly of diameter not less than 5 mm.

The bottom guide shall made of MS section & it shall be fixed in the floors. This guide shall have 12 mm dia MS anchors of shape and spacing as shown in the drawing welded to it. 4 nos ball bearings16 dia ,with 16 dia stainless steel pin shall be fitted at bottom of each sliding leaf of the door.

The sliding shutter shall be provided with recessed handles and lock of approved make lockable on both sides. Each sliding leaf shall also have tower bolt.

The entire assembly of door shall be such as to have smooth & easy operations by a single person.

19.12.4.3 Erection

The doors shall be erected complete with all necessary hardware, operating mechanisms, equipment, wiring etc. complete, to suit sizes of openings. Upon completion, doors shall be in best operating condition. All installation and erection work, shall be done in accordance with the manufacturer's specifications. The Contractor shall arrange to have at no extra cost to NPCIL, the services of the manufacturer's Supervisor during erection. Any drilling to or cutting of concrete, masonry etc. shall be made good after erection of shutters.

19.12.4.4 Paint and Finish

Shutters shall be painted with one coat of red lead or zinc chromate primer in shop. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat. The doors shall be given final coats as given in the schedule and/or as directed by the Engineer.

19.13 STEEL DOORS AND WINDOWS

19.13.1 DOUBLE PLATE FLUSH DOORS

a) Double plate flush doors shall conform to IS: 4351 and shall be made from best quality 18 G galvanised mild steel sheets and shall be of hollow metal construction 45mm thick. Door frames shall be from the best quality 16 G pressed steel sheets. All doors shall be insulated with spun mineral wool / polyurethane foam insulation for sound deadening. All hollow metal doors shall be flush type as shown on drawings and spot welded to reinforcing members both vertically and horizontally. Reinforcing members shall be from steel sections spaced not over 150mm apart and shall extend for the full height of doors. The members shall be strictly as shown on drawing and/or as instructed by the Engineer. The doors to be provided shall be as per the drawings and shall be as per the approval of the Engineer. Generally, the doors frames shall be 45mm x 45mm x 6mm MS angle sections, shutters made of 43mm rolled steel channel section framework with stiffeners of 40mm x 40mm x 3mm M.S. angle section spaced approximately 45cms c/c, skin plate of one face of the shutter welded to the frame and stiffeners and the other face fixed with machine screws after inserting insulation material, all other details remaining as per the drawings and specifications. The mounting of the door shutters shall ensure leak tightness.

b) Built in louvers shall be stationary inverted 'V' blades and fabricated from 20 G cold rolled carbon steel sheets conforming to IS: 513. They shall be of sizes indicated in "Door Schedule" and completely installed in doors. Doors with vision panels shall have the openings formed into the face sheets so that no glass frame is required.

c) All bolts, counter-sunk screws, adjustable, fixing lugs, sleeves, chips etc. shall be provided for proper anchorage and support.

d) Doors and frames shall be fitted and reinforced for all hardware from templates.

e) Wherever required, provisions shall be made for fixing louvers (made of 16 G steel sheets) and/or 6 mm thick sheet glass, as shown on drawings. Glazing beads where required shall be from 20 G steel and shall be removable.

f)The steel doors shall be provided with 6 mm thick clear sheet glass vision panel of 240 mm x 340mm in each leaf.

g) The finished work shall be up to the satisfaction of the Engineer.

19.13.2 DOOR THRESHOLD

Wherever required, thresholds shall be provided as shown on drawings or schedule. Doors without threshold shall have bottom tie of approved type. Finished overall dimensions for doors shall conform exactly as shown on drawings.

19.13.3 STEEL WINDOWS, SASHES, VENTILATORS ETC.

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions and as shown in the on drawings. The details as called for in the above specifications shall

be applicable for coupling mullions, transom, weather bars, pivot arrangement for ventilators, fixtures and fastening etc.

All Finished overall dimensions shall conform to exactly as shown in the drawings. Individual members shall be of adequate strength and sections as per relevant IS codes and as shown in the drawings. All welds shall be dressed flush on all exposed and contract surfaces.

Where composite unit openings are shown in the drawings, the individual window units shall be joined together with requisite transoms and mullions and/or as shown in drawings. All projected out window shall be outside glazed, fixed with putty or metal glazing beads as shown on the drawings and/or specified under Schedule of Items. Where aluminium glazing beads are specified they shall be extruded aluminium channel 17/32" X 7/16" X 3/32" unless otherwise shown on drawings.

19.13.4 FITTINGS FIXTURES AND HARDWARE

Hardware and fixtures shall be as specified in "Door Schedule" and of best quality from the manufacturer as approved by NPCIL.

The Hardware and fixtures shall be of heavy-duty type and the door closers of extra heavy-duty type. Finish shall be dull bronze finish and/or anodised aluminium as specified in "Schedule of Items", except butts for interior and door closers. Interior butts shall be prime coat finish and door closers sprayed bronze.
The Contractor shall submit samples of each type of hardware and fixture to the Engineer for approval. The approved samples shall remain with the Engineer for comparing with the actual supply and only those conforming to the approved samples shall be accepted.

The Door closers shall be from approved manufacturer with ISI certification and manufactured and installed as per relevant IS Codes and good Engineering practices.

19.13.5 SHOP PAINT

The shop paint shall be best zinc phosphate primer of approved manufacturer. Before assembly, all surfaces shall be given a coat of rust resisting paint. After assembly, all exposed surfaces shall be cleaned and smoothened and two coats of approved make enamel paint shall be uniformly applied over the surface.

19.13.6 INSTALLATION

In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081 latest edition, and as shown in the drawings and 'DOOR SCHEDULE'. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvres etc. including transom and mullions for composite units in respective places as shown in then drawings. Keeping proper lines and levels, and in approved workman like manner. The installation shall be done according to the instructions of the manufacturer, and/or as approved by the Engineer. Care shall be taken to see that

framework is not loaded with the weight of masonry or used for securing scaffolding or other temporary staging. Temporary struts may be fixed across the widths preventing sides bulging inwards, which should not be removed till brickwork is set. Care shall be taken to protect the hinges from getting embedded in the mortar while filling the gap between the frame and the masonry opening. If necessary, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take every precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor without any extra charges and finished as per original, after installation.

After installation of steel doors, windows etc. all abrasions to shop coat of paint shall be retouched and made good with the same quality of paint used in shop coat. Rates quoted shall also include minor rectification at site if required such as welding of fixtures, making screw holes and providing screw and rectification of dents formed in the doors and shutters.

19.14 FIRE PROOF DOORS

19.14.1 SCOPE

The work under this section shall include supply and/or erecting and installing fireproof doors as shown in approved manufacturer's drawing with all material complete.

The scope of work shall also include assembly and erection of composite types of fireproof doors. Supplying and/or fixing of all door accessories and hardware and are also included in the scope.

The fire doors shall be single / double leaf fire rated hollow galvanized MS pressed steel flush doors conforming to BIS : 3614 (Part-1), along with frame at all elevations, with or without removable panels and with or without panic bar having fire rating as approved. The Fire doors shall be of galvanised MS sheets for frames and leaves, mineral wool / PUF/ any other fire retardant insulation material, mastic caulking and grouting the frame, reinforcing and insulating the shutters with fire retardant material including heavy duty SS hinges, thresholds, fittings complete with frame, fittings, fixtures, handles, aldrops, latches, necessary access control hardware, necessary gaskets, drop seal, smoke seal, etc for air tightness. The vision panel shall be of borosilicate float glass or approved equivalent of size 240 mm x 340 mm or as specified in drawing with same fire rating including necessary beading, mastic cement, cleaning and also all hardware as per door schedule including one coat of approved primer and two coats of approved fire resistant / intumescent paint as necessary as per drawings, door schedules and specifications.

All the doors shall have provisions for installation of access control devices such that these devices if installed at a later date shall not impair the basic functions of the door as a fire barrier. These provisions shall be in the form of providing a separate steel plate of approved dimensions of the same material as the parent door, fixed to the

main door at an approved location.

The fire rating of the door shall be clearly embossed on the doors.

The testing of Fire proof doors shall be carried out as per BIS:3614 Part-II standards for approved fire rating, for full size door with vision panel and all fittings and fixtures shall be conducted at approved laboratory for 3 nos. of doors. One door shall be tested from the first lot before shipment to site and remaining at random from balance supply.

19.14.2 DRAWING

Fire proof doors shall be as manufactured by manufacturer qualified by NPCIL. Before starting fabrication of all fire proof doors the contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

19.14.3 APPLICABLE CODES

Following are some of the important I.S.Codes as relevant to this section:

I.S: 3614 - Fire doors
I.S: 1038 Steel door, windows and ventilators
I.S: 4351 - Steel door frames
I.S: 1081 - Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.

19.15 ROLLING STEEL SHUTTERS

19.15.1 SCOPE

This specification covers the design, supply of materials, fabrication, delivery and erection of rolling shutters with motor drives and/or manual operation including all accessories as herein after specified.

19.15.2 GENERAL DESCRIPTION OF CONSTRUCTION DETAILS

The doors shall be of best quality rolling steel service doors adhering to the dimensions and details shown on drawings and schedule.

a) Slats for shutter shall be made from tested bright cold rolled, annealed M.S. Strips, not less than 18 gauge thickness, machined, rolled at 75 mm rolling centres, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.

b) Rolling grills shall be constructed out of 6 mm dia. rods at 35 mm centres running horizontally flexible connected with vertical links spaced not more than 200mm

centres. Alternatively, rolling grills shall be made from perforated slates of approved design reinforced with 6mm dia. rods.

c) End locks shall be heavy type and provided at each end of alternate slats unless specified otherwise in the schedule.

d) Bottom bars shall be finished with two angles not less than 6mm thick for external shutters. When shown on drawings a flexible weather strip shall be applied to make tight contact with the floor.

e) Steel guides shall be of angle frames secured to the metal frames or masonry at openings. Guides shall be of such depth as to retain the shutter under a wind pressure of 150 kg/sq.m. or as specified in IS: 875 for the double rolling steel shutters a central guide which is movable by sliding by mechanical arrangement shall be provided. Material for guide channels shall conform to IS: 513 latest editions.

f) Shafts shall be of steel pipe of sufficient size to carry the torsional load with a maximum deflection of $1/360^{th}$ of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.

g) Hoods shall be formed of not less than 20 gauge steel, suitably reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision to securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as described in Schedule or as desired by the Engineer.

i) Power unit shall be suitable for 3 phases, 50 cycles 400 Volt AC power supply and shall be higher floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metres per minute. The electric motor shall be 3-phase 415V AC, 50Hz. TEFC enclosure complying with NPCIL specifications PB-E-293. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built – in overload protection, a geared limit switch and one push button station located inside the building unless otherwise stated in schedule of drawing. It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge electrically connected to stop the travel of the door on meeting an obstruction.

j) Operating chains shall be of tested quality, heavily galvanised and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength grave cast iron; machine moulded from machine cut patterns.

l) Bracket plate thickness shall be minimum 3.15mm.

19.15.3 OPERATION

19.15.3.1 MANUALLY/ MECHANICALLY OPERATED SHUTTERS

Manually operated shutters shall be easily operable by one person. In general, manually operated shutters shall be push pull type for openings up to 9 sq. m. in area. Larger shutters shall be either chain or gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as described in Schedule or as desired by the Engineer.

19.15.3.2 POWER OPERATED SHUTTERS

These shall be operable from a push button station conveniently located beside the door or as shown in the drawings. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for in schedule, externally mounted shutters shall be operated by control mechanism located inside the building. Limit switch shall also be included. The power drive shall be so designed that electric motors may be removed without affecting operation by means of an auxiliary endless chain gear operator.

Motor driven shutters shall have the following compulsory operation system. Mechanism shall be galvanised and of tested quality and shall be guaranteed to prevent chain from leaving wheel and of sufficient length to terminate approximately 600 mm above floor. Reduction gear shall be extra strong, cast without teeth for machine-finished pattern. Necessary lubrication shall be provided.

19.15.4 ERECTION

The shutters shall be erected complete with all necessary hardware, operating mechanisms; equipment, wiring etc. complete, to suit sizes of openings. Upon completion, shutters shall be in best operating condition. All installation and erection work, shall be done in accordance with the manufacturer's specifications. The Contractor shall arrange to have at no extra cost to the owner, the services of the manufacturer's Supervisor during erection. Any drillingor cutting of concrete, masonry etc. shall be made good after erection of shutters.

19.15.5 PAINT AND FINISH

Shutters shall be painted with one coat of zinc phosphate primer and two coats of approved synthetic enamel paint unless specified otherwise.

19.15.6 ELECTRICAL WORK

All electrical work shall be in strict accordance with the latest Indian Electricity Rules or other approved codes as specified by the Engineer**.**

19.15.7 SHOP INSPECTION AND TEST AT MANUFACTURER'S WORK

After completion of the manufacture of different components of the rolling shutter,

drive and other components/ accessories of the rolling shutter, arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

If desired by the Engineer tests shall be carried out at the manufacturer's works in accordance with the approved standards in the presence of the Engineer. Four copies of all the test certificates shall be submitted for approval, if required by the Engineer.

19.15.8 ACCEPTANCE TEST AT SITE

After the equipment has been installed at site the contractor shall carry out performance tests to the satisfaction of the Engineer, after which the shutters shall be accepted. The doors shall be smoothly operable under all ambient conditions. All controls and locking devices shall have fault free performance.

19.15.9 DRAWINGS

The manufacturer / supplier of the rolling shutters shall be got approved by NPCIL before carrying out the work. Prior to fabrication of rolling shutters, the contractor has to measure exact size of the structural opening at site. Fabricated door shall suit to the actual structural opening at site. The Contractor then shall prepare necessary drawings/ detailing of the rolling shutters as per specification, which they intend to supply and seek prior approval of the Engineer. The contract drawings to be furnished by the Contractor shall include but not be limited to the following:

a) Foundation and anchorage drawings for the equipment and drive and their auxiliaries with similar detailed drawings for other equipment.

b) Dimensioned assembly and sub-assembly drawings showing plans and sections of the equipment, instruments and safety devices etc. clearly indicating limiting dimensions, if any.

c) Complete assembly drawings wiring and connection diagram for all instruments, gauges and controls.

19.15.10 GUARANTEE

The design of the rolling shutter shall be made for withstanding a wind pressure of 150 kg/m2. The Contractor shall give one year's guarantee against operational and material defects and for safety against the design wind pressure.

19.15.11 APPLICABLE CODE

IS: 6248 - Metal rolling shutters and rolling grills.

19.16 CHAIN LINK FENCING AND DOOR

19.16.1 SCOPE

This specification covers the fabrication and installation of wire-link fencing and doors with necessary hardware.

19.16.2 GENERAL

The Fencing shall be constructed of M.S. pipe/ angle frame with welded wire-mesh cladding.

The chain-link doors shall have either single or double shutters of sizes as indicated in the 'Door Schedule'.

The door shutters shall be constructed of M.S. angle frame with welded wire-mesh cladding. The door frame shall be made of M.S. angles built in the wire link partition or in the brick masonry.

19.16.3 SHUTTER FRAME

The frame for door shutter shall consist of two vertical and three horizontal members securely welded together. The shutter frame shall have pivoted arrangement for swing.

19.16.4 WIRE LINK

Welded wire mesh of 50mm x 50 mm with mesh made of 3mm diameter from standard manufacturer shall be used. The mesh shall be made from high tensile wires welded at every intersection. The welded wire mesh shall be positioned inside the angles of the framework. The wire mesh shall be properly stretched and welded to the angle frame.

19.16.5 DOOR FRAME

The door frame shall be made of 80 NB GI Pipe and M.S. angles with necessary provisions to revive hardware. The finished work shall be strong and rigid, neat in appearance and free from defects. Doors shall not have more than 6 mm clearance at jambs & head and not more than 3 mm clearance at the meeting stile edges for pair door.

19.16.6 INSTALLATION

Door frames and shutters shall be assembled and installed such that frames and doors are set plumb, square, level, and at their proper location. All necessary hardware including hasp and staple for locking, pull handle, etc. shall be furnished. The frame

shall be securely anchored with hold fasts at brick masonry openings.

19.16.7 CLEANING AND PAINTING

All welds shall be dressed flush on all exposed and contact surfaces. Steel frame members, wire-mesh and welds shall be cleaned of all rust, scale, grease and other foreign matter and then given a prime coat of zinc phosphate primer.

The finished work shall be to the satisfaction of the Engineer-in-charge.

19.17 FLOORING, SKIRTING AND DADO

19.17.1 SCOPE

This specification shall include furnishing of all labour, materials, and equipment, necessary to complete the different types of flooring work as shown in the drawings. Work under this section shall include:

i) Indian Patent Stone Floor (IPS)
ii) Concrete floor with metallic hardener
iii) Tiled floor (with underbed)
iv) Glazed tiled flooring and dado
v) Vacuum dewatering floors with ironite finish
vi) Cement Skirting and dado In-situ
vii) Precast tile skirting
viii) Ceramic tile flooring and dado
ix) PVC tile floor
x) Acid and/or alkali resistant floor
xi) Kota stone flooring and skirting
xii) Vitrified polished tile flooring and skirting
xiii) Granite flooring and dado/ cladding
xiv) PVC Electro static conductive flooring
xv) Precast cement concrete interlocking paver blocks

Any integral finish to the base concrete indicated in drawing or schedule like finishes F1, F2 & F3 for formed surfaces and finishes U1, U2 & U3 for unformed surfaces shall be deemed to have been provided in the structural slab.

19.17.2 PREPARATION OF BASE

For all type of flooring, skirting and dado work, the base cement concrete slab or the masonry surface shall be cleaned of all dirt with water and hard brush. If required the base surface shall be hacked or otherwise roughened to obtain a good bond. The surface shall be clean, free from grease, oil, dust, loose particles, etc. and thoroughly soaked with water to prevent absorption of mixing water from the base course. Before placing the under bed, and excess standing water shall be mopped out. Before laying the flooring, skirting or wall finish, approval of the Engineer shall be obtained

as to the acceptability of the base.

19.17.3 INDIAN PATENT STONE (IPS)

a) Preparation of base shall be as specified above. The patent stone floor unless otherwise stated shall have a minimum thickness of 40mm. The under-bed shall consist of cement concrete with 10mm down, clean, well-graded, hard approved stone chips and clean, sharp, coarse sand. Elongated or thin flake like fragments of stone shall be avoided. The proportion of the mix shall be 1 part cement, 1parts sand and 2 parts stone chips by volume.

b) Water content shall be minimum, sufficient to give a workable consistency, which will allow finishing without excessive trowelling. Generally water cement ratio of 0.4 should suffice. The floor shall be cast in panels not exceeding 5 sq.m. in area and no side more than 2.5m long. Panels shall be made using aluminium strips. The casting sequence shall be in a chequered board fashion, no two adjacent panels being cast before the contraction of the previous one has taken place. The edge of each panel into which the floor is divided shall be supported by flat bars of steel or wood duly oiled to prevent sticking. The bars shall be removed before filling in adjoining panels. At least 48 hours shall elapse before the concreting in the adjacent bay is commenced. After laying, the under bed shall be levelled, compacted and brought to proper grade with a screed or float.

c) Then a layer of minimum 6mm thickness shall be laid over the green under bed and trowelled smooth with a mixture of cement and sand (1:1 by volume). The under bed and topping shall be completed in one operation.

d) The topping shall be trowelled smooth to the satisfaction of the Engineer. Any marks of trowel shall be mopped with a soft cloth to give a clean, even and smooth surface.

e) Where specified on drawings the thickness of the under bed shall be adjusted to make the total thickness as shown in the drawings.

f) When polishing is to be done, if specified in the drawings and/or “Schedule of Quantities” it shall be done in a manner as approved by the ENGINEER.

19.17.4 CONCRETE FLOORING WITH METALLIC HARDENER

19.17.4.1 GENERAL

The specified hardening system shall be applied by a specialist applicator certified by the manufacturer of the system strictly as per the written method statement submitted by the manufacturer.

a) THICKNESS

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth over 28 mm thick concrete base. Total thickness shall be 40 mm thick.

b) MATERIAL

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand, soluble alkaline compounds or other injurious materials. Actual samples shall be tested prior to use at site.

c) MIX

Proportion of metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction, 1 part metallic hardener shall be mixed dry with 4 parts of cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to two parts of stone chips by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

d) LAYING

The concrete floor shall be laid as per the specification of Concrete work and levelled up to the required grade. The forms, if any, shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible.

12 mm thick finish shall be laid while the concrete under bed 28 mm thick is still very green within 3 hours of laying the latter. The finish shall be of uniform thickness and free from trowel marks, pin hole, etc. The topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. The surface shall be smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

19.17.4.2 **SUBSTRATE CONDITION**

The grade of concrete for substrate should be preferably M20. At the time of construction of floor, as soon as the plasticity of the mix is reached, the surface of the freshly poured concrete shall be smoothened out and shall be flattened out with the vibrating straight edge. This concrete should be dense and compact which could be obtained by adding plasticizers like Plastiment BV 40 or equivalent (0.3% by weight of cement or it may vary due to site condition). It is preferable to use a mechanical trowel for smoothening operation.

19.17.4.3 **LAYING**

The ready mix non-metallic hardener compound shall be spread over the newly laid smooth concrete surface at a stage when a nail mark of 3-4mm shall be obtained at standard pressure. The spreading shall be done by hand or with a suitable apparatus @ approximately 6.0 kg/m² for a thickness of 3 mm surfacing.

Time should be given till the mixture has been uniformly moistened by the surface water contained in the green concrete. The surface shall be smoothened out with a mechanical trowel which shall be maintained perfectly flat, operating at a low speed.

Immediately, after the flooring surface is finished, it shall be protected from rapid drying. As soon as the floor is hardened sufficiently, it shall be kept moist for at least 3 days by wet gunny bags.

19.17.5 VACUUM DEWATERING SYSTEM OF FLOORING WITH IRONITE FINISH

19.17.5.1 GENERAL

a) Thickness, material and mix shall be as per specification on "concrete flooring with metallic hardener" included earlier in this chapter.
b) Grading of constituents of concrete and slump shall be as per manufacturer's recommendation.

19.17.5.2 JOINTS

The concreting shall be done in bays as recommended by the manufacturer. In absence of which bays of 20 M x 20 M shall be followed. Aluminum strips shall be provided for separation of panels.

19.17.5.3 LAYING AND WORKMANSHIP

All arrangements including installation of guide rail, positioning of pipes for water and drainage, shall be placed either by pump or manually. Poker vibration and tremix surface vibrators are used sequentially to obtain proper leveling and compaction. Suction mat shall be used with proper arrangement of suction holes to vacuum pump, draining line, etc. so as to achieve recommended pressure by the manufacturer on the concrete surface. Proper care shall be taken to drain out excess water from concrete. Normally concrete shall be subjected to suction for a period of 1 to 2 min per centimeter thickness depending on the particle shape of the mix. Immediately after vacuum dewatering the surface is power floated with skim floater. To obtain smooth surface skim floater fitted with troweling blades shall be used. The floating and troweling operation shall be completed within one hour for concreting.

19.17.6 TILED FLOOR WITH UNDERBED

19.17.6.1 GENERAL

The tiles shall be (a) plain cement tiles (b) plain coloured tiles, and (c) terrazzo floor tiles, conforming to IS: 1237 – latest edition and of dimensions as shown of under bed drawings. The wearing face of these tiles shall consist of plain or coloured cement for items (a) and (b) and white or coloured cement and marble chips for item (c), size, colour and proportions of which shall be as per instructions of the Engineer. All angles of tiles shall be right angles, and the colour and texture of the wearing face

shall be uniform throughout its thickness, which shall not be less than 6mm. Colour shall be non-fading and lime-proof and the face of tiles shall be plane, free from cracks, depressions and projections and reasonably parallel to the back face.

The portion of cement to aggregate in the backing of tiles shall not be leaner than 1:3. Colouring material wherever used shall not exceed 10% by weight of cement used in the mix.

19.17.6.2 **MATERIALS AGGREGATES**

a) Aggregates used for mortar for fixing the tiles shall conform to IS: 383 – latest edition.

b) The cement used for fixing the tiles and cement grouting shall conform to IS: 12269 latest edition – or white cement of approved quality.

c) Pigments incorporated in mortar or used for Pigments grouting shall be stable and non-fading.

d) Water shall be clean and free from oil, water acid, alkali and organic or vegetable matters.

e) Aggregates used for the terrazzo topping aggregates shall be marble chips of size varying from for 1mm to 20mm. The proportioning of chips of terrazzo various grades shall be as per directions topping of the Engineer. Marble powder used for the topping shall pass through IS Sieve No. 30.

f) The delivery of tiles shall be so arranged as to minimise handling. Adequate precautions shall be taken to prevent accidental damage to tiles while unloading. The tiles shall be stored under cover to prevent exposure to dampness, sun, rain, accidental injury or straining.

19.17.6.3 **LAYING AND WORKMANSHIP**

a) Preparation of the base shall be as laying specified under 1.28.2 above. The surface shall be thoroughly soaked with water after soaking with water, the under bed of thickness as shown on drawings shall be evenly as smoothly spread. The mortar for under bed shall be composed of 1 part cement and 3 parts sand. The under bed shall be well consolidated and brought to proper grade, to a level below the finished floor level equal to the thickness of the tiles. The tiles shall then be placed before the under bed has set.

b) The tiles shall be soaked in water for 10 to 12 minutes and allowed to dry for the same length of time. The under bed shall be thoroughly moist, and Portland cement shall be hand-dusted over this immediately before the tiles are laid. The tiles shall then be placed upon and firmly pressed on the under bed until exactly even with the finished floor level. The joints shall be carefully grouted and filled with cement grout

of the same colour as the matrix of the tiles. The joints shall not be more than 1.5mm wide.

c) The setting of tiles shall be so done that minimum rubbing is required later on. Initial grinding and polishing of tiles shall be done in the shop and the final rubbing and polishing shall be commenced only after the floor as well as the joints have set and done in a manner approved by the Engineer. Chequered or grooved tiles whether plain or terrazzo, shall always be polished by hand.

d) All work shall be cleaned thoroughly and left in an acceptable condition on completion. No harsh abrasive cleaning powders, acid or steel wire shall be used for cleaning the tiles. Curing shall start on the next day after laying and shall continue for 14 days. The entire work of laying, polishing, finishing and cleaning etc. shall conform for 14 days. The entire work of laying polishing, finishing and cleaning etc. shall conform to IS: 1443 latest edition. Tiles shall be selected and used, such that colour of each area of the floor remains uniform.

19.17.7 GLAZED TILE FLOORING AND DADO

19.17.7.1 MATERIALS

The glazed tiles shall be 6 mm thick premium quality tiles conforming to IS 15622 of approved shade and make. The top surface of the tiles shall be glazed with a mat finish of uniform colour and texture and free from flaws, cracks, chips craze, specks, crawling or other imperfections. These shall be sound, true to shape with true and straight edges, non-absorbing and non-fading having a texture, dense and homogenous. The edges and the underside of the tile shall be completely free from glaze so that these may adhere properly to the surface below. The tolerances shall be +1.5mm for length and breadth and +0.5mm for thickness. Before bulk supply, the contractor shall give samples of tiles to the Engineer for approval. Bulk supply shall only be adopted if it conforms in all respects to the approved samples kept with the Engineer.

White cement, sand, pigments and water shall be as specified.

19.17.7.2 HANDLING AND STORAGE OF TILES

The delivery of tiles shall be so arranged as to minimise handling. Adequate precaution shall be taken to prevent accidental damage to tiles while unloading and these shall be stored under cover in a manner approved by the Engineer.

19.17.7.3 LAYING AND WORKMANSHIP

a) Preparation of base shall be as specified. The under bed as shown in the drawings shall be laid with a mortar consisting of 1 part of cement and 3 parts of clean, sharp, coarse sand. The thickness of the under bed shall be at least 20mm thick for flooring and 10 mm thick for dado or as shown in the drawings. While still green, the under

bed shall be deeply scratched. The under bed shall be laid not earlier than 48 hours before commencing to set the tiles.

b) A mortar setting bed 6mm thickness shall be laid over the under bed to make an even and true surface; over which the tiles shall be laid. This layer consists of 1 part of Portland cement, 1 part of lime putty and 3 parts of clean, sharp, medium sand. The under bed shall be thoroughly saturated with water immediately before applying the mortar setting bed. The setting bed mortar shall be applied over such an area as can be covered by tiles before the initial set of mortar. After the mortar setting bed has been levelled, a skin of neat Portland cement shall be trowelled to the mortar setting bed immediately before the tiles are set.

As soon as the mortar setting bed has sufficiently hardened, all tiles shall be firmly secured in place and gently beaten in, with finished surface brought to desired level. When grouting the glazed tiles, special care shall be taken to prevent scratching of the glazed surface. All surplus grout or mortar shall be removed before it has set or hardened and the face of tiles left clean. The completed work shall be free from cracked, broken or otherwise damaged tiles, No joint shall be more than 1.5mm thick. The joints shall be flush pointed with white or coloured cement to match the tile surface and cured for seven (7) days.

19.17.8 CERAMIC TILE FLOORING AND DADO

19.17.8.1 FLOORING

Non-slippery ceramic tile flooring shall be laid using premium quality mat finished 6mm thick ceramic tiles conforming to IS: 15622 in approved size (minimum 300 mm X 300), make and shade. The tiles shall be laid as per approved pattern over 20mm thick cement mortar 1:4 bedding, close jointed & pointed with matching cement slurry using white cement mixed with pigment, finished to levels / slope or plumb as required including cutting of tiles, curing, acid washing etc. all complete as per manufacturer's specifications and direction of Engineer. The quoted rates shall include the provision for covering of floor tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.8.2 DADO

Ceramic tile dado shall be laid at all the elevations using premium quality ceramic tiles average 6mm thickness of approved size (Min 450mmx300mm), shade and make conforming to IS: 15622. The tiles shall be laid on walls with average 10 mm thick underbed with cement mortar 1:3 (1 cement : 3 coarse sand) and 6mm thick setting mortar, jointed with white cement slurry with matching pigment and curing, cleaning etc all complete. The final surface shall project at least 6mm beyond the plastering, but in no case shall the total thickness including under bed be less than 20mm. The surface shall be truly vertical and free from any scratched or cracked tiles. The quoted rates shall include the provision for covering the tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.9 CEMENT SKIRTING AND DADO IN-SITU

a) The height of cement skirting and dado shall be as shown in drawings and/or instructed by the Engineer. Preparation of the base shall be as specified earlier.

b) The mortar for underbed shall consist of 1 part of cement and 3 parts clean, sharp, coarse sand (by volume), mixed with adequate amount of water to make it workable (not too wet) and shall be thrown on the wall. After finishing with a wooden float, a neat cement paste of minimum 3mm thickness (6mm when polished) shall be applied and pressed to be finally finished with English trowel.

c) The total thickness shall be such that the finished surface projects 6mm beyond plastering, but in no case shall the thickness be less than 19mm or as specified on the drawing. The junction with floors and corners shall be rounded to 25mm radius and/or as instructed by the Engineer. Curing shall be done for a minimum period of seven days.

d) If polishing is specified on drawings and/or schedule of items, the surface shall be rubbed and polished as per standard practice approved by The Engineer.

19.17.10 PRECAST TILE SKIRTING

This shall be done exactly in the same way as specified above. The plaster at the upper edge of the dado shall be finished neatly as directed by the Engineer.

19.17.11 PVC TILE FLOOR

This shall include the quality of materials and the general requirements for the installation of different types of tiles manufactured from vinyl resins including cover base set with sticker on concrete or masonry base in the locations shown in the drawings.

19.17.11.1 MATERIALS

a) The type of tile shall be as indicated on the drawings, schedule and/or bill of quantities. Three types of Vinyl floor tile are covered.

i) Type - V

The tile shall be composed of 100% Vinyl from face to back with alkaline resisting colour pigments and other plastic compounds.

ii) Type VA

The tile shall be of Vinyl – Asbestos consisting of a through blend of Vinyl plastic resins, asbestos fibres, and alkali resisting pigments and fillers from face to back.

iii) Type VL

The tile shall be Vinyl-laminated consisting of a top-wearing surface of solid vinyl permanently fused to applicant, felt cushion backing.

b) Cove base shall be extruded PVC (100% putty) with moulded top-set cover, colour, and the height of the base shall be as indicated on the drawings, schedules, and/or as approved by Engineer.

c) The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or other physical defects which affect appearance or serviceability.

d) All edges shall be cut true and square. The colour shall be non-fading and uniform in appearance, insoluble in water and resistant to alkalies; cleaning against and unusual floor polishes.

e) Samples of tiles and cove base shall be submitted to the Engineer and must be approved before work is started. Samples shall bear the labels stating the colour gauge and manufacturer's name. Colour, designs and sizes shall be approved by the Engineer after submission of samples. The thickness of the tiles shall be as indicated in the Schedule of Quantities.

f) Adhesive and cements shall be furnished as recommended by the manufacturer of the tiles. The adhesive shall have a short during time and long life in addition to toughness.

g) The tiles shall be square n shape and of approved dimensions and shall conform to the requirements of IS: 3461 and IS: 3462. The tolerance in dimensions shall be +1.5mm and in thickness +0.5mm.

19.17.11.2 INSTALLATION

19.17.11.2.1 GENERAL

The tiles shall be kept in the room to be tiled for at least 24 hours prior to laying to bring them to the same temperature of the laying area. The work should not the carried out under high humidity conditions. For air-conditioned space, the flooring shall not be laid until the conditioning units have been in operation for at least seven (7) days. During this period the temperature shall neither fall below 20° C. These conditions shall be maintained during laying and for 48 hours thereafter.

19.17.11.2.2 PREPARATION OF SUB-FLOOR

a) The surface to receive this finish shall be firm, even textured but not too smooth, without undulations and other deficiencies. If an under bed is laid the same shall be cured for at least seven (7) days by keeping it moist and fully dried. Before commencing the laying operations, the sub-floor shall be examined for evenness and dryness. The sub-floor shall be broom clean and free of paint, wax, grease or oil. Cracks shall be filled with crack filler.

b) The layout of the PVC on the sub-floor to be covered should be marked with guidelines. The PVC flooring shall be first laid for trials and approval without using the approved adhesive.

c) The adhesive shall be applied uniformly by using a notched trowel to the sub-floor and to the backside and edges of the tiles and allowed to surface dry. Any adhesive squeezed out through the joints and contaminating the face of the tiles shall be removed immediately. An appropriate solvent shall be used to remove any adhesive that has hardened. The traces of solvents shall be removed and the tiles cleaned before reuse.

d) The tiles shall be laid true, level and even exactly to the approved pattern and close to each other with minimum gap between joints. It is preferable to start laying of the tiles from the centre of the area. The tiles should be lowered in position and pressed firmly on to the adhesive. After laying, the tiles shall be rolled over, in two directions, with a light wooden roller weighing about 5 Kg. to ensure full contact with the underlay. If the edges tend to curl up, weights should be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. Any undulations noticed on the tiling surface shall be rectified by removing and relaying the tiles after thorough cleaning of the underside of the affected tiles. Work should be constantly checked against guide lines in order to ensure that all four edges of adjacent tiles meet accurately. Tiles shall be fitted carefully to and around all permanent fixtures. Borders shall be fitted accurately.

e) A minimum period of 24 hours shall be given after laying the flooring for developing proper bond of the adhesive. During this period, the flooring shall not be put to service. It is preferable to take up PVC flooring work after completion of plastering, painting, false ceiling and other decorative works so as to avoid any damage to the flooring.

f) Cove base shall be firmly cemented to the walls and accurately scribed to trim and finish.

g) The exposed edges of PVC tiles are doorways and other locations shall be provided protection against damage by metallic edge strips securely fastened to the sub-floor.

h) When flooring has been laid and fixed, it shall be thoroughly cleaned of surplus adhesive. The flooring shall then be cleaned with a wet cloth soaked in ware soap solution. All scraps, packing materials and debris shall be removed.

19.17.11.3 ACCEPTANCE

Improper application of the adhesive or imperfect embedment of tile in the adhesive as evidenced by ridges in the surface, by lack of even and uniform bearing, by loose bond, or by curled loose edges will be cause for rejection. All such defects shall be remedied to the satisfaction of the Engineer prior to acceptance.

19.17.11.4 GUARANTEE

All work executed under this specification shall be guaranteed free of defects in material and workmanship for a period of one year after completion of the work. Upon written notice of any defect in material or workmanship, repairs or replacements shall be made at no expense to Corporation. Corporation shall, however, arrange for the removal and replacement of all fixtures and equipment attached to the surface on which the work will be done.

19.17.12 ACID AND/OR ALKALI RESISTANT FLOOR

19.17.12.1 MATERIALS

The Acid and/or alkali resistant tile or rolls shall be to true and straight edges, shall be non-absorbing, without stains, non-fading, and obtained from approved manufacturers.

The rolls shall be 3 mm thick Thermo Plastic Polypropylene glass lined and shall be guaranteed to resist acid and alkalies of about 30% concentration. The laying of Acid proof rolls shall be carried out as per manufacturer's recommendation strictly and by a specialised agency.

The tenderer shall specify the characteristics of the tiles or rolls and shall enclose the manufacturer's literature for the same confirming their service ability for both acids and alkalis. The Contractor shall submit samples of tiles or rolls for approval to the Engineer and the bulk supply will only be accepted if it conforms in all respects to the approved samples kept with the Engineer.

19.17.12.2 LAYING AND WORKMANSHIP OF TILES

a) The surface should be levelled, dried, cleaned of dust, and should not be too smooth (sand finish) prior to pasting of PPG roll. The PPG roll should be cut into desired size for pasting. The required quantity of pasting compound should be mixed from the two components. The hardener should be added further in this mixture. The mixture is to be applied to the surface and the back side of the PPG roll after laying the fibre mat as per manufacturer recommendation and pasted by applying dead weight by putting sand bags etc. The pressure may be applied by jacks on the vertical surfaces.

b) Thermoplastic sheets should be welded by using fusion welding technique as per manufacturer's specification.

c) The Contractor shall furnish full details regarding the materials for the different treatments described above pertaining to this flooring work as per manufacturer's specifications, and shall lay and set the rolls properly in full conformation with the manufacturer's instructions. The entire work shall be done in workman like manner to the complete satisfaction of the Engineer.

d) The Contractor shall give a guarantee for the satisfactory life of the floor for a minimum period of one year under operating conditions. All defects appearing within

this period shall be rectified to the satisfaction of the Engineer by the Contractor at no extra cost to Corporation.

19.17.13 KOTA STONE FLOORING AND SKIRTING

Kota Stone shall be of best quality and obtained from approved sources. Kota stones shall not be less than 20mm thick for flooring and 20mm thick for skirting or as specified in schedule and shall be cut to the required sizes, as approved by the Engineer. The stones shall have to be machine cut and double machine polished. The edges to be pointed shall be true to line and dressed wherever found necessary to the full depth all round. The stones shall be hard, sound, and free from cracks, veins and other defects and of uniform colour. In case of Kota stones available in different shades, the samples shall be submitted for approval of the Engineer.

19.17.13.1 LAYING AND WORKMANSHIP

Before laying the flooring the surface to laying be paved, shall be thoroughly hacked, cleaned of all mortar scales, concrete lumps, loose materials etc. Unless and until, the surface is approved by the Engineer, the paving shall not be taken in hand. A bedding of cement mortar (1:4) of 20 mm thickness for flooring shall be laid evenly and to the required slopes as directed. The stones shall then be truly and evenly set in a thin paste of neat cement applied to sides, bottom and to the prepared base. The stones shall then be tamped down with wooden mallet until they are exactly in true plane and line with the adjacent stones. All stones shall be extended up to the masonry wall and underside of plaster. The stones shall be close jointed and joints shall be as thin as possible.

The cement that oozes out thorough the joints shall be wiped clean. The joints shall then be pointed with matching cement and finished neatly. The flooring shall be cured for seven (7) days. The entire surface and flooring shall be re-polished with machine to the satisfaction of Engineer.

19.17.13.2 KOTA STONE SKIRTING

Kota stone skirting shall be laid against a bedding of cement mortar (1:3) 12mm thick to the full height of skirting to a true plane, level and plumb. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. The continuous horizontal groove at the top of skirting shall be provided as per drawing or as directed by the Engineer. No extra will be paid for grooves. The skirting shall be cured for seven (7) days. The skirting surfaces shall be re-polished with had to the satisfaction of the Engineer.

19.17.14 VITRIFIED POLISHED TILE FLOORING AND SKIRTING/DADO

19.17.14.1 FLOORING

Vitrified polished tiles shall be of premium quality of size 600mm x 600mm of approved make and shade, conforming to IS: 15622 having minimum thickness of 9

mm. The tiles shall be laid in approved pattern over 20mm thick cement mortar 1:4 bedding. The tile slabs shall be close jointed & pointed with matching pigmented white cement slurry and shall be finished to levels / slope as required. Scope of work also includes cutting of tiles to the required size , curing, washing etc. complete with all materials, tools labour etc. all complete as per manufacturer's specifications and direction of the Engineer. The quoted rates shall include the provision for covering of floor tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.14.2 DADO

Vitrified polished tile skirting/ dado shall be of approved make and shade, conforming to IS: 15622 having minimum thickness of 9 mm. This shall be laid at all elevations in approved pattern laid in skirting over and including on 12 mm thick cement mortar 1:3 (1 cement: 3 coarse sand) and jointed with neat white cement slurry with pigment of matching shade to match the shade of the tile including curing, cleaning etc. all complete as per manufacturer's specifications and direction of the Engineer..

19.17.15 GRANITE FLOORING AND DADO/ CLADDING

19.17.15.1 FLOORING

Granite slab shall be of 1st quality in approved colour and size (Minimum 600mmX600mm). Granites slabs shall be provided and laid in 20 mm nominal thickness, with inlay for the border as flooring design, laid in approved pattern over base 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand) and jointed with white cement slurry mixed with pigment to match the shade of the slab.The scope of the work shall also include surface preparation, rubbing, curing, moulding and mirror polishing complete as per manufacturer's specifications and as directed by the Engineer.

19.17.15.2 DADO

Providing and fixing 20 mm nominal thick granite slab of 1st quality as wall cladding with approved colour and size (to cover the entire height of the dado in single piece without any joint and minimum 600mm width) laid in approved pattern over a base of 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand) jointed with white cement slurry mixed with pigment complete as directed including filling the gaps between the base mortar and granite slab with 1 : 2 cement slurry and making 'V' grooves wherever required, inclusive of stainless steel fisher clamp with expansion bolts at least 2 nos. for each slab wherever necessary, including rubbing, curing and mirror polishing complete as per specifications and as directed by Engineer. Quoted rate shall include supplying and providing stainless steel clamps as necessary with expansion bolts or any other accessories required to complete the dado work.

19.17.16 PVC ELECTROSTATIC CONDUCTIVE FLOORING AND SKIRTING

19.17.16.1 FLOORING

PVC Electrostatic conductive flooring and skirting 2 mm thick shall be installed over integral concrete floors finish/IPS/ hardonite flooring. The material specification and laying procedure shall be as per NPCIL Specification No. PPE-2273 (latest Rev.)

19.17.16.2 SKIRTING

PVC electrostatic conductive skirting shall be minimum 2 mm thick and shall be supplied and installed at various elevations inside main plant buildings over concrete / plaster surfaces satisfying all the requirements laid down in NPCIL technical specification PP-E-2273. The scope shall include all accessories / material required for installation of the same such as copper grounding strips, welding rods, surface preparation / levelling of floor, adhesive etc. as per requirements and testing at site all complete as per drawing, manufacturer's specifications and direction of the Engineer.

19.17.17 PRECAST CEMENT CONCRETE INTERLOCKING PAVER BLOCKS

Precast cement concrete interlocking pavers blocks shall conform to IS 15658. Paver blocks shall be of M-40 grade and 80mm thick factory made coloured blocks made by block making machine with strong vibratory compaction. The blocks shall be of approved colour and shape. Cement Concrete paver blocks shall be laid in approved pattern over 50mm thick compacted bed of fine sand, filling the joints with fine sand etc. all complete as per manufacturer's specifications and the direction of the Engineer.

19.18 GENERAL PAINTING ON INTERIORS & EXTERIOR SURFACES

19.18.1 SCOPE

a) This specification covers general painting on concrete, plastered and steel surfaces both interior and exterior as shown in drawings, schedules or as directed by the Engineer.

b) The Contractor shall inspect the surfaces of works completed by other agencies prior to the application of paint. If surface to be finished cannot be put in suitable condition for painting by customary preparatory methods, the painting contractor shall notify the Engineer in writing or assume responsibility for and rectify and unsatisfactory finishing that results.

c) Before commencing painting, the contractor shall obtain the approval of the Engineer in writing regarding the scheduling of work to minimize damage, disfiguration or staining by other trades. He shall also undertake normal precautions to prevent damage, disfiguration or staining to work of other trades or other installations.

19.18.2 MATERIALS

a) Materials shall be of the highest grade products of well known approved manufacturer and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name, and colour shade, with labels intact and seals unbroken.

b) All materials shall be subject to inspection, analysis and approval by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade be obtained from the same manufacturing batch.

c) All paint shall be subject to analysis from random samples taken at site from painter's bucket, if so desired by the Engineer.

d) All primer coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

e) All unspecified materials such as shellac, turpentine or linseed oil shall be of highest quality available and shall conform to the latest I.S. specifications. All such materials shall be made by reputable recognized manufacturers and shall be approved by the Engineer.

f) All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

19.18.3 **STORAGE**

The contractor shall arrange for safe and proper storage of all materials and tools. The storage space if allotted within the building shall be adequately protected from damage, disfigurement and stains. Paints shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken by the Contractor to prevent fire.

19.18.4 **PREPARATION OF SURFACE**

Before starting the work the Contractor shall obtain the approval of the Engineer regarding the soundness and readiness of the surface to be painted.

19.18.4.1 MASONRY, CONCRETE AND PLASTERED SURFACE

Before taking up painting works F3 finish shall be carried out on concrete surfaces. Plastered Surface shall be wire brushed and sand papered, clean and free of all oil, grease, efflorescence, mildew, loose paint or other foreign and loose materials. Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and uniformly textured. Where this type of resurfacing may lead to the finishing paint being different in shade from the original surfaces, the resurfaced area shall be treated with minimum one coat of cement primer, which should continue to the surrounding area for a distance of minimum 100 mm.

Surface with mildew or efflorescence shall be treated as below:

a) MILDEW

All mildew surface shall be treated with an approved fungicide such as ammonia wash consisting of 7g of copper carbonate dissolved in 80 ml liquor ammonia and diluted to 1 litre with water, or 2.5 percent magnesium silica fluoride solution allowed to dry thoroughly below the paint is applied.

b) EFFLORESCENCE

All efflorescence shall be removed by scrubbing the affected surfaces with a solution of muriatic acid in water (1:6 to 1:8) and washed fully with clear water and allowed to dry thoroughly.

19.18.4.2 **METALSURFACE**

All metal surfaces shall be absolutely clean, dry and free from wax, grease or dried soap films. All steel and iron surfaces, in addition, shall be free from rust. All steel or galvanized iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction. Prime coat for steel work shall, however, be applied by the fabricator. Any abrasion in shop coat shall be touched up with the same quality of paint as the original coat.

19.18.5 PAINTING

Various types of finishing shall be done as indicated in the 'Interior Finish Schedule' and/or as on drawings. The colour shall be in accordance with 'Painting Schedule' or as selected by the Engineer.

19.18.5.1 ACRYLIC PLASTIC EMULSION PAINT

Acrylic plastic emulsion paint shall conform to IS: 15489. It shall be water-based acrylic co-polymer emulsion with rutile titanium dioxide and other selected pigments and fungicide. It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to escape without peeling or blister. The paint, after it is dried, shall be able to withstand washing with mild soap and water without any deterioration in colour, or without showing flaking blisters or peeling.

Plastic emulsion paint shall be of premier quality conforming to IS 15489. It shall be applied in minimum two coats over a coat of approved primer to interior concrete, plaster & other surfaces after cleaning / scrubbing of the surfaces with wire brushes, soft brushes, sand papers, steel sheet scrappers and mechanical grinder etc. for removing all kind of burrs, imperfections, undulations and other such defects existing in the surface including filling surface imperfections such as holes, dents, cracks by using mixture of white cement & fine sand (in the ratio of 1:3) to achieve plain & even surface. The scope of work includes spreading of suitable and clean protection covering on all exposed surfaces to protect them from staining. All surfaces

surrounding to painted area including window frames & glasses shall be cleaned to sparkling clean condition using suitable thinners, detergents, chemical cleaners etc. under the scope of the item as directed, at all elevations as indicated in the drawings including labour, materials, scaffolding, preparation of the surface, protecting & cleaning etc. all complete as per specification and direction of the Engineer.

All concrete surfaces shall be F3 finished before taking up the painting works. Quoted rates of painting shall include cost of F3 finish. Lime gauged cement plastered surfaces shall not be painted for at least one month after plastering. A sample patch shall be painted to check alkali reaction if so desired by the Engineer. Painting shall be strictly as per manufacturer's specification.

19.18.5.2 SYNTHETIC ENAMEL PAINT

Synthetic enamel paint shall be made from synthetic resins and drying oil with rutile titanium dioxide and other selected pigments to give a smooth, hard, durable and glossy finish to all exterior and interior surfaces. White and pastel shades shall resist yellowing and darkening with aging. The paint shall conform to IS: 2932 & IS: 2933. Glossy synthetic enamel paint shall be used on metal surfaces. Ready mix matt synthetic enamel paint shall be used on wall surfaces.

Synthetic enamel paint shall be of approved make and shade premium quality mat / glossy (as directed). It shall be painted in minimum 2 coats to give an even shade on steel surfaces at all elevations after erection including surface preparation and touch up with zinc phosphate primer wherever required. The scope also includes providing and removing scaffolding, all as per manufacturer's specifications, drawings and direction of the Engineer. The rate shall be inclusive of surface preparation with wire brushing and touch up with zinc phosphate primer.

Synthetic enamel paint shall be applied on properly premiered surface. Subsequently, coat shall not be applied till the previous coat is dry. The previous coat shall be lightly sand papered for better adhesion of subsequent coats.

19.18.5.3 ACID, ALKALI RESISTING PAINT

Acid and alkali resistant paint shall be of approved make and colour conforming to IS: 9862. The paintshall be applied in minimum 500 micron DFT over a coat of approved primer on prepared surfaces of flooring, ceiling and walls and other surfaces at all elevations. The scope of work includes all labour, materials, scaffolding, preparation of the surface, protecting & cleaning etc. all complete as per manufacturer's specification and das per direction of the Engineer. Primer coat shall be as per manufacturer's instructions.

19.18.5.4 POLYURETHENE PAINTING

19.18.5.4.1 GENERAL

Polyurethane painting on concrete and steel surfaces shall be done at locations

wherever specified in the drawings. Generally the external surfaces of the specified buildings shall be painted with polyurethane paint after completion of the work.

19.18.5.4.2 **SCOPE**

The scope of work covered under this specification is supply and application of one coat of primer and two coats of polyurethane finish paint of approved make for total dry film thickness of 125 microns (excluding 75 micron thick primer) on exterior surfaces.

19.18.5.4.3 **MATERIALS**

a) Primer compatible for PU paint shall have outstanding resistance properties and shall contain a high level of penetrating pigment, which renders superior performance when applied over concrete and it should be compatible when over coated with polyurethane paint.

a) The finish paint shall be two-component air-drying acrylic aliphatic polyurethane coating.

c) Suitable thinner for the above will be as per the manufacturer's recommendations.

d) Finish paint shall be glossy/ matt finish of approved shade and as specified by the engineer.

19.18.5.4.4 **DESCRIPTION**

The surface shall be cleaned of dust, loose particles, finished and cured properly. Biological growth if any, accumulated on the surface over the period shall be removed completely. Painting shall commence with application of one coat of 75 micron thick primer and finished with 125 micron DFT of polyurethane paint in two coats. The shade of the finish paint is generally light grey in colour and Contractor shall obtain prior approval of Engineer before commencement of work. Method of painting shall be either brush application or using air less spray equipmentusing a pump with nozzle tip of size 0.33 mm to 0.45 mm and more than 2000 psi pressure.The rate quoted shall cater for both methods.

A) Primer shall be two pack epoxy primer with outstanding resistance properties and shall contain a high level of penetrating pigment which renders superior performance when applied over steel/ concrete having the following properties.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Density	ASTM D 4052	g/cc	1.09 + 0.05 at 25°C
Mixing Ratio, by weigh	ASTM D 4052	ratio	100(Base): 35(Hardener)
Flexural Strength	ASTM C 580-02	Mpa	35 at 7 days

Tensile Strength	BS 6319, Pt 7	MPa	22 at 7 days
Compressive Strength	ASTM C 579	MPa	70 at 1 Day 75 at 3 Days 80 at 7 Days
Adhesive Bond Strength	ASTM D 4541	MPa	>1.5
DFT of Primer	ASTM D 1005	Micron	75

B) The two component polyurethane paint shall have the following parameters.

PROPERTY	TEST METHOD	UNIT	ACCEPTACE VALUE
Volume of Solids	ASTM D 2697	%	57±3
Pot Life	ASTM C603-90	Min	120 (at 25 deg C) 50 (at 40 deg C)
Mixed Density	ASTM D 4052	Kg/Ltr	1.2 (at 25 deg C)
Mixing Ratio, by Volume	ASTM D 4052		4(Base) : 1 (Hardner)
Touch Dry	ASTM D 1640	Min	90 (at 25 deg C)
Recoatable	ASTM D 1640	Hour	6 – 8 (at 25 deg C)
Final Curing Time		Day	7 (at 25 deg C)
Bond Strength	ASTM D 4541	MPa	>2 (Concrete Failure)
Abrasion Resistance , CS17 wheel	ASTM D 4060	Mg/1000 cycles	<125
UV Resistance	ASTM G 53	Hour	>1000
DFT in two Coats of PU Paint	ASTM D 1005	Micron	125

The acceptance criteria shall be based on Manufacturer test certificate except for Bond & Abrasion Resistance test, which shall be performed (one sample per lot) at independent approved Laboratory at the cost of contractor. The test certificate shall clearly specify the PU material as “Aliphatic”.

19.18.5.5 EPOXY PAINTING ON STEEL AND CONCRETE SURFACES

19.18.5.5.1 GENERAL

Epoxy painting on concrete and steel surfaces shall be done at locations wherever specified in the drawings.

19.18.5.5.2 SCOPE

The scope of work to be performed under this specification comprises of supply and application of heavy duty high build epoxy paint of approved make for painting of concrete and steel surfaces in various buildings and areas specified in the drawing, for walls, ceiling, floors and fabricated structural steel members as per relevant drawing and specifications to the thickness as specified in the drawings including surface preparation.

19.18.5.5.3 MATERIAL SPECIFICATIONS

For the areas, important from radiological considerations, where decontamination and

radiation resistance properties are required, the material shall conform to PP-M-1219 as applicable and as specified in the drawings or decided by the Engineer. This material shall be Polyamide cured two pack epoxy coating in mix and use form.

The areas which are not important from radiological consideration as specified or decided by the Engineer, material shall meet the requirements under relevant clause of this section.

19.18.5.5.3.1 **INTENDED USE**

19.18.5.5.3.1.1 **For areas important from radiological considerations**:

The epoxy coating would be used for painting the concrete floors, ceilings and walls. Mild steel surfaces on inorganic zinc silicate primed fabricated structural steel surfaces, construction joints caulked with polysulphide or epoxy mortar caulking compound, metallic expansion joints made from steel and copper etc. The materials used in the coating should not form radioactive isotope on absorbing neutrons. The paint should form a thick, radiation resistant, abrasion resistant, impact resistant, non-adsorbent, de-contaminable, humidity resistant, hot water and steam resistant liner.

19.18.5.5.3.1.2 For areas not important from radiological considerations:

The epoxy coating can be used for painting the concrete floors, ceilings and walls over Epoxy based compatible primer and on Mild steel surfaces over inorganic zinc silicate primed fabricated structural steel surfaces, construction joints caulked with polysulphide or epoxy mortar caulking compound, metallic expansion joints made from steel and copper etc. The paint should form a thick, abrasion resistant, impact resistant, non-adsorbent, humidity resistant liner.

19.18.5.5.3.2 **QUALIFICATION**

19.18.5.5.3.2.1 **For the areas important from radiological considerations:**

The qualification and procurement of epoxy paint shall be in accordance with PP-M-1219 as applicable. At the time of bulk supply samples shall be drawn from the batch in presence of representative from NPCIL, sealed and got tested by the contractor for batch tests in accordance with PP-M-1219 as applicable. The rate for application of paint shall include all the costs related with procurement.

19.18.5.5.3.2.2 **For the areas not important from radiological considerations:**

The Epoxy paint shall have following properties:

a) **For Epoxy on concrete floors**: The Epoxy shall be high build solvent free, self-smoothing, 4 component (Base, Hardener, Filler & Pigment) material. The DFT of coating (Excluding Primer) shall be minimum 1200 micron for its use on floors unless specified otherwise.

Property	Acceptance criteria	Reference Standard
Mixed Density	1.6+/- 0.05 kg/ liter	ASTM D14752
Pot Life	Min 40 min at 25 ^{0} C Min 15 min at 40 ^{0} C	ASTM C603
Setting time for foot traffic	15 Hour at 15 ^{0} C	ASTM D5895
Maximum Service Temperature	60 ^{0} C	ASTM 24712
Compressive Strength	24 MPa at 1 day 50 MPa at 7 days	ASTM C579
Flexural Strength	18 MPa at 7 days	BS 6319 PART 3
Tensile Strength	10 MPa at 7 days	BS 6319 PART 7
Abrassion Resistance H22 Wheel 1000 cycles – CS17 wheel	Less than 230 mg Less than 85 mg	ASTM D2240
Hardness, Shore D	Min 80	ASTM D2240
Adhesive Bond strength to concrete at 7 days	>1.5 MPa (Concrete failure)	ASTM D4541

b) **For Epoxy on concrete walls & structural steel**: The Epoxy shall be high build solvent free, 3 component (Base, Hardener & Pigment) material. The DFT of coating (Excluding Primer) shall be 250 micron for concrete walls & 200 micron on structural steel, unless specified otherwise.

Property	Acceptance criteria	Reference Standard
Mixed Density	1.48+/- 0.05 kg/ liter at 25 ^{0} C	ASTM D 14752
Volume Solids	100 %	ASTM D 2697
Pot Life	Min 60 min at 25 ^{0} C	ASTM C603-90
Setting time for foot traffic	2 days at 25 ^{0} C	ASTM D 5895
Compressive Strength	60 MPa at 7 days	ASTM C579
Flexural Strength	38 MPa at 7 days	ASTM C 580-02
Tensile Strength	8 MPa at 7 days	ASTM C307
Abrassion Resistance H22 Wheel 1000 cycles – CS17 wheel	Less than 230 mg Less than 130 mg	ASTM D2240
Hardness, Shore D	Min 80	ASTM D2240
Adhesive Bond strength to concrete at 7 days	More than 1.5 MPa Concrete failure	ASTM D4541

19.18.5.5.4 **SURFACE PREPARATION**:

Generally all surfaces to be painted shall be cleaned of oil, grease and other foreign matter. If the surface is very oily a detergent wash may be applied. The surface shall then be rubbed with No. 60 to 80 emery paper and the dust removed thoroughly with a clean cotton cloth.

19.18.5.5.4.1 CONCRETE SURFACES

Air water jet at a pressure of 7 Kg/cm2 shall be applied through a nozzle having a tip orifice of 1.5mm. The surface shall be allowed to dry. Pin holes if any exposed due to air water jetting shall be filled with cement paste and excess cement mortar shall be removed after drying by rubbing with emery paper followed by wiping with clean cloth.

In the case of floors, all laitance, stains and other deleterious substances shall be removed by using a floor polishing machine followed by a thorough air water jetting and cleaning. Oil and grease shall be removed by wiping with cloth soaked in thinner or acetone.

19.18.5.5.4.2 STEEL SURFACES

All steel work shall be cleaned of rust, scale, dirt, oil, weld splatter and other deleterious substances by shot blasting.

19.18.5.5.5 EQUIPMENT FOR PAINTING

Generally, only airless spray equipment of ratio not less than 66:1 shall be used for all painting works. Only trained personnel shall be allowed to operate the airless spraying equipment. The capacity of the equipment shall be such that it will provide maximum dry film thickness without sagging of the paint film. However, at places, where airless spray equipment cannot be used, painting with brushes shall be permitted at the discretion of the Engineer-in-charge only.

19.18.5.5.6 APPLICATION OF PAINT

General

Painting shall commence from top of walls and shall be worked down. Floors shall be painted from one corner working towards exit to avoid walking over painted areas. The paints shall be mixed and applied in accordance with manufacturer's instructions. Only approved primer coat shall be applied on the concrete or steel surfaces. The final finish paint should give a dry film thickness as specified in drawings/ specifications. The thickness shall be made up in minimum number of coats as possible.

The curing time between successive coats shall be around 16 hours unless recommended otherwise by the paint manufacturer.

On concrete surfaces, inert filler shall be applied after the first coat to cover the uneven surface. It shall be noted that inert filler material shall not be applied over the entire surface as such layer will lead to loss of adhesion of the subsequent layers of paint. After application of the inert filler the surface shall be rubbed down with Nos. 80, 120 and 140 (as the case may be) sand paper and the rubbed surfaces cleaned by air jetting followed by cleaning with soft cloth before the successive coat of paint is applied. Each coat of paint except the final coat shall be slightly roughened using sand paper to obtain good adhesion of the successive coat of paint.

The paint shall be spread uniformly without runs, sags or brush marks (in case of brushing). Care shall be taken during spraying operations to hold the nozzle sufficiently close to the surface (not closer than 300mm) being painted to avoid evaporation of the volatile constituents of the paints and loss of materials into the air. The air pressure shall be kept at the required level through the entire painting operation. Each coat of paint shall be inspected after curing for the finish and dry film thickness. Necessary compositor plates shall be fixed on to the surface during painting, for checking the dry film thickness at various intervals as may be necessary. Wet film thickness gauges shall also be used during the painting and the thickness of wet film shall be recorded.

19.18.5.5.7 APPLICATION OF SELF LEVELING EPOXY FLOORING

The floor receiving the self-leveling epoxy flooring must be sound, dry, fine-grained and load bearing, free of laitance, loose and brittle particles and shall also be free from substrate and substances which impair adhesion such as oil, grease, rubber skid marks, paint or other contaminations.

The bond strength of the substrate must be at least 1.5 MPa. Ensure the compressive strength of the floor concrete is at least 25MPa and that floor slabs directly in contact with the ground have a proper vapour barrier installed and the moisture content of substrate shall not be higher than 4% throughout.

The temperature requirements shall be in the range given below:

A] Substrate temperature: 15°C - 35°C
B] Material temperature: 15°C - 30°C

The priming is essential to seal the concrete surface prior to the application of the self-level epoxy flooring. For primer shall be applied using medium nap roller ensuring a complete coverage without holidays, if after drying the surface appears patchy due to high absorption, recoating of primer shall be done in such areas. Primer shall be allowed to dry before commencing topcoat application of the self-level epoxy floor coating.

All mixing should be done mechanically, using a slow speed drilling machine fitted

with a paddle, taking care to ensure that the mixing head is well within the material during mixing.
Applicator must wear spiked shoes during application. Mixed material shall be poured onto the primed and sealed surface and spread to full specified thickness using a pin screed or a notched trowel to achieve the specified thickness. The spread material should be immediately rolled with a spiked roller to release entrapped air and remove trowel marks. Control rolling shall be continued until all air is released well before the material starts stiffened.

19.18.5.5.8 PRECAUTIONS TO BE TAKEN

Required oil free compressed air at correct pressure shall be available with suitable compressors.

The equipment with all its accessories shall be cleaned immediately after the painting is completed with suitable thinner after painting.

All material such as paints, thinner, inert filler and Primer shall be stored safely, handled carefully and account of consumption recorded regularly. The paints used are volatile and hence proper ventilation shall be maintained in the areas of painting.

Explosion meters shall be used to constantly check the fume concentrations to avoid any explosion. The area to be painted shall be well ventilated by using fans/air blowers.

Sufficient lighting arrangements shall be ensured before start up of painting.

Proper staging and scaffolds shall be ensured while painting at heights.

Embedment, equipments pipes etc. shall be suitably masked before the painting commences.

After the painting, areas shall be cleaned of stains if any.
Care shall be taken to see that no welding/ Gas cutting is carried out where painting work is in hand or near to storage area.

19.18.5.5.9 Maintenance of records

A daily progress record shall be maintained.

19.18.5.5.10 Handling precautions

All the precautions must be taken to avoid direct contact of resin and hardener with skin. The persons handling epoxy resin and hardener must use rubber or polythene gloves. Parts of the skin, which come in contact with resin or hardener, should be washed with lukewarm water and mild soap. Manufacturer's recommendation on these aspects should be followed.

19.18.5.6 ANTI CARBONATION, ANTI CORROSIVE AND WATERPROOF COATING

19.18.5.6.1 SCOPE

The specification described here covers material description, physical and mechanical properties, testing, applicable codes and standards, acceptance criteria, surface preparation and QA requirement etc. for protective coating using Aliphatic acrylate system on external surface of buildings unless specified otherwise.

19.18.5.6.2 MATERIAL

The protective coating on the external concrete surfaces shall be pure aliphatic acrylate system. It shall be single component; solvated aliphatic acrylic resin based coating for protection of concrete from carbonation, chloride ions, weathering and industrial pollution.

19.18.5.6.3 SURFACE PREPARATION

The surface shall be clean and free from loose particles, oil, grease, or any other contamination. The concrete surface shall be cleaned with wire brush and shall be washed with clean water. The surface having oil and grease shall be cleaned with detergents.

The surface irregularities such as blow holes, honeycombs, crevices and surface blemishes shall be filled with polymer modified cement putty mortar to achieve smooth and level surface this shall be allowed to cure by spraying water for two days and to dry for one day.

The substrate shall be in dry condition before the application of protective coating for better performance. The compatibility of this system shall be checked with the existing coating system, if any.

19.18.5.6.4 APPLICATION

Prepared Concrete substrate shall be applied with a compatible coat of primer at least 2 hours before application of Coating. The Primer shall have following properties.

PROPERTY	UNIT	TEST METHOD	ACCEPTANCE VALUE
Mixed Density	Kg/ltr	ASTM D 6237	0.95
Volume Solid	%	ASTM 5201	Min 32%
Over Coating Time	Hrs	ASTM D 1005	2 (at 25 ^{o}C)

Over the primer the protective coating shall be applied using brush or roller or airless spray. The complete protective coating shall be applied in minimum one primer and two main coats. The first and the second main coat shall be applied approximately

with a gap of 24 hours at right angles to each other. At low temperature, the subsequent coat shall be applied after ensuring that the earlier coat is fully dry.

19.18.5.6.5 **CURING**

The aliphatic acrylate based protective system is naturally air cured. Hence, no separate curing is required.

19.18.5.6.6 **COVERAGE**

The coverage depends on the type of surface (concrete, plaster, masonry) and surface finish. The Engineer In Charge shall check the coverage as per the manufacturer's specification. Engineer-in-charge shall verify the quantity of material used at site along with bills from the manufacture and the coverage specified in the manufacturer's specification.

The protective coating shall be applied in two coats over a primer coat. Each coat shall have a minimum thickness of 75 microns. The total dry film thickness inclusive of Primer shall be minimum 225 microns.

19.18.5.6.7 **STORAGE AND SHELF LIFE**

The material shall be stored under cover, out of direct sun light and shall be protected from extremes of temperature. The shelf life shall be as per the manufacturer's specification.

19.18.5.6.8 **Properties**

The properties of aliphatic acrylate based protective system are as follows. The base and system shall be pure aliphatic acrylate base and single component system.

PROPERTY	UNIT	TEST METHOD	ACCEPTANCE VALUE
Density	Kg/ litre		1.10 (min)
Volume solids	%	ASTM D 5201	37% (min)
Dry film thickness (DFT) for 1 Primer in white shade + 2 Top Coats	Microns	ASTM D 1186	225 microns in 1 Primer + 2 Top Coats
Adhesion with Concrete/ plaster surface	MPa	ASTM D4541	3.0 or concrete failure
Water vapour permeability test	gm/sq.m/day	ASTM D 1653	7 gm/sq.m/day at 75% RH at 25C (max)
Water penetration test	% weight gain	IS 3085	NIL at 5 kg/cm^2 hydrostatic test

Flexibility -Standard bend test		ASTM D 522	No cracks on the surface in 1/8 inch Mandrel
QUV- condensation test	Hours	ASTM G 53 for 500 hours	Passes - No discolourisation and chalking
A.C. Impedance Test in 3% sodium chloride	Coating resistance	Using Electrochemical impedence measurement for a frequency range of 100 KHz to 0.01Hz with AC amplitude of 20 Mv.	Initial value: $9x10^9$ Ohms (min) Final value after 30 days: $1x10^7$ 0hms (min)
CO2 diffusion resistance	Equivalent air layer thickness, R	AS/NZS 4548.5 – 1999: Taywood Method	>70m
	Equivalent Concrete Layer Thickness		>170 mm

Note: A.C. impedance test for the protective coating is required for application on RCC surface. This test may not be required for application on masonry/ PCC surfaces.

19.18.5.6.8.1 **Material**

Base: Aliphatic Acrylate Solvented System
Components: Single component

19.18.5.6.8.2 **Volume Solids**

Test Method: ASTM D 5201 –97 Standard practices for calculating formulation physical constants of paints and coatings.

19.18.5.6.8.3 **Dry Film Thickness**

Test Method: ASTM-D-1186: Test method for non-destructive measurement of dry film thickness of non magnetic coatings applied to ferrous base.

Methodology for adopting on concrete/masonry/plaster surface: Cleaned steel plates shall be fixed to the concrete surface firmly at regular intervals during application of protective coating. The dry film thickness (DFT) measurement shall be carried at every 100 sq.m area or part there off.

19.18.5.6.8.4 **Adhesion with concrete/ plastered surface**

Test Method: ASTM-D-4541-02: Standard test method for Pull-off strength of coating using portable adhesion testers.

19.18.5.6.8.5 **Water Vapour Permeability test**

Test Method: ASTM-D-1653: Standard test method for water vapour transmission

of organic coating films.

19.18.5.6.8.6 **Water penetration Test**

Test Method: Water penetration resistance tested by immersing coated concrete cubes (5 cm x 5 cm x 5 cm size) for 12 days. Even at the end of 12 days, the weight gain shall be NIL to negligible.

19.18.5.6.8.7 **Flexibility- Standard bend test**

Test Method: ASTM-D-522: Standard test method for mandrel bend test for attached organic coatings.

19.18.5.6.8.8 **QUV- Condensation Test**

Test Method: ASTM-G-53: Standard practice for operating light and water exposure apparatus (fluorescent UV- condensation type) for exposure of non-metallic materials.

19.18.5.6.8.9 **Impedence Test (in 3.0% NaCl solution)**

Test method: Electrochemical impendence measurements for a frequency range of 100 kHz to 0.01 Hz with an AC amplitude of 20mV.

19.18.5.6.9 TESTING

The material shall be tested as per this specification by the contractor at no extra cost to NPCIL. Each batch of material used for the NPCIL job shall be tested in any of the approved independent laboratories. The independent test certificates along with the manufacturer's test certificate shall be submitted to NPCIL. The independent testing shall be witnessed by NPCIL representative, If felt necessary by the Engineer.

19.18.5.6.10 PACKAGING AND SHIPMENT

Materials delivered at site shall be clearly marked with legible and intact labels with manufacturer's name, brand name, product identification, manufacturing & expiry dates and batch number. The products shall be in original, unopened / sealed containers. Material shall be stored in areas where temperatures conform to manufacturer's recommendations and instructions.

19.18.5.6.11 SAFETY PRECAUTIONS

The work shall be carried out by an authorized contractors/applicator

The application shall comply with the procedure given above, all current relevant codes of practice and the Building Regulations.

All materials shall be stored clear of ground and moisture with weather protective covering. All the materials shall be kept away from sources of ignition.

The protective coating shall not be applied during inclement weather or when ambient condition is not allowing proper application.

Safety scaffolding, access ladders etc shall be provided in accordance with the current industrial safety and all the health and safety regulations shall be adhered to.

Care shall be taken during storage and use to avoid contact with eyes, mouth, skin and food stuff. The container shall be sealed after use.

19.18.6 PROTECTION

Furniture and other movable objects, equipment, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationery equipment shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as per instruction of the Engineer.

19.18.7 CLEANING UP

In addition to the provision in 'Conditions of Contract' the Contractor shall, upon completion of painting etc., remove all marks and make good surfaces, where paint has been spilled, splashed or splattered, including all equipment, fixtures, glass furniture, fittings, etc. to the satisfaction of the Engineer.

19.18.8 ACCEPTANCE CRITERIA

a) All painted surfaces shall be uniform and pleasing appearance (gloss/ matt finish).
b) All varnished surfaces shall be of uniform texture and high glossy finish.
c) The colour, texture etc. shall match exactly with approved samples.
d) All stains, splashes and splatters of paints and varnishes shall be removed from surrounding surfaces

19.19 WATER SUPPLY, DRAINAGE AND SANITATION

19.19.1 SCOPE

The specification covers the general requirements for providing and laying water supply, piping, and providing and laying drainage lines.

19.19.2 CODES AND STANDARDS

Some of the important Codes and Standards relevant to this specification shall be followed: Latest editions shall always be consulted.

The following IS Codes shall be applicable:

IS: 1172 - Code of basic requirements for water supply drainage and sanitation.

IS: 1200 - Methods of measurement of building and civil engineering works.

IS: 1239 - Steel Tubes, Tubulars and other wrought steel fittings. (Pt. I & II)

IS 16098-2-Structured-Wall Plastics Piping Systems for Non-Pressure Drainage and Sewerage –specification

IS 7634-2- Plastics Pipes Selection, Handling, Storage and Installation for Potable Water Supplies - Code of Practice, Part 2: Laying and jointing of polyethylene (PE) pipes.

IS 14333 -High density polyethylene pipe for sewerage

IS: 1742 - Code of Practice for building drainage.

IS: 5329 - Code of Practice for sanitary pipe work above ground for buildings.

IS: 3076 - Specification for Low density polyethylene pipes for potable water supplies.

IS: 4984 - High density polyethylene pipes for potable water supplies.

IS: 458 - Pre cast concrete pipes (with and without reinforcement) - specification

IS: 783 - Code of Practice for laying of concrete pipes.

IS: 784 - Pre-stressed concrete pipes.

IS: 1726 - Specifications for Cast Iron Manhole Covers and Frames.
IS: 5961 - Specification for Cast Iron gratings for drainage purposes.

IS: 5219 - Specification for cast copper alloys traps. Part-1 - ‘P' & 'S' traps.

IS: 771 - Specifications for Glazed fire-clay sanitary appliances.

IS: 772 - Specifications for general requirements for enameled cast iron sanitary appliances.

IS: 774 - Flushing cistern for water closets & urinals (Other than plastic cisterns) - specifications.

IS: 775 - Cast Iron brackets & supports for wash basins and sinks.
IS: 2548 - Plastic seats and cover for water closets – specifications.

IS: 2527 - Code of Practice for fixing rain water gutters and down-pipes for roof drainage.

19.19.3 DRAWINGS

a) Checked and approved drawings showing locations of sanitary and water supply fixtures will be furnished to the Contractor and all drawings so furnished shall form a part of this specification. The Contractor shall refer these drawings for all information contained thereon which pertains to and required for his work. He is, however, not to commence detail plumbing, water supply and drainage on the basis of drawings unless such drawings or parts of such drawings are officially released as 'Released for Construction'. Revision to drawing and any new drawings made to include additional work by the Contractor shall be considered a part of this specification and contract.

b) Unless otherwise specified, the plans and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and accordingly the job shall be carried out for completeness as required whether each item is mentioned here or not.

c) Based on line diagrams/drawings furnished by the Engineer, the Contractor will have to prepare detailed working drawings indicating the positions of fittings, valves, joints, nature, type and location of supports, connections to main lines etc. Four prints of each of these detailed drawings shall be submitted to the Engineer for approval. The drawings shall be got approved before proceeding with the execution of the work. The Contractor shall obtain permission from all local statutory authorities for all proposed works prior to commencement of execution and necessary fees, etc. shall be borne by him. The Contractor should, after completion of all works, give "as built" drawings incorporating all field changes made, for reference and use of the client. The final payment due to the Contractor will be effected only after such drawings are finalized.

d) Construction shall not be started until the Contractor has received copies of such drawings upon which the Engineer has endorsed approval. The approval of the Engineer of any of the drawings shall not relieve the Contractor from his responsibility for correctness of Engineering workmanship, fit of parts, details, materials, errors or commissions of any all work shown thereon. The Engineer's approval shall constitute approval of the design, sizes of pipes and layout only. The approval shall not invalidate any claim the Owner may make for damages on account of faulty construction.

e) The Engineer will return one copy of the Contractor's drawings marked with his approval/comments. The Contractor shall furnish the Engineer 2 prints and one reproducible of all final drawings for record purposes.

19.19.4 PIPING FOR PLANT DRAIN WORKS

a) Double walled corrugated pipes, conforming to IS:16098, Part 2

For equipment (plant) drain works underground double walled corrugated pipe conforming to IS: 16098, Part 2, stiffness class SN 8 shall be used. These pipes will be used for external buried (underground) pipe lines. Work involved includes providing, jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS : 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

b) HDPE pipes conforming to IS:4984

For equipment (plant) drains works underground HDPE pipes of higher diameter conforming to IS:4984, grade PE 100, pressure rating PN 6 shall be used. These pipes will be used for external exposed pipe lines. Work involved includes providing, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

19.19.5 PIPING FOR PLANT SEWER WORKS

a) Internal sewer works

For internal sewer works of main plant buildings under floors or against walls, HDPE pipes conforming to IS: 14333, grade PE 100, pressure rating PN 12.5 shall be used. Scope of work shall include providing HDPE pipes and fittings, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Laying and jointing shall conform to IS: 7634 (Part-2).Scope shall also include cutting and trimming of pipes, preparation of bends as per requirement at site, taking suitable supports from Ceiling and walls/ preparation of bed etc. all complete as per drawings, manufacturer's specifications and direction of the Engineer.

b) External sewer works

i) For external sewers under gravity flow underground double walled corrugated pipe conforming to IS: 16098, Part 2:2013stiffness class SN 8 shall be used.Scope of work shall include providing pipes and fittings, laying or fixing in position, including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Scope shall also include laying and jointing of pipes conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

ii) For external sewers under pressure, underground HDPE pipes conforming to IS: 14333, grade PE 80, pressure rating PN 6 shall be used. Scope of work shall include providing pipes and fittings, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Scope shall also include laying and jointing conforming to IS : 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

19.19.6 WATER SUPPLY PIPING AND FITTINGS

a) All water supply pipes shall be 'C' class (heavy duty) galvanized M.S. pipes of the specified internal diameters, conforming to IS: 1239**.** The pipes shall be fixed in longest possible lengths with all necessary bends, tees and couplings, reducing tees, etc. in perfect straight lines vertically and horizontally. For joining pipes threads of tube sand fittings shall be smeared with white lead and screwed down together with jute threads smeared with lead. Exposed surfaces of pipes shall be coated with 2 coats of oil paint if required by the Engineer. G.I. pipes shall be embedded in a chase out in internal wall chase shall be filled with cement mortar when directed at no extra cost. All G.I. pipes inside shaft shall remain clear off walls by at least half an inch. They shall be fixed with galvanized malleable iron bat clamps.

b) All brass or chromium plated fittings shall be of approved make and of the best quality, heavy cast or drawn brass, thoroughly annealed and shall be seamless.

19.19.6.1 **VALVES**

Valves shall be of best quality gun metal sluice valves unless specified otherwise, of screw down type with cast iron hand-wheel. Valves up to and including 15 mm diameter shall have threaded sockets.

19.19.6.2 **SUPPORTS**

a) Supply pipes, ladders, soil drain rain water and waste pipes etc. installed in a vertical position shall be hold firmly in place by GI/ W.I. clamps unless projecting ears with fixing holes are provided at socket and of pipes or by approved inserts wall fastened to the walls or structural framing.

b) Sleeves shall be provided for all pipes passing through walls floor and partitions, except at locations specifically forbidden by the Engineer. All sleeves shall be painted steel pipes. Pipe hangers where provided shall not be wider apart than 1.5 m on centres for cast iron pipes. General scheme for support arrangement shall be got approved by the Engineer before it is erected in position. The Engineer shall have the right to increase the number or strengthen or modify the supports at site.

c) All piping, where not concealed and where location is not specifically fixed by drawings shall run parallel and as close as possible, to wall.

19.19.6.3 **PLUMBING WORK**

The pipes before being laid shall be thoroughly cleaned specially the inside of pipes if required. Socket ends of pipes shall always face upstream of effluent flow. The drains shall run in perfect straight lines between manholes. The trenches shall not be filled in until the joints have been tested and alignment of drains and connections into and from the manhole and their positions have been examined and certified and certified by the Engineer, if required. The whole of sanitary work comprising provisions of drainage and water supply arrangements including sanitary and water fittings and fixtures complete in all respects shall be carried out in accordance with the rules and regulations of the local authority through the agency of a licensed plumber. If required, the Contractor shall have to get all materials brought on site for incorporation in the work approved by the local authority at his own expense.

19.19.6.4 **PROTECTIVE PAINTING**

All exposed wrought iron clamps, steel suspenders or brackets for fixing the pipes to the wall face in case of vertical pipes and suspending the horizontal run of pipes shall be painted with one coat of zinc phosphate primer and two coats of paint of approved make and shade.

19.19.7 **TEST AND GUARANTEE FOR WATER SUPPLY, SOIL AND VENT SYSTEM**

a) Water supply lines shall be tested to a hydrostatic pressure of 12 times the design water pressure at any point over a period of 24 hours. All soils, waster, rain water pipes and vents shall be tested under a pressure of 3 meters of water. Rain water pipes shall be tested to a height of water equivalent to the height of the building plus 3 meters to ensure no leakage in case of choking sections by first installing test plugs in all openings, erecting 3 metres stand pipe, filling the system with water or by hydrostatic plus air test. Pipes shall be deemed to have passed the test, if water level in the stand pipe remains reasonably constant for a period of one hour.

b) The Contractor shall deliver to NPC upon completion of this work under this Contract a written guarantee: -

i) That for a period of one (1) year after acceptance by the Engineer, plumbing and drainage work shall be free from defective material and workmanship;

ii) That for a period of one (1) year after acceptance by the Engineer the Contractor shall be responsible for the tightness of all joints make by him;

iii) That he at his own expense, repair and replace all such defective work, and all other work damaged thereby, which becomes defective during the term of guarantee;

iv) After the completion of the work, the Contractor shall obtain and hand over to NPC necessary certificates from the local authority/authorities concerned at no extra cost to NPC.

19.20 SANITARY FITTINGS/ FIXTURES AND TOILET REQUISITES

19.20.1 MATERIAL

All sanitary fixtures shall be of the best quality from approved manufacturers. Contractor has to obtain the approval from the Engineer, the names of the manufacturer whose product he proposes to use. All fixtures shall bear the seal of the approved manufacturer. All fittings, screws, gratings, etc. shall be chromium plated. The connecting lead pipes and bends shall weigh at least 3 kg per 25 mm diameter per metre length. After the fixtures are brought to the site, the Contractor shall arrange for their inspection by the Engineer and only after the approval, the fixtures shall be installed. All broken, damaged or rejected fixtures shall be removed from the site within two days after inspection.

19.20.2 INSTALLATION

All sanitary fixtures shall be installed to required level and plumb in the best workman like manner skilled labours and it shall be securely anchored to walls and floors.

All fixtures likely to be damaged shall be covered and protected during the progress of the building work, and uncovered after completion. Fixtures and accessories shall include all anchors and screw plates, screws, bolts, toggle bolts, expansion shields, set screws, wood blockings and plugs, lead connecting lead-pipes, etc. as required by the type of fixtures and accessories selected and by the type of construction to which they are connected. All fixtures and fittings shall be connected by water-tight joints. No dripping shall be accepted. All holes in walls and floors as required shall be made to the minimum desired size and depth only and they shall be properly made good and finished to match the existing finish. All brackets, supports, etc. shall be painted with a prime coat of anti-corrosive paint.

19.20.3 SANITARY FITTINGS &FIXTURES

The contractor has to mention the names of the manufacturers of the fixtures he intends to use. The sanitary fittings &fixtures shall be as described here under.

19.20.3.1 WATER CLOSETS

a) WESTERN STYLE

European water closet shall be of premium quality of size 710*390*765 mm of approved make and shade comprising of

(i) Double siphonic pattern coupled water closet with integral 'P' trap 180 mm roughing in and 'S' trap 250 mm roughing in,in glazed vitreous chinaware of matching colour.

(ii) 10 litres capacity PVC slim type single flushing low level flushing cistern (Dual Flush Tank white) with all fittings complete.

(iii) 15 mm NB heavy quality CP inlet connection pipe with brass unions and wiped solder joints at ends.

(iv) 15 mm NB screw down easy clean variety heavy quality CP brass angle valves with C.P. flange of superior quality.

(v) Germfree EWC solid seat cover (white) with C.P. brass hinges and rubber buffers of approved brand.

(vi) Jet spray provision with 1 Meter PVC tube (stainless steel) with 01 nos 15mm dia CP brass angle valve with CP flange as approved.

(vii) 15 mm NB heavy quality GI pipes and specials for overflow from cistern upto 150 mm above floor level, concealed in wall and terminated with 15 mm NB brass mosquito proof jali etc. all complete as per direction of the Engineer.

The European water closet shall be installed properly in all line and level as per direction of the Engineer.

b) INDIAN STYLE

Orissa type water closet shall be of premium quality of approved make and shade with 'P' or 'S' trap in vitreous chinaware best quality first grade with or without vent, having size 580mm x 440 mm or equivalent. It shall have following accessories.

(i) 10 liters capacity PVC slim type single flushing low level flushing cistern Dual Flush Tank with all fittings fitted over a pair of CI or MS bracket etc.

(ii) Lead valve loss syphon 15 mm nominal size, 32 mm NB GI flush pipe heavy quality of appropriate length with brass unions at end, wiped solder joints etc. complete.

(iii) 15 mm NB GI overflow pipe concealed in wall and brought down to 15 cm above floor level with mosquito proof jali at end as per specification.

(iv) 15 mm NB heavy type CP brass inlet connection with brass unions and wiped solder joints at ends.

(v) 15 mm NB heavy type CP brass screw down angle valve with C.P. brass flange of superior quality on inlet connection, recess concreting using 1:5:10 nominal mix as per site requirements.

The scope shall include all accessories, necessary brackets, supports, fittings, screws, gratings etc., installation including cutting and making good necessary opening chases etc. all complete as per specifications, drawing and as directed by the Engineer.

The WC pan shall be installed as per manufacturer's specifications. The W.C. pan shall be sunk in floor. The floor should slope towards the pan, care being taken not to damage the pan in the process of fixing. It shall be fixed on the proper cement concrete base taking care that the cushion is uniform and without having any hollows between the concrete base and the pan. The joint between the pan and the trap shall be made with cement mortar (1 cement: 1 sand) and shall be leak proof.

19.20.3.2 URINALS

(a) LIPPED URINAL

The lipped urinal shall be of premium quality white vitreous chinaware flat back lipped front urinal of approximate basin size 465 x 355 x 265 mm of approved make with PVC flushing cistern with all fittings, fitted on CI brackets, standard size galvanised iron flush pipe, waste pipe and CP brass spreaders with brass union, push cocks, specials, connecters & stopcock, CP brass fittings etc. and GI clamps, painting of fittings and brackets, cutting chase and making good the walls etc. all complete. The urinal shall be bowl type, flat back of angular, lipped front basin and shall be of glazed stoneware. It shall be fixed in position by using wooden plugs embedded in wall and screws of proper size.

The flushing of the urinals shall done for one urinal basin with 5 litres capacity automatic or equivalent with PVC flushing cistern. The flushing of the urinals shall done for range of two urinal basins with 10 litres capacity automatic or equivalent with PVC flushing cistern. It shall be supported on a pair of C.I. cantilever brackets which shall be embedded /fixed to wall by means of wooden plug and screws. The cistern shall be connected to urinal basin by means of C.F. brass flush pipe with fittings. The pipe shall be fixed by using proper holder – bat clamps.

The joint between the urinal basin and flush and waste pipe shall be made by means of putty or white lead mixed with chopped hemp.

(b) URINAL PARTITIONS

The Urinal partitions shall comprise of be premium quality black granite of 18mm thick with rounded exposed corners etc. as approved by Engineer. It shall be in size 600 x 1000 mm or as approved by the Engineer. The scope

shall include installation of partitions by cutting the wall & making good the same after fixing the partitions in approved pattern including all materials, labour, fittings and fixtures complete as per specification and direction of the Engineer.

19.20.3.3 WASH BASINS

(a) STANDARD WASH BASIN

The standard wash basin shall be premium quality glazed vitreous chinaware wash basin of approved make and colour having size 550 mm x 400 mm or equivalent. This shall include one pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make., 32 mm NB CP brass waste coupling heavy quality with rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved., 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, One no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm dia B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti-corrosive bituminous paint etc. and accessory required for installation and fixing of the wash basin all complete as per the direction of Engineer. The wall plaster on the rear shall be cut to overhang with top edge of the basin.

(b) OVAL SHAPED WASH BASINS

The oval shaped was basin shall be of premium quality glazed vitreous chinaware wash basin of approved make and colour having size 560 mm x 450 mm or equivalent. This shall include one pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make., 32 mm NB CP brass waste coupling heavy quality with C.P. grating, rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved., 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, One no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm diameter B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti-corrosive bituminous paint etc. and any other accessory required for installation and fixing all complete as per the direction of Engineer.

19.20.3.4 SINK

(a) VITREOUS CHINAWARE LABORATORY SINK

The vitreous chinaware laboratory sink shall be of premium quality glazed conforming to BIS 771 Part-2 of bowl size 600mm x 400mm x 200mm with

integrated drain board of approved make including all fittings, CI brackets, CP brass chain with rubber plug, angle valve and connector etc. complete with 40 mm CP brass waste fitting and 40 mm CP brass trap with necessary CP brass union, CP brass connecting pipes and any other accessory as required etc. complete as per specification and direction of the Engineer. The scope includes installation of the sink as per manufacturer's specification.

(b) STAINLESS STEEL SINK

The stainless steel sink shall be of premium quality of SS grade 304 glossy finish having size 600 x 400 x 200 mm (24"x18"x8") with edges rounded off. All fittings, fixtures, waste connection etc. shall be of standard size and appropriate for use with SS sink material. Accessories shall include: GI brackets: 32 mm NB CP brass waste coupling heavy quality with rubber plug and chain: 32 mm NB CP brass bottle trap with extension piece and wall flange: 15 mm NB CP brass inlet connection with all brass unions and wiped solders joints and all accessories such as choke stop stainer, outlet pipe upto floor trap and any other accessory as required. The sink shall be installed as required complete as per specifications and direction of engineer in charge.

19.20.3.5 **WATER CONNECTION**

Water connection to flushing cistern, wash basins and sinks shall be by means of PVC/ GI pipe connection pieces, with stop C. P. Brass cocks. The size of the PVC pipe connection and stop cock shall depend upon the size of water connection.

19.20.4 **TOILET REQUISITES**

a) MIRROR

Mirror shall be of premium quality cut edge mirror 6mm thick of overall size 600X450mm especially fabricated with superior glass (of approved quality) with designer acrylic PVC frame of approved colour and make mounted all-round with 6mm thick non-water absorbent Acrylic/PVC material backing fixed with cleats using C.P. brass screws and washers all complete as per the specifications and directions of Engineer. Scope shall include supply and fixing of mirror.

b) SHOWER SETS

Shower rose shall be of premium quality easy clean CP brass shower rose. It shall include shower arm 190mm long and wall flange of superior quality with 15 mm inlet of 100 mm diameter revolving type etc. all complete. Shower sets shall be swivel type

CP brass shower rose, complete with water valve, supply pipes, and any other accessory etc. Scope shall include supply and fixing of shower rose.

c) GLASS SHELVES

Glass shelves shall be of premium quality of size 600 x 125 mm of sheet glass 6 mm thick or equivalent with CP brass brackets and guard rails, fixed to wooden cleat with CP brass screws. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

d) TOWEL RAILS

Towel rods shall be of premium quality CP brass heavy quality of size 600 x 20mm with a pair of CP brass brackets, wall flanges etc. fixed to wall with CP brass screws, screwed on to rawl plugs. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

e) LIQUID SOAP DISPENSERS

Liquid soap dispenser shall be of premium quality of CP brass with CP brass lid and brackets fixed to wooden cleat with CP brass screws. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

f) TOILET ROLL HOLDER

Towel roll holder shall be of premium quality of size 150 mm x 150 mm or equivalent recess type in white glazed vitreous chinaware including cutting into wall and making good the same all complete. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

g) COAT HOOKS

Coat hooks shall be of premium quality CP brass two pronged hooks fixed to wall / door with CP brass screws and rawl plugs including cutting and making good the wall etc. complete. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

20 BUILDING JOINTS

20.1 EXPANSION JOINTS

20.1.1 SCOPE OF WORK

The work shall include providing and installing sealed expansion joints for various buildings in accordance with the requirements and details given in the specifications, drawings, schedule of quantities, together with the manufacturer's instructions, all to the complete satisfaction of the Engineer. The typical details of Expansion joint system are given in the enclosed drawing. The drawing given here is indicative. The contractor has to get the drawing prepared & approved before its actual use. The joints shall be designed utilizing extruded aluminum base members, self aligning / centering arrangement and support plates as applicable. The work involves sealing the Expansion Joints using properly designed extruded seals which may be mechanically fastened between extruded metal shapes, depending on the application. The design shall allow for joint movement in all direction and shall guard against water ingress. The latter shall be provided for all external joints, joints in areas in contact with water and at all other locations as directed by the Engineer. The complete details of the material proposed to be used shall be furnished to the Engineer for his approval. The material shall be used only after obtaining the written approval of the Engineer. The contractor shall furnish the necessary documents, prepared by the manufacturer of the expansion joints, to enable the Engineer to satisfy himself regarding the suitability of the materials and adequacy of the design of the expansion joints.

20.1.2 The Work shall be carried out by the manufacturer or through an experienced manufacturer approved applicator, with the prior approval of the Engineer. In case, the work is carried out by the manufacturer-approved applicator, the manufacturer will have to provide the guarantee for the successful performance of total system including material & workmanship.

20.2 MATERIALS

20.2.1 The Expansion joint materials shall be procured from manufacturers such as Sanfield (India) Ltd. / Z. Tech (India) Pvt. Ltd/ BASF or any other equivalent as approved by the Engineer and shall be installed by the manufacturer themselves and not by any distributor / agent / any other externally appointed agency so as to guarantee the quality of workmanship.

20.2.2 The Material shall conform to the following Codes / Publications.

a) Aluminum Extrusions shall conform to ASTM B221. The alloy shall be 6063-T5 or Indian equivalent IS 63400.

b) Aluminum sheet and plates shall conform to properties of ASTM-B209. The alloy shall be 6063-T5 or Indian equivalent IS 63400.

c) Steel Shapes shall conform to ASTM-A36 or Indian equivalent IS: 2062.

d) Stainless Steel shall conform to ASTM-A-479 Gr. 304 or Indian equivalent IS: 6529 Gr. 0.4Cr18Ni10.

e) **Bronze Extrusions:** Materials shall be Architectural Bronze 385 Alloy.

f) **Electrometric Compression Seal**: these shall be preformed extruded multi-web cellular section of Chloroprene (Neoprene). Chloroprene shall conform to Clause 915.1 of IRC: 83 (Part II) and satisfy the Physical properties as Durometer Type "A" Shore hardness of 55±5and a tensile strength of 2000 PSI (min).

g) **Moisture barrier**: shall be vinyl EPDM / bituminous modified moisture barrier as recommended by the joint manufacturer or an approved equivalent, all as subject to the approval of the Engineer.

h) **Fire rated joint system**: shall have independent laboratory test reports reflecting the endurance result of the materials run to time temperature curve.

i) **Elastomeric Joint Systems**: Material shall be a flexible extruded poly vinyl chloride or manufacturer's alternate material exhibiting a Shore "A" hardness of 64±5 with U.V. Stabilizer. Provide multi-cellular profile able to transfer loads to adjacent aluminum extrusions. The profile shall be flexible and exhibit a non-slip exposed surface that remains flat during all phases of movement. Block-out required for installation shall be provided at site by the contractor as per the dimensions given by the manufacturer.

j) Lubricant adhesive used shall be a one-part moisture curing polyurethane and aromatic hydrocarbon solvent mixture and shall conform to ASTM D4070.

k) **Visual seal**: shall be a flexible extruded poly vinyl chloride / santoprene or manufacturer's alternate material exhibiting Shore "A" hardness of 64±5 with U.V. Stabilizer. Other properties shall be in accordance with manufacturer's standard physical properties.

l) **Functional seal**: shall be flame retardant vinyl material.

m) **Sealant**: shall be a one-part polysulphide base synthetic rubber / Silicon sealant as per Manufacturer Specifications.

n) **Self-Centering Arrangement**: shall exhibit circular sphere ends that lock and slide inside the corresponding aluminum extrusion cavity to allow freedom of movement and flexure in all directions including vertical displacement so as to accommodate multidirectional seismic movement without causing stress to Joint components.

o) The materials used for Expansion Joints (other than air seal & metazeal type joint) shall have following properties.

Item Description	Given Specification	Indian Equivalent	Parameters to be Checked	Acceptable Values

Aluminium Extrusions. / Sheets & Plates	Alloy 6063-T5	IS 63400	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 15.00 21.00 8.00
Steel Shapes	ASTM – A36	IS: 2062	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 36.00 58.00 20.00
Stainless Steel	ASTM – A 479 Gr. 304	IS 6529 Gr. 0.4C Ni10	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 30.00 75.00 30.00
Neoprene Compression Seals	ASTM – D 2628	IRC – 83 (Part II) & MORT&H Specifications	Hardness (Shore "A") Elongation (%) [Min.] Tensile Strength (MPa) [Min.] Compression Set (%) [Max.]	55 +/- 5 250.00 13.80 28.00

20.3 JOINTS FOR NORMAL LOCATIONS

The Contractor shall provide all necessary accessories, related parts, devices, anchors etc. required for completing the installation of expansion joints in following locations.

a) Floor to Floor Joints at all internal locations
b) Roof to Roof Joints
c) Floor to Wall Joints at internal locations
d) Roof to Wall Joints
e) Wall to Wall Joints in exterior locations
f) Wall to Wall Joints & Slab to Slab Joints in case of underground trenches
g) Wall-to-Wall Joints & Slab to Slab Joints in case of underground tunnel subjected to ground water pressure from outside & water pressure from inside
h) Tunnel & Wall junction in case of underground structures.

20.4 JOINTS FOR CRITICAL LOCATIONS / HYDROSTATIC CONDITION APPLICATION

In case of underground structures which are susceptible for leakage due to ground water & hydraulic structures the expansion joint shall be provided with Airseal / Aladin type of expansion joint and/or Metazil type of expansion joint of M/S Sanfield / M/s BASF/ M/s Kanta Flex or any other equivalent with approval of Engineer. These joints are to be provided on the water face or both the faces depending on the wall thickness, severity of leakage & functional requirements as specified in the drawing or as directed by Engineer. These materials shall be qualified based on water hold test to the specified pressure and shall meet the following specifications.

20.4.1 AIR SEAL/ALADIN TYPE JOINT

The work shall consist supply and installation of Expansion Joint System model Airseal/Aladin of M/s Sanfield /M/s BASF or equivalent in accordance with the approved drawings and shall meet the following specifications.

The joints shall be designed utilizing neoprene profile, air pressurization and bonding in place with a specially formulated epoxy adhesive as per specifications.

The material shall be preformed, watertight, ozone and UV resistant, resilient and flexible neoprene profile with ribs on side faces for proper adhesion and bonding with the surface. The Joint shall be installed by air – pressurization technique only. Complete adhesion of the Epoxy to the neoprene seal profile and Joint Gap walls shall be achieved by air inflation during the installation. The relaxed (uncompressed) width of the seal shall be equal to the Joint Gap value and the Seal shall be always installed in uncompressed position so as to allow maximum expansion & contraction movements. The Joint system should be able to sustain water pressures upto 2 Bars minimum.

The structural sealing joint profile shall be preformed and manufactured from an extruded neoprene compound exhibiting the physical properties listed in the table below.

TABLE 20.1
PHYSICAL PROPERTIES NEOPRENE COMPOUNDS

SL. NO.	*PHYSICAL PROPERTIES*	TEST METHOD	REQUIREMENT
1	Tensile Strength, Min.	ASTM D 412	2000 PSI
2	Elongation @ break, Min.	ASTM D 412	250 % Min.
3	Hardness, Type A Durometer	ASTM D 2240	65 + / - 5 Points
4	Oven Aging 70 hrs. @ 212 ^{o}F	ASTM D 573	
4.a	Tensile Strength	ASTM D 412	20 % loss Max.
4.b	Elongation	ASTM D 412	20 % loss Max.
4.c	Hardness	ASTM D 2240	0 to + 10 Points
5	Ozone Resistance @ 20 % Strain	ASTM D 1149	No Cracks

The adhesive used to fix the Airseal/ Aladin type joint with concrete/ steel surface shall be resistant to most common organic and inorganic acids in diluted form, also resistant to alkalis, water, oils, grease, etc. It shall have following properties.

SL. NO.	*PHYSICAL PROPERTIES*	TEST METHOD	REQUIREMENT
1	Tensile Strength, Min.	BS 6319	10 MPa @ 7days
2	Compressive Srength, Min. @ 25deg cen.	ASTM C 580	40 MPa at 1 day 60 MPa at 7 days
3	Flexural Strength	ASTM C 580	20 MPa at 7 days
4	Pot Life	ASTM C603-90	50 min at 25 deg cen. min at 40deg cen
5	Bond Strength, Min	ASTM D 4541	2 MPa.
6	Slant Bond Strength		13 MPa

7	Setting Time	ASTM D 5895	1 day Initial Cure 5 Days Final Cure

20.4.2 META ZEALTYPEJOINT

The work shall consist supply and installation of Expansion Joint System model Metazil of M/s Sanfield / M/s Z-tech or equivalent as approved by Engineer in accordance with the approved drawings and shall meet the following specifications.

The joints shall be designed utilizing a low density, closed cell, expanded polyethylene joint material and specially formulated epoxy adhesive for Bonding purpose as per specifications.

The material shall be a preformed, waterproof, ozone and UV resistant, resilient and flexible expansion Joint material. No Halocarbon gases or volatile hydrocarbons shall be used in the manufacturing of the product. The product should have a working movement range of 60% compression and 30% tension. The Joint system should be able to sustain water pressures up to 2 Bars minimum. The same shall be demonstrated conducting water hold tests simulating site conditions. The product should be suitable for Potable water applications and should have ADA Compliance. The material shall exhibit the properties listed below.

PROPERTY	TEST	REQUIREMENTS
Density, Min.	ASTM D 3575	2.5 to 3.5 lb./cf
Tensile Strength, Min.	ASTM D 3575	70 psi
Water Absorption, Max.	ASTM D 3575	1.0 %
Compression Set, 22 hrs. @ 50 %	ASTM D 1056	
24 hrs. Recovery	(Residual Set, Max.)	8 %
Elongation @ break, Min.	ASTM D 3575	175 %
Tear Strength, Min.	ASTM D 624	13 psi

NOTE: For critical Joint locations, where the thickness of structural member (wall / slab) is exceeding 230 mm. Double layer Treatment comprising of Airseal on the critical / outer exposed face i. e. the face in contact with water / earth soil and Metazeal on the inner face is to be applied.

20.5 FABRICATION

20.5.1 Aluminum sections shall have factory-drilled holes spaced as per manufacturer's recommendation. Extrusions shall be miter cut at the site to suit directional changes.

20.5.2 Extrusions shall be supplied to site in their original packing in lengths as fabricated to suit the building dimensions.

20.5.3 Steel shapes shall be supplied in lengths as fabricated to suit the building dimensions.

20.5.4 Aluminum sections shall have mill finish unless otherwise specified.

20.5.5 Steel sections shall be blast cleaned and suitably treated against corrosion prior to their dispatch to the site. The cleaned metal surfaces which come in contact with the seal shall be protected against water logging / rusting till the seal and the adhesive are placed against the metal surface.

20.5.6 The Details of the finished colours offered by the manufacturer for Stainless Steel and Elastomeric components shall be furnished to the Engineer to enable him to exercise his choice.

20.6 EXECUTION

The expansion joint system shall be installed strictly as per the manufacturer's instructions and as directed by the Engineer. The work shall be carried out by the manufacturer or through an experienced manufacturer approved applicator, with the prior approval of the Engineer. In case, the work is carried out by the manufacturer-approved applicator, the manufacturer will have to provide the guarantee for the successful performance of total system including material & workmanship.

20.7 QUALIFICATION OF MATERIALS

For qualification of material at site contractor shall supply the Test Certificates for the material confirming the properties given in above-mentioned tables. In addition to above one sample (3 specimens) from each batch supplied at site, shall also be tested at independent approved laboratory for all the desired properties listed above, in case of Neoprene compression seals & Airseal.

20.8 EXPANDED POLYSTYRENE BOARDS FOR EXPANSION AND ISOLATION JOINTS

20.8.1 GENERAL

Expansion and isolation joints in concrete structures shall be provided with expanded polystyrene boards of specified thickness and form expansion joints shall be provided with 500 micron thick polyethylene sheets as per the relevant drawings.

20.8.2 SCOPE

The scope of work covered under this specification is as follows:

- Supply and use of approved quality polystyrene boards wrapped in 250 micron thick polyethylene sheet at various expansion and isolation joints in all main plant buildings.

- Supply and use of 500 micron thick polyethylene sheets as form separation joint, wherever required.

20.8.3 MATERIAL

- High density polystyrene boards conforming to IS: 4671 of density 35 kg/m^3.
- Polyethylene sheets conforming ton IS: 5210 of 250 micron & 500 micron thickness.

20.8.4 DESCRIPTION

Heavy duty expanded polystyrene boards of specified thickness and sizes shall be wrapped all round with 250 micron thick polyethylene sheet. These boards shall be placed in the locations (both in vertical and horizontal) as specified in the relevant drawings. Polyethylene sheet shall be properly secured and tied in position with expanded polystyrene boards.

Wherever specified, 500 micron thick polyethylene sheet as form separation layer.

20.9 WATERSTOPS

20.9.1 GENERAL

Water stops made of polyvinyl chloride (PVC) or galvanised MS sheet shall be provided in construction joints as indicted in the relevant drawing and specifications for all main plant buildings including underground structures and tunnels.

20.9.2 SCOPE

The work under this specification comprises of

- Supply, delivery, install in position water stops in accordance with the requirements of specifications
- Polyvinyl chloride water stops
- PVC fix cap.
- Galvanised MS sheet water stop of 3.15 mm thick. Installation including necessary site connection by furing/welding.
- Testing of joints and DPT for 100% of the weld length.

20.9.3 MATERIALS

PVC water stops : Material shall conform to the following Standards of the American Society for Testing Materials (ASTM)

D412-66 Tentative method of Tension Testing of Vulcanized Rubber

D624-54 Standard method of Test for Tear Resistance of Vulcanized Rubber

D2240-64-TTentative method of Test for Indentation Hardness of Rubber by means of a Durometer

PVC fixocap type 38 or equivalent conforming to IS 4461

Metal water stops of 3.15 mm thick conforming to IS 2062 galvanised for dry film thickness of 60-100 microns.

20.9.4 **DESCRIPTION**

Generally water stops shall be provided in construction joints as indicated in the drawing, water stops may be PVC of different width (with or without centre bulb), fixco cap of standardtype GI water stopper of 3.15 mm thick plate made to different width. Generally, Fixo-cap shall be provided in expansion joints of underground tunnels and PVC water stops shall be provided in water retaining structures unless specified otherwise by the Enginner .. The shear key shall be provided wherever specified and the water stops are generally located in the centre of wall at the construction joints or near to the edges in case of earth retaining walls and half of width shall be embedded into concrete. Necessary holding arrangement shall be made to ensure that water stops does not displace during concreting. It should be noted that, there shall not be any through supporting arrangement in order to prevent leakages. Continuity of the water stops shall be established by fusing or welding as the case may be. PVC water stops shall be joined together by fusing and metal water stops shall be 75 mm overlapped and welded on both sides. 100% dye penetrant test shall be carried on all joints. As far as possible care shall be taken to minimise the number of joints and also in-situ fusing/ welding.

21 Aluminium Lineal False Ceiling

Aluminium lineal suspended ceiling work shall be executed in flat, tapered, curved or circular form, both in plan and in section together with coves, etc. as required as per design.

21.1 General

Aluminium lineal ceiling shall be of Hunter Douglas as manufactured by Luxalon Building Products or approved equivalent together with all accessories and fittings such as carrier and clip, carrier splice, edge cover profile and corner splices, cross "T" connection near to the wall, etc.

21.2 Materials

21.2.1 Panels

The panels shall be 84C or 84R as per Luxalon's catalogue or approved equivalent and either plain or micro perforated. The length of the panel shall be 6m approximately. The panels shall be of any colours as approved by the Engineer, according to manufacturer's colour chart.

21.2.2 Panel carriers

Panel carriers shall be 4mm dia enamelled aluminium of satin black colour as per Luxalon's catalogue. The edges shall be provided with edge cover profile with a gap of specified width from the wall.

21.2.3 Suspension

The panel shall be suspended from the suspension system as mentioned in the relevant clause by means of adjustable turn buckle / level adjuster etc. In addition to the suspension system, the panel carriers shall be suspended by means of adjustable suspension steel rods of 4mm diameter with threaded rods and nuts for micro levelling, fixed to the slab/ beam by expansion fasteners. The expansion fasteners shall be fixed with epoxy/polyester resin. Seismic anchoring and isolation shall be provided as directed by the Engineer. Bracing shall be provided as specified for Gypboard ceilings.

21.2.4 Acoustic Pads

Acoustic pads shall be laid on top of perforated panels. Acoustic pads shall be of the approved manufacturer and shall consist of an insulation of 25mm thick glass wool pad having a density of 32 kg/cum wrapped in glass cloth. The provision of these acoustic pads for perforated ceiling is deemed to be part of the quoted rate and noting extra shall be payable for the same.

21.3 **SHOP DRAWINGS**

Shop drawings shall be prepared for all suspended ceiling work by the Contractor. The shop drawings shall show the entire installation system, including framing around light fixtures, ducts, grilles, access panels, etc. Shop drawings shall be submitted to the Engineer for approval. It will be the responsibility of the Contractor to co-ordinate with all the service Contractor’s doing work in ceilings, to incorporate appropriate suspension systems free of ducts, pipes, cable trays etc.

21.4 **APPROVALS**

The Contractor shall submit catalogues, samples of all items to be used in the ceiling and samples of workmanship, for approval of the Engineer.

22 GLASS AND GLAZING

22.1 **Scope**

The work in general shall consist of supplying and fixing all glass and glazing including all clips putty, mastic cement, etc., wherever required as shown on drawings and specifications.

In general, wherever applicable and unless otherwise noted, the work shall conform to IS 1081. Fixing and Glazing of metal (Steel and Aluminium) Doors, Windows, and Ventilators.

22.2 Installation

22.2.1 General

The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions, unless otherwise stated in the drawing or schedule. All glass shall be of superior quality from approved manufacturer like Modiguard or equivalent, having uniform refractive index and free from flaws, streaks, laminations and bubbles. The glass should be free from “wavy and rainbow formation”. Float glass for glazing and framing purposes shall conform to IS : 1761 . The glass shall be brought to site in the original packing from the manufacturer and cut to size at site. The cut edges shall be straight and free from chips, spalls or any other damages. Wherever clear glass is specified, it shall be flat drawn float glass and shall be at least 6mm thick. Where wire glass is mentioned, it shall be thick rolled glass with centrally embedded wire mesh of Georgian type. Where obscure glass is mentioned, it shall have a cast surface on one side. Heat absorbent and glare reducing glass shall be 'Calorex' of Modiguard , having a thickness of 6 mm unless specified otherwise in the schedule of Quantity. The Contractor shall submit samples of glasses for prior approval of the Engineer.

22.3 Putty

In general, the putty shall conform to IS:419. The putty shall be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing. Quick setting putty shall be used for windows and sashes except when glare reducing glass is used.

Neoprene gaskets with snap-fit glazing beads shall be fixed as per manufacturer’s instruction and shall sit snugly against glass to give a leak proof installation.

22.4 Glazing, Setting and finishing

All glazing clips, bolts, nuts, putty, mastic cement, etc. as required shall be supplied by the Contractor.

All glass shall be thoroughly cleaned before putting in position. Each glass pane shall be held in place by special glazing clips of approved type. As specified in relevant IS Codes, four glazing clips shall be provided per glass pane, except for large panes where six or more clips shall be used as per the Engineer's instructions. All holes that may be necessary for holding the clips and for all other attachments, shall be drilled by the Contractor at his own cost.

Glass panels shall be set without springing, and shall be bedded in putty and back puttied, except where moldings are specified. Putty, mastic cement, etc. shall be

smoothly finished to a true even line. Obscure and figured glass shall be set with smooth side out.

Necessary glazing clips, putty mastic cement etc., shall be supplied by the Contractor. The Contractor shall be responsible for damage of glass supplied by NPCIL during handling, transportation, fixing etc. and shall replace the same at his own cost.

After completion of glazing work, the Contractor shall remove all dirt, stains, excess putty, etc. clean the glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at Contractor's own cost.

22.5 **Float glass for Doors**

Float glass for vision panels in door shall have a minimum thickness of 4.0 mm unless otherwise specified or shown on drawings.

22.6 **Acceptance Criteria**

a) All installation shall be free from cracked, broken or damaged glass. Edge of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipping cracked or ungrounded edges.

b) Glazing shall be carefully done to avoid direct contact with metal frames.

c) All glass shall be embedded in mastic or fixed by neoprene gaskets to give a leak proof installation.

d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer.

22.7 **Drawings**

The contractor has to submit the drawings based on the above specification while quoting for these items.

23 ROOFING INSULATION, WATER PROOFING ETC.

23.1 SCOPE

The work under this specification shall cover all insulation and waterproofing necessary for the roofing work as shown in the drawings.

23.2 INSPECTION OF SURFACES

Prior to start of the work, the surfaces on which waterproofing /insulation is to be applied shall be inspected by the contractor and any visible/ noticeable defects found in the surfaces shall be rectified. The water ponding test shall be conducted by

ponding water on the roof slab and maintaining minimum 50 mm head of water on it for a period of 3 days. Any noticeable leakage/ seepage shall be corrected by the contractor at no extra cost to NPCIL. The surface then shall be made clean and dry before laying screed concrete/ starting roof insulation / waterproofing work.

23.3 SCREED CONCRETE

The grading shall be provided by an under bed using M-15 grade concrete (with max 10 mm aggregate) prepared properly to the satisfaction of the Engineer Unless otherwise specified, the grading shall be done in such a way so as to ensure a run-off gradient of not less than 1 in 120. The minimum thickness at low points and/or valleys shall not fall below 25 mm. After curing the under bed for 7 days, insulation work shall be taken up with prior approval of the Engineer. The screed concrete shall be laid on the invert of gutters for maintaining slope in the gutter.

Fillets at junction of roofs and vertical walls/ pedestals etc. shall be provided along with the roof screed concrete. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

23.4 INSULATION

23.4.1 MATERIAL

In case of structure where thermal insulation requirements are specified in the drawings or as decided by the Engineer, the concrete surface shall be applied with polyurethane foam (PUF) insulation. The PUF should be a 75 mm thick layer of two components high density spray applied polyurethane resin foam. The spray PU foam is carried out by a smooth spraying or pouring (for small areas) action to obtain the fill. The spray application to be done using specially designed spraying machine. The product must comply to class B2 as per DIN 4102, part 1 and shall exhibit the following properties:

PROPERTY	**ACCEPTANCE VALUE**	**TEST METHOD**
Core Density	40 Kg/m^3	DIN EN ISO 845,
Thermal conductivity (λ),	< 0.024W/(m.K)	DIN 52612
R-Value of 50mm thick,	> 2.1	ECBC Code
Compressive Strength,	DIN 53423,	>175KPa
Flexural Strength,	DIN 53423,	> 250KPa
Closed Cells	ISO 4590	90%
Water Vapour Diffusion	DIN 52615	60
Water absorption,	DIN 52848	<2.25%

23.5 WATER PROOFING

23.5.1 FOR BUILDING ROOFS

After completion of the curing period of the roof slab/ screed concrete and insulation (wherever applicable), the top surface shall be waterproofed using a solvent free spray applied polyurethane membrane.

In case of concrete prior to application of PU membrane, the surface should be ensured to be sound, clean and free from grease, oil or loose particles, laitance free shall have at least 1.5N/mm2 surface strength and moisture content shall be less than 4%. The concrete can be considered sufficiently dry when the relative humidity at the surface falls to 75% or less when measured with a hygrometer conforming to BS 8201 Appendix A. The preferred surface pretreatment for concrete is grinding or scarifying as necessary for concrete or when the primer has become soiled or when the re-coating interval has been exceeded.

The scope of work shall cover supply and application of one coat of primer (DFT 75 micron) and polyurethane membrane of approved make for total dry film thickness of 2200 microns comprising 2000 Microns thick (DFT) base coat of aromatic/ aliphatic PU and 200 Microns thick (DFT) UV resistant Aliphatic PU top coat excluding primer on flat or curved roofs.

a) Priming shall be done when the temperature of the substrate is at least 3 degrees above the dew point with a two pack epoxy primer with outstanding resistance properties and shall contain a high level of penetrating pigment which renders superior performance when sprayed over concrete having the following properties:

PROPERTY	TEST METHOD	UNITS	ACCEPTANCE VALUE
Density	ASTM 4052	g/cc	1.09 + 0.05 at 25°C
Mixing Ratio, by weight	IS 104		As per manufacturer recommendations
Flexural Strength	ASTM C 580-02	MPa	>30 at 7 days
Tensile Strength	BS6319 Pt 7	MPa	>20 at 7 days
Compressive Strength	ASTM C 579	MPa	>65 at 1 Day >70 at 3 Days >75 at 7 Days
Adhesive Bond Strength	ASTM D 4541	MPa	>1.5 at 25°C

For acceptance of material listed in above table, Manufacturer Test Certificate (MTC) from manufacturer confirming to above specified properties except for Tensile, Compressive &Bond strength shall be acceptable. The Tensile, Compressive & Bond strength tests shall be conducted by the contractor as per QAP in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL at no extra cost to NPCIL.

On the tacky primer surface, sand shall be broadcasted using dried, graded silica sand (size 0.3 to 0.9 mm) on to applied Primer Coat prior to its hardening. The sand shall

be evenly spread over the entire primed surface at the rate of 0.8 to 1.0 Kg/m2. When the surface is sufficiently cured, the surface is vacuumed to remove any loose sand.

The waterproofing system base coat shall be solvent free, two-component, fast setting, seamless spray applied Aromatic / Aliphatic Polyurethane (PU) membrane installed over the roof on primed substrate (concrete screed) using a pneumatic machine as per the manufacturer's specifications. The machine for application shall have optional pressure monitor kit to assure on mixing ratio. The pressure gauge shall monitor the spray pressures on both sides and shall automatically shut down the sprayer in case of non-acceptable conditions, like running out of material, pump cavitation, packing failures, leaks in valves or fittings, or plugged filters. The two component spray applied PU membrane for base coat shall have a total average dry film thickness of 2000 microns (excluding primer and top coat, with no single value less than 1800 microns). It shall possess the following properties:

Sr No	**Property**	**Test Method**	**Values**
1	Solids Content	ASTM D2697	> 95%
2	Density	ASTM D1475	>1.0 g/cm3
3	Ready for Light Traffic	DIN 53213	Max. 60 seconds
4	Adhesion Strength	ASTM D4541	Minimum 3.5 N/mm^2
5	Tensile Strength	ASTM D 412	> 8 MPa
6	Impact Strength	ASTM G14	>190 N/sq mm
7	Elongation at break	ASTM D 412	>400%
8	Average Tear Propagation	DIN 53363	>35 N/mm
9	Tear strength	ASTM D624	>25 N/mm
10	Puncture Resistance	ASTM E 154	>300 N
11	Crack bridging	ASTM C 836	No crack till 5 mm crack width
12	Shore Hardness (Shore A)	ASTM D2240	>65
13	Taber Abrasion Resistance	ASTM D4060	< 70 mg
14	Water Vapor Transmission	ASTM E 96	0.11 g/m2/day
15	Root Resistance	DIN 4062	No penetration

For acceptance of material listed in above table, solid content, density, tensile strength, % elongation at break, crack bridging & shore A hardness shall be performed in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL for every individual batch. For all other tests, MTC from manufacturer conforming to above specified properties shall be acceptable. Pull off adhesion test shall be done at site as per relevant standards using a portable pull off adhesion tester. All the laboratory tests shall be conducted by the contractor as per QAP at no extra cost to NPCIL.

b) The solvent free, two-component, spray applied base Polyurethane membrane system shall be protected using a two-component polyurethane UV stable aliphatic top coat having average 200 microns thick DFT (with no single value lesser than 150 microns). The top coat material shall have following properties:

Sl No.	Property	Test Method	Values
1.	Elongation at break (14 days)	ASTM D 412	>150%
2.	Tensile Strength (14 days)	ASTM D 412	>10 Mpa
3.	Tear strength	DIN 53515	>60 N/mm
4.	Density (Mixed)	At 20ºC	1.2 g/cm^3
5.	Viscosity (Mixed)	ASTM D2393	2000-4000 CPS at 23 degree C
6	Accelerated UV resistance	ASTM G 154	>1000 hours i.e No cracking, blistering or flaking
7	Shore A Hardness	ASTM D 2240	89

For acceptance of material listed in above table density, tensile strength, % elongation at break & shore "A" hardness as applicable shall be performed in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL for every individual batch. For all other tests, MTC from manufacturer confirming to above specified properties shall be acceptable. All the laboratory test shall be conducted by the contractor as per QAP at no extra cost to NPCIL.

23.6 PROTECTION SCREED CONCRETE

The water proofing done on roof other than OC dome shall be protected against damage due to working of other agencies on the roof top, wherever specified or decided by the Engineer. The membrane shall be overlaid with a layer of M-15 grade concrete (with max 10 mm aggregate) for a thickness of 50mm. The concrete shall be laid in panels of 2m x 2m, with an expansion groove 10 mm wide and 15 mm deep between the panels. The expansion groove shall be sealed with polyurethane sealant.

23.7 TESTING OF THE ROOF WATER PROOFING

The water proofing system on roof other than OC dome shall be tested by ponding water for a depth of 50 mm over the membrane layer, before laying the protective screed concrete. The water shall be retained for a period of 24 hrs and inspected for leakages if any. In case leakage/ seepage of water is observed, the contractor shall identify the leakage/ seepage spots and take corrective action as per manufacturer's recommendations at no extra cost to NPCIL. Repair procedure shall have the approval of the Engineer. The cost of testing the water proofing system is deemed to be included in the item rate for water proofing.

23.8 PROJECTING PIPES AND PEDESTALS ON ROOF TOP

The pedestals on the roof top and pipes passing through a roof on which water proofing treatment is to be laid, a cement concrete angle fillet shall be built around it. The spray PU water proofing treatment shall be taken over the fillet in the manner shown in drawings. Where pipe is passing through pipe sleeve embedded in concrete, a 20 mm Square groove shall be cut at top of concrete around pipe sleeve and the

same shall be filled with a hydro-swelling polymeric paste of 1.5kg/litre mix density. The paste shall be formulated to exhibit low premature swelling (less than 50% within 12 hours) and shall not release super absorbents during its service life. The re-swelling paste shall have low swelling pressure; not exceeding 0.25 MPa at full swelling capacity; confined between mortar & cement concrete angle fillet.

23.9 QUALITY ASSURANCE & SUPERVISION

A detailed work procedure in line with this specification and manufacturer's specification with resources deployment shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work. Contractor shall carry out testing of materials as per direction of Engineer and shall submit testing reports and manufacturer's test certificates to the Engineer. A strict check on coating thickness and consumption of coating material shall be exercised by Contractor's QA Engineer and necessary records in this regard shall be submitted to NPCIL. Contractor shall provide necessary assistance to NPCIL in supervision of roof insulation and water proofing work and checking of PU coating thickness.

During the entire process of work under this specification, the Contractor shall arrange at his own cost the supervision of the work on insulation, water proofing and flashing by the manufacturer's representative to ensure that the work is being executed as per manufacturer's specifications and instructions.

23.10 GUARANTEE

The Contractor shall be responsible for maintaining the roof top insulation for a period of 10 years from the date of acceptance of the water proofing work by the Engineer. The Contractor shall make periodical inspection especially before start of the rainy season and repair the waterproofing for any apparent defects to ensure effectiveness of water proofing during the guarantee period.

The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for 10% of the cost of roof insulation and water proofing works carried out. The bank Guarantee shall be valid for a period of five years from the date of acceptance of the water proofing work by NPCIL.

24 SURFACE DRAINS, UNDERGROUND TUNNELS, TRENCHES, SEWAGE CONVEYING SYSTEM ETC.

24.1 SCOPE

This specification covers furnishing all materials, plant, labour, equipment tools and services for the complete and proper construction of storm water, surface drainage, pitching using fly ash bricks and culverts as specified herein and shown in the drawings including all surveying and setting out necessary for the same and clean up of working areas.

24.2 GENERAL

All drains and culverts shall be constructed at the locations shown in the drawings or as directed by the Engineer. Care shall be taken to avoid clogging of the drains during progress of the work and should any drain become clogged or obstructed from any cause until final acceptance of the work, it shall be cleaned in a manner as approved by the Engineer or replaced by the contractor at no extra cost to NPCIL.

24.3 EXCAVATION

Excavation for storm water/ surface/ cut off drain and for culverts/ for laying RCC hume pipes shall be carried out as per the requirements covered in the technical specification for 'Excavation, Dewatering and Backfilling'

The excavated material shall be removed from the excavated/ adjoining area and disposed of at location(s) as directed by the Engineer.

24.4 STORM WATER/ SURFACE DRAINAGE

Where shown in the drawings, storm water/ surface drainage shall be constructed consisting of RCC trenches. Storm water/ surface drains shall be placed to prevent ground water from flowing directly into the structures and shall be constructed to a line and grade to allow proper drainage over the area of the site to the nearest natural drainage and in turn to the nearest natural water body. The contractor shall construct the storm water/ surface drainage system as per the details shown in the drawings.

24.5 PITCHING

Fly ash bricks of nominal size of 230x110x70 mm having compressive strength of minimum 75 Kg/sq cm shall be used in the work. Bricks shall be laid over sloped/ flat surfaces of the drain over well prepared and compacted bed of insitu soil. The joints between the bricks shall be filled with 1:6 cement mortar. Provision of weep holes with filter media etc. shall be provided in the pitching.

24.6 CUT OFF DRAINAGE

Where shown in the drawings, deep cut off drains shall be constructed at the various elevations to a line and grade to allow lowering of ground water levels and to arrest seepage water and surface runoff and direct the same to the nearest natural drainage for further flow to the nearby water body. The cut off drains shall consist of deep trenches, with concrete lining finished smooth of the bottom and the side facing as given in the drawing.

24.7 CULVERTS

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per drawings and as directed by the Engineer after clearing the site etc. as per specifications of Earthwork. The construction of culverts shall be done true to

line and levels as shown in drawings. The specification for masonry and/or plain and reinforced concrete shall be followed as applicable**.**

24.8 REINFORCED CONCRETE SPUN PIPES

24.8.1 GENERAL

The drainage pipes unless otherwise shown in the drawings or instructed by the Engineer shall be made of R.C.C. and shall be of class NP3.

Pipe culverts shall also be made of reinforced concrete pipe and shall be of class NP3. All pipes materials shall meet the requirements of IS: 458-Latest edition and shall be procured from approved manufacturers with collars as per manufacturers standard specifications.

24.8.2 APPLICABLE CODES

The manufacture, testing, supplying, jointing and testing of pipes at worksite shall comply with the code of practices, latest revisions, as given below:

IS: 456 Code of practice for plain and reinforced concrete

IS: 458 Specification for concrete pipes (with and without reinforcement)

IS: 783 Code of practice for laying of concrete pipes

IS: 3597 Method of tests for concrete pipes

24.8.3 CARTING AND HANDLING OF PIPES

Pipes and fittings shall be transported from factory to work sites by the Contractor and he shall be responsible for the safety of the pipes in transit and loading/unloading. Any pipe, which shows sufficient damage to preclude it from being used, shall be discarded. Dragging of pipes along concrete or similar pavements shall not be allowed.

24.8.4 STORAGE OF PIPES

Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom to keep the stack stable. The stack shall be in pyramid shape with height of pyramid not exceeding 1500 mm.

24.8.5 LAYING OF PIPES

a) Laying of concrete pipes shall correspond to IS: 783 – Latest edition – and specification given below. Safety requirements to be provided while laying of pipes shall conform to IS: 3764.

b) The foundation bed for pipe shall be excavated true to lines and grades shown in the drawings or as directed by the Engineer. When trenching is involved its width on either side of the pipe shall not be less than 150 mm not more than one-third the diameter of pipe unless otherwise instructed / permitted by the Engineer. The sides of the trench shall be as nearly vertical as possible. Side slope, shoring, bailing out water, etc. as required shall be done by the contractor without any extra cost. Side slope, if there be any, shall be removed by the contractor without any extra cost. Pipes shall be carefully lowered with the help of tripods with chain pulley blocks or any other mechanical means in the approved trenches. In no case pipe shall be dropped. Pipes damaged during lowering shall be rejected by the Engineer. After laying of the pipes are completed, back-filling of the trenches shall be done in 250 mm layers measured loose, clods and lumps broken, watered and compacted with iron rammers to the satisfaction of the Engineer. The surplus spoils shall be transported and filled in low-lying areas within the plant area, as instructed by the Engineer.

c) When bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock / boulders in the area shall be removed and space filled with approved earth free from stone of fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

d) Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

e) When two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

f) Laying of pipes shall start from the outlet and proceed towards inlet. Pipes are to be laid perfectly true both in alignment and to gradient specified. Pipes must be secured in place with approved backfill material tamped under it except at the collar. Precaution shall be taken to ensure that dirt do not enter jointing space. Pipes shall be laid such that the marking on pipes appears at the top of the pipes.

g) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS: 783 – Latest edition – having a projection ratio of not greater than 0.70, in which the pipe shall be carefully bedded on fine granular materials in an earth foundation, carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height, and in which the earth filling material shall be thoroughly rammed and tamped in layers not exceeding 15 cm in depth around the pipe for the remainder of the lower 30 percent of its height.

h) If the pipe is laid in trench, pipe bedding shall be first class bedding as per IS: 783.

i) When indicated on the drawings or directed by the Engineer, the pipe shall be bedded on a cradle constructed of concrete having a mix not leaner than N/20. The shape and dimension of the cradle shall be as indicated on the drawing or directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete has set.

j) The drop walls shall be made with first class brickwork or stone masonry in 1:4 cement mortar.

k) The pipe culverts shall be made with proper care regarding the invert of the pipe, gradient, if any, etc. as specified on drawings and / or instructed by the Engineer.

24.8.6 Where R.C.C. pipes are encased in concrete at road crossings or at other places the pipes shall be suitably supported avoiding reinforcements of concrete blocks, and joints properly done before concreting is taken up. Concreting of total height of the block may be done in one single operation or may be done up to some height for pipes to be properly laid in position and the remaining height of the block concreted subsequently.

24.8.7 The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part cement and 2 parts of clean sand with only enough water for workability. Procedure of jointing shall be as per IS: 783 – Latest edition.

24.9 ROOF DRAIN PIPING

24.9.1 Double walled corrugated pipe (For underground works)

Underground double walled corrugated pipe conforming to IS: 16098, Part 2, stiffness class SN 8 shall be provided for roof drains works. The scope of work includes supplying pipes including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes and any other fitting, fixtures, accessories required to complete the job etc. all complete as per manufacturer's specification and direction of the Engineer.

24.9.2 HDPE pipes for Roof drains works (Above ground)

HDPE pipes conforming to IS: 4984, grade PE 100, pressure rating PN 6 shall be used for elevated roof drain works. Scope of work includes supply of pipes including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. and any other fitting, fixtures, accessories required to complete the job etc. all complete as per manufacturer's specification.

24.9.3 RAIN WATER DOWN COMERS

24.9.3.1 GENERAL

Rain water down comers shall be ultra violet stabilized UPVC rain water pipes conforming to IS: 13592 Type-A and shall run along the exterior wall / column surface of all main plant buildings, unless specified otherwise.

24.9.3.2 SCOPE

The scope of work comprised in this specification are as follows:

- Supply, erection, fixing UPVC pipes at various elevations of main plant buildings including UPVC/ heavy cast iron roof drain and floor drain, all fittings and fixtures and including leak testing of the erected system.

- Supply, fixing necessary fittings inclusive of shoes, gratings, bends, sockets etc.

24.9.3.3 MATERIALS

- Ultra violet stabilized UPVC rain water pipes conforming to IS: 13592 Type-A and fittings conforming to IS 5382/ IS14735.

24.9.3.4 DESCRIPTION

Rain water down comers shall run along the exterior surface of walls/ columns and longitudinally over the roof and to be secured well to walls/ columns with strong clamps/ brackets as specified in the relevant drawings. Where desired by the Engineer these may have to be installed in chases cut in the structure. The brackets may be of galvanized iron/ anti-corrosive material clevis type, split ring or perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer shall be provided against the vertical surface. All bends and junctions shall be supplied with water-tight clean outs.

Roof drains at top shall be provided at locations as specified in the drawing and shall be provided with suitable MS gratings where ever specified.

25 QUALITY CONTROL, SURVEILLANCE AND ASSURANCE REQUIREMENTS

25.0 SCOPE

This chapter specifies requirements to be incorporated in the Contractor's quality assurance program for construction. The Contractor is responsible for planning and developing a program that assures that all his management, design and technical responsibilities for quality are incorporated and executed effectively. The program is aimed primarily at ensuring an efficient quality management in construction and taking corrective actions, when necessary.

Planning and detailed written procedures are essential for specifying how such activities as the following, which affect quality, are to be performed and controlled.

a) Design management whenever applicable

b) Procurement

c) Construction

d) Special processes

e) Measuring and testing equipment

f) Inspection and test

g) Handling, storing, preservation, packaging and shipping.

h) Item identification and traceability

i) Documentation and quality records.

j) Disposition of non conformances and corrective action.

25.1 APPLICABILITY

The requirements of this chapter apply to the construction activities when specified in a contract.

25.2 CONTRACTORS RESPONSIBILITIES

The Contractor's responsibilities

a) To develop and implement the controls and quality assurance procedures, specified herein, that will promptly detect and dispose of, or prevent, non-conformances to contractual requirements.

b) To comply with the NPCIL's requirements as specified in the contract.

c) To prepare a quality assurance manual which shall be submitted for the Purchaser's concurrence before the contract is awarded or at the latest before the work starts. This manual should cover activities of building design consultant, proof check consultant and building contractor and their subcontractors.

d) To prepare a quality plan which shall be submitted to the Purchaser before the work starts, as required in 25.3.3 (b).

e) To update and resubmit the quality assurance manual and quality plan to reflect current practices when significant changes occur in the Contractor's program or organization in order to improve its effectiveness or to prevent recurrence of non-conformances.

f) To initiate corrective measures promptly when the quality assurance representative notifies the Contractor of deviations from established requirements.

25.3 DEFINITIONS AND REQUIREMENTS

25.3.1 QUALITY ASSURANCE PROGRAM

The Contractor shall plan, establish, implement and maintain a quality assurance program that complies with the requirements of this chapter.

25.3.2 ORGANISATION

The Contractor shall :

a) Clearly define management policies, objectives and responsibilities for quality assurance, including the responsibility of each division within a multi-divisional organization. The responsibility and authority for quality of those managing and performing the work and of these auditing and verifying conformance to quality requirements shall be defined and their relationships shown on organization charts.

b) Provide for the review by management of the status and adequacy of the quality assurance program.

c) Appoint a representative who shall report regularly to management at a level that ensures that quality assurance requirements are not subordinated to design, manufacturing, construction or delivery and define his authority to resolve quality matters. Purchaser shall be notified of the appointment in writing.

d) Define the responsibility and authority of personnel who are primarily responsible for quality assurance and their organizational independence during audits and define the responsibility and authority of personnel who are primarily responsible for quality control and their organisational independence to :

- identify and record quality problems
- initiate or recommend or provide solutions through designated channels.
- verify the implementation of dispositions.
- control further processing, delivery or installation of a non-conforming item or service until the deficiency or unsatisfactory condition has been resolved.

Note that, generally, audit personnel shall not be within the pattern of daily activities.

e) Use competent persons for inspection, other than those performing or directly supervising the work being inspected, unless specifically designated otherwise in the quality plan. Such persons shall report to an adequate level of management,

excluding direct reports to supervisors responsible for producing the work being inspected.

Generally, inspectors shall verify the conformance to the specifications and drawings. In cases of problems or difficulties they shall request clarification from the design or other competent organisations and initiate appropriate measures.

If examinations, being a part of the whole inspections, are performed and documented by works personnel, the extent of the inspections by the independent personnel may be reduced, if such has been provided for by the quality plant.

25.3.3 **QUALITY ASSURANCE DOCUMENTS**

a) **QUALITY ASSURANCE MANUAL**

i) The Contractor shall :

- Prepare a quality assurance annual, approved and signed by a senior management official, and submit it for the Purchaser's concurrence before the contract is awarded or at the latest before the work starts. A quality assurance manual submitted under a previous contract or tender maybe referred to.

- Review and update the manual to reflect current quality assurance polices and procedures and resubmit the resulting manual.

- Implement the program according to the provisions specified in the manual.

ii) The quality assurance manual shall deal as appropriate with the following :

Organization - The manual shall define the organizational measures as specified 25.3.2.

Quality plan - The manual shall identify the group responsible for the quality plant specified in 25.3.3 (b) and define its main principles and features in adequate procedures.

Quality assurance procedures - Documented quality assurance procedures as specified in 25.3.3(c) shall be included or shall be outlined and cross- referenced. Referenced QA procedures shall be made available to the quality assurance representative.

Manual review - A statement shall be incorporated for reviewing and updating the manual as specified in 25.3.3. (a)(i).

b) QUALITY PLAN

i) The Contractor shall :

- Plan the inspection and test activities

- Identify in the quality plan the inspections and tests to be performed on the items listed in the contract, in compliance with contractual and/or technical requirements.

- Submit the plan for the Purchaser's concurrence following the award of the contract and before the work starts. Referenced inspection and test specifications and/or procedures shall be made available to the quality assurance representative during the implementation of the quality plan.

- Update the plan during the life of the contract to reflect current conditions of manufacturing, construction, inspecting and testing and resubmit the plan to the Purchaser.

b) ii) The quality plan may be of any format to suit the Contractor's system. The quality plan shall deal as appropriate with :

- Identification of the characteristics or items to be inspected and tested.

- Identification of required inspection, test and special process operations and their relative location in the construction cycle. The Contractor may include additional in-process inspection points for his own evaluation of quality which will not be subject to acceptance and witness by the quality assurance representative.

- Reference to inspection, test and special process procedures, standards, acceptance criteria and sampling plan, if any.

- Indication of hold points beyond which the activity shall not proceed until the required inspections or tests have shown satisfactory results and have been documented.

- Provisions for the Purchaser to insert witness points at which activities are to be observed. The activity may nevertheless proceed beyond a witness point should the Purchaser fail to attend in spite of due notification.

b) iii) The quality plans for subcontracted items, when concurred with by the Contractor, shall be submitted to the Purchaser as applicable, for concurrence & insertion of witness points.

c) <u>QUALITY ASSURANCE PROCEDURES</u>

The Contractor shall have procedures for the following specific requirements should they apply to the contract :

Document control	Cl.25.3.3
Design Control	Cl.25.3.5
Procurement	Cl.25.3.6
Measuring and testing equipment	Cl.25.3.7

Inspection and test	Cl.25.3.8
In-process inspection	Cl.25.3.9
Final inspection	Cl.25.3.10
Inspection status	Cl.25.3.11
Identification and traceability	Cl.25.3.12
Preservation, handling and storage	Cl.25.3.13
Construction	Cl.25.3.14
Special processes	Cl.25.3.15
Quality records	Cl.25.3.16
Non-conformances	Cl.25.3.17
Corrective actions	Cl.25.3.18

Each QA procedure shall define, as applicable, such things as: its purpose and scope; who is responsible for what; how all steps are to be performed; what materials, equipment and documentation are to be used; how it is all controlled.

Forms used shall be exhibited.

QA procedures shall be updated when necessary.

25.3.4 SPECIAL REQUIREMENTS

The Contractor shall

a) Establish measures to ensure that all essential quality related documents including but not limited to those listed below are reviewed for adequacy and approved for release by authorized personnel.:

i) Quality assurance manual required by 25.3.3 (a)

ii) Quality plan required by 25.3.3 (b)

iii) Quality assurance procedures required by 25.3.3(c)

iv) Design documents required as a consequence of 25.3.5

v) Procurement documents required by 25.3.6

vi) Calibration procedures required by 25.3.7

vii) Inspection and test procedures required by 25.3.8

viii) Manufacturing documents required by 25.3.13

ix) Special process procedures required by 25.3.15

b) Establish distribution lists for the above mentioned documents, update and maintain them in the current form to assure that the proper personnel are issued

with all the documents necessary to perform the work.

c) Make the applicable issues of these documents available at areas where these activities are performed.

d) Establish and update lists of applicable documents for construction and distribute them systematically. Controlled distribution is required for these lists only.

e) Ensure that changes to documents receive the authorizations by the same organizations as the initial documents unless other organizations are specifically designated. Maintain a record of changes as they are made. Written notes or documents are acceptable provided that they are made by authorized persons according to established procedures. Documents shall be revised and re-issued after a practical number of changes have been issued.

25.3.5 DESIGN CONTROL

a) General

The supplier shall establish and maintain documented procedures to control and verify the design of the product in order to ensure that the specified requirements are met.

b) Design and development planning

The supplier shall prepare plans for each design and development activity. The plans shall describe or reference these activities, and define responsibility for their implementation. The design and development activities shall be assigned to qualified personnel equipped with adequate resources. The plans shall be updated as the design evolves.

c) Organizational and technical interfaces

Organizational and technical interfaces between different groups which input into the design process shall be defined and the necessary information documented transmitted and regularly reviewed.

d) Design input.

Design input requirements relating to the product, including applicable statutory and regulatory requirements, shall be identified, documented and their selection reviewed by the supplier for adequacy. In complete, ambiguous or conflicting requirements shall be resolved with those responsible for imposing these requirements.

Design input shall take into consideration the results of any contract review activities.

e) Design output

Design output shall be documented and expressed in terms that can be validated against design input requirements.

Design output shall :

i) Meet the design input requirements.

ii) Contain or make reference to acceptance criteria;

iii) Identify those characteristics of the design that are crucial to the safe and proper functioning of the product (e.g. operating, storage, handling, maintenance and disposal requirements).

Design output documents shall be reviewed before release.

f) Design review

At appropriate stages of design, formal documented reviews of the design results shall be planned and conducted. Participants at each design review shall include representatives of all functions concerned with the design stage being reviewed, as well as other specialist personnel, as required. Records of such reviews shall be maintained .

g) Design verification

At appropriate stages of design, design verification shall be performed to ensure that the design stage output meets the design stage input requirements. The design verification measures shall be recorded.

NOTE : In addition to conducting design reviews, design verification may include activities such as

- performing alternative calculations.
- Comparing the new design with a similar proven design,, if available.
- Undertaking tests and demonstrations, and
- Reviewing the design stage documents before release.

h) Design validation

Design validation shall be performed to ensure that product conforms to defined used needs and / or requirements.

NOTES:

11. Design validation follows successful design verification .

12. Validation is normally performed under defined operating conditions.

13. Validation is normally performed on the final product, but may be necessary in earlier stages prior to product completion.

14. Multiple validations may be performed if there are different intended uses.

i) Design changes

All design changes and modifications shall be identified, documented, reviewed and approved by authorized personal before their implementation.

25.3.6 PROCUREMENT

a) Selection of Subcontractors

The Contractor shall identify items to be procured. He shall undertake the following :

i) Determine for these subcontracted items the applicable Quality Management Requirements. Classification of these Quality Management Requirements shall be in such a y that the overall quality is not impaired. The classification list shall be submitted to the Purchaser for acceptance.

ii) Evaluate and select subcontractors in accordance with of the applicable Quality Management Requirements with regard to their ability to meet subcontract and quality requirements.

iii) When `off the shelf' items are to be procured, evaluation of subcontractor may not necessarily be required. The Contractor shall nominate to the quality assurance representative those materials, parts and components that belong to this category.

b) SUBCONTRACT REQUIREMENTS

The Contractor shall include in subcontracts the following, as applicable:

i) A clear description of the items or services to be procured including technical data and inspection and test requirements by reference to standards, technical specifications, drawings, etc.

ii) A designation of the applicable Quality Management Requirements to be applied to the items and exceptions, if any.

iii) A designation of the Contractor's QA procedures to be implemented by the subcontractor, if applicable.

iv) Instructions for the submission, retention and disposition of quality records.

v) Requirements for packaging and shipping, where applicable.

vi) A statement related to the right of access to the subcontractor's premises and records for audit and/or surveillance by the Contractor or the Purchaser.

vii) Instructions for notification of witness points.

viii) Requirements for the subcontractor to report non-conformances.

ix) Applicable requirements to be extended to lower tier subcontractors, if any.

Subcontract documents shall be reviewed and approved in accordance with 25.4.4 (a).

All unpriced subcontracts and associated reference data shall made available on request for review by the quality assurance representative.

c) **Amendments to Subcontracts**

The Contractor shall process amendments to sub- contracts in the same way as the initial subcontract and reference the initial subcontract number in the amendments.

d) Verification of the Quality Management System Implemented by the Sub-contractor Refer applicable Quality Management Requirements.

e) **Receiving Inspection**

To the extent that is practical, receiving inspection shall be specified in the quality plan.

The Contractor shall:

i) Identify and inspect items on receipt to ascertain that they comply with contractual requirements. In determining the amount or nature of receiving inspection, consideration shall be given to the surveillance exercised at source and documented evidence of quality conformance. Receiving inspection shall cover as a minimum: verification of deterioration or damage during transport, identification control, review of required documentation.

ii) Initiate corrective action with sub-contractors when non-conforming items are received, as required by the nature and frequency of non-conformances.

iii) Hold incoming items until the required inspection and/or test have been completed or the necessary inspection and/or test reports have been received and verified except when items are released under positive recall.

25.3.7 MEASURING AND TESTING EQUIPMENT

All measuring and testing equipment and devices used to verify characteristics that can affect item quality shall be controlled and maintained. At prescribed intervals, or prior to use, they shall be calibrated and adjusted against certified equipment having a known valid relationship to nationally recognized standards. Where no national standards exist, the basis employed for calibration shall be documented.

No special calibration and control measures are necessary on rulers, tape measures, levels and other such devices, if normal commercial practices provide for adequate accuracy and/or if large tolerances are allowed for the corresponding measurements.

The Contractor shall:

a) Include in calibration procedures; equipment type, frequency of checks, description of check method, acceptance criteria and action to be taken when results are unsatisfactory. Exception will be allowed for measuring and testing equipment for which calibration is simple and does not require a specific detailed procedure. The Contractor shall identify those types of measuring equipment for which he has not provided calibration procedures.

b) Identify measuring and testing equipment with a tag, sticker, or other suitable indicator to show the calibration status.

c) Maintain calibration records for measuring and testing equipment.

d) Assess and document the validity of previous inspection and test results when measuring and testing equipment are found to be out of calibration.

For concreting and earthwork activities :

e) The above mentioned requirements are mandatorily applicable only to the following equipment and instruments :
- laboratory scale
- concrete batching plant
- compression test machine
- tensile test machine
- prestressing pressure gauge
- soil-cement batching plant
- gauge for mechanical splicing
- grout batching machine

For all other equipment and instruments, the requirements are non-mandatory but they may be used as a guide.

25.3.8 INSPECTION AND TEST

a) The Contractor shall provide for the performance of inspections and tests as specified in the quality plan. These inspections and tests shall be carried out in accordance with written procedures that define the method, the materials, instruments or equipment to be used and acceptance/rejection criteria.

The Contractor shall amend the selected inspection methods in cases where their unsuitability is demonstrated.

b) Inspections and tests shall be documented on inspection and test reports that identify as a minimum the item inspected or tested, applicable drawings, specifications or procedures, the date of inspection or test, the inspector, tester or data recorder, the type of observation, the results, the acceptability and the action taken in connection with any deficiencies identified.

25.3.9 **IN-PROCESS INSPECTION**

The Contractor shall:

a) Identify, inspect and/or test items as required by the quality plan.

b) Monitor process methods, where inspection is not feasible.

c) Hold items until the required inspections and/or tests have been completed or necessary reports have been received and verified except when items are released under positive recall. Release under positive recall shall not preclude (a) above.

For concreting activities :

i) The Contractor shall establish adequate measures for preconcreting, in-process and post-concreting inspections to be performed as applicable.

ii) A part of these inspections and the documentation thereof may be delegated to the works personnel. In such cases, the independent inspections can be reduced to an extent to be defined in the quality plan or in the inspection procedures.

This applies particularly to the case where a specialist is incorporated into the work staff for difficult or sophisticated tasks such as reinforcement placing, prestressing, etc.

iii) Such measures do not preclude complete independent inspections to be performed on a programd basis or as a consequence of results obtained.

25.3.10 **FINAL INSPECTION**

The Contractor shall :

a) Identify, inspect and/or test the completed item as required by the quality plan.

b) Verify that the item has been inspected at all points shown in the quality plan and that the records are adequate and complete.

25.3.11 **INSPECTION STATUS**

The Contractor shall :

a) Provide means for assuring that required inspections and tests are performed and that the acceptability of items with regard to inspections and tests performed is known throughout manufacturing and construction.

b) Establish and maintain a system for identifying the inspection/acceptance status by means of tags, stamped impressions, or other physical means to be affixed to the item or its container or by means of inspection records.

c) Show the identity of the Contractor and his inspector on any inspection marking used.

d) Provide for measures for controlling status indicators including the authority for application and removal of tags, stamps or other marking.

e) Identify non-conforming items.

25.3.12 **IDENTIFICATION AND TRACEABILITY**

The Contractor shall establish and maintain as adequate system to :

a) Identify each item (lot, component or part) to the applicable drawing, specification or other technical document, throughout the whole construction process.

b) Assign to each item a unique identification where specific traceability is required by the contract.

c) Record this identification on all process, inspection and test records, where traceability is specified.

d) List the items that do or do not require traceability concerning concrete activities.

25.3.13 **PRESERVATION, HANDLING AND STORAGE**

The Contractor shall :

a) Establish, maintain and document a system for the preservation, storage and handling of all items from the time of receipt through the entire construction process and subsequent storage to prevent abuse, misuse, damage, deterioration or loss.

b) Periodically inspect stored items for condition and shelf-life expiry.

c) Inspect and test-special handling tools and equipment at specific times to verify that the tools and equipment are adequately maintained and will not damage the items and will ensure safe and adequate handling.

d) Use specific written procedures for lifting of critical or high value items.

25.3.14 **CONSTRUCTION**

a) The Contractor shall clearly define the responsibilities for the documented preparation of works.

This written preparation shall consist of instructions or work assignments. It shall be established in accordance with the construction schedules and be available to the works and inspection personnel prior to commencement of work. This work instruction will document the following :

- Work methods
- sequence of operations
- workmanship criteria
- type of equipment needed
- special working environment, if any.

For concreting and other common civil work activities, these instructions may be included in drawings, specifications or other design documents.

b) The Contractor shall ensure that prior to release for construction all jigs, fixtures, tooling masters, templates, and patterns used for verifying quality are controlled. The extent and frequency of tool control shall be defined.

25.3.15 **SPECIAL PROCESSES**

The Contractor shall :

a) Identify those special processes subject to the requirements of this clause. Special processes shall include welding, heat treating and non- destructive examination, as applicable.

b) Establish documented procedures to assure that these processes are accomplished under controlled conditions by qualified personnel using qualified documented procedures and suitable equipment in accordance with applicable codes, standards, specifications, criteria and contractual requirements.

c) Maintain documentation for currently qualified personnel and processes according to the requirement of pertinent codes and standards.

d) Define the necessary qualifications of personnel and procedures for special processes not covered by existing codes or standards, or where item or service quality requirements exceed the requirements of established codes or standards.

e) Not consider concreting as a special process. However, the Contractor shall ensure that foremen and vibrator operators are properly selected from experienced or trained personnel prior to assignment of works and are given regular training by concrete placement experts as needed.

25.3.16 **QUALITY RECORDS**

The Contractor shall :

a) Maintain quality records as evidence that :

i) The quality assurance program meets the requirements of these Quality Management Requirements (manual, procedures, quality plan).

ii) The items or services meet contractual or other applicable technical requirements (specifications, drawings, calculations, manufacturing, inspection and test procedures).

iii) Personnel and procedures for special processes are qualified as required by 25.3.15.

iv) Measuring and testing equipment is calibrated as required by 25.3.7

v) The procurements meet the requirements of 25.3.6

vi) Corrective actions are being taken and are effective as required by 25.3.18

vii) Audits are performed as required by 25.3.19.

b) Maintain final performance quality records which include as appropriate :

i) as build records
ii) material test reports or certificates
iii) non-destructive examination records or certificates.
iv) inspection and test records.
v) non-conformance reports.
vi) concrete batch plant printout.

Items (iii) and (iv) apply to those operations performed after receipt of materials from the supplier.

c) Identify, index and file quality records for easy retrival.

d) Retain quality records for the time specified in the contract. If not specified, final performance quality records shall be retained for 10 years.

e) Provide a suitable environment for storing of records to minimize deterioration or damage and to prevent loss (the use of a double filing system is an acceptable

method).

25.3.17 **NON-CONFORMANCES**

The Contractor is responsible for the identification and disposition of all non-conforming items, including those of sub-contractors. Final acceptance of the Contractor's disposition of those items that violate contractual requirements is the prerogative of the Purchaser. The Contractor shall :

The Contractor shall :

a) Verify NPC certification.

b) Examine NPC supplied items on receipt for completeness and proper type and to detect transit damage. Further receiving inspection is not required unless the Contractor needs actual characteristics for subsequent work or unless specified in the contract. Examination may be deferred until further processing is scheduled if items are in sealed containers or have special preservation or packaging.

c) Control NPC supplied items from receipt onwards according to the requirements of this standard.

d) Report promptly in writing to the quality assurance representative, any NPC supplied items found damaged, lost, non-conforming, or otherwise unsuitable or unnecessary for use either on receipt or while in the Contractor’s custody.

25.3.18 **CORRECTIVE ACTION**

The Contractor shall :

a) Investigate the causes of significant or recurring non-conformances and take appropriate action to prevent repetition.

b) Document and have reported to appropriate levels of the Contractor's management causes of significant conditions that adversely affect quality and the corrective action taken.

25.3.19 **VERIFICATION OF QUALITY**

25.3.19.1 **INITIAL EVALUATION**

Quality Assurance Program, Facilities and Physical Resources :

Prior to the award of a contract, and to the performance of the activity, the Purchaser shall evaluate the Contractor's quality assurance program, manufacturing facilities and resources to determine whether the requirements of this section can be met.

In the event of the Contractor not fulfilling all applicable requirements, NPC may award the contract provided that he takes the responsibility for those QA requirements that will not be met by the Contractor. In such a case, the exceptions shall be clearly defined in the contract.

25.3.19.2 **QUALITY PLAN**

NPC shall evaluate the quality plan and all revisions thereto in order to determine its acceptability.

NPC shall indicate witness points on the accepted quality plan.

In addition, NPC shall perform surveillance according to the accepted quality plan.

25.3.19.3 **ACCESS**

The Contractor shall provide for reasonable access of the competent authorities and of NPC to his premises and records for audit and surveillance purposes.

LIST OF ANNEXURES

1. Annexure – 1: Typical details of Bore log data & Geotechnical Parameters of Natural Soil
2. Annexure – 1A: Geotechnical Parameters of Improved Soil
3. Annexure – 2: Procedure for preparation and approval of design documents
4. Annexure – 3: Digital value of Response spectra of SSE
5. Annexure – 4: Information to be Submitted Alongwith the Bid for the proposed agency for Civil Works
6. Annexure – 5: Details of Company
7. Annexure – 6: Proposed Deployment of Plant & Machinery
8. Annexure – 7: Technical Details to be Supplied along with Bid

LIST OF TENDER DRAWINGS

1. Drawing no. GHAVP- 1&2/10120/2001/DD- Borehole Location Layout
2. Drawing no. GHAVP- 1&2/10000/5001/GA- Main Plant Layout
3. Drawing no. GHAVP- 1&2/24200/ 2011 TO 2018/ GA - Control Building GA drawings
4. Drawing no. GHAVP-1&2-29700-2001-SK- Terminal Point of Turbine Island Package
5. Drawing no. GHAVP-1&2/29700/5002/GA - Outdoor Tunnel & Trenches Layout
6. Drawing no. GHAVP1&2/16000/2003 and 2004/DD – Excavation Drawings
7. Drawing no. GHAVP1&2/15300/5001/GA – Surface Drain Layout
8. Drawing no. GHAVP1&2/15200/5101/GA – Plant Water Drainage Layout
9. Drawing no. GHAVP1&2/15200/5001 and 5002/GA – Roof Drain Layout
10. Drawing no. GHAVP1&2/15200/5201/SK – Sanitary Sewer Layout
11. Drawing No.-.GHAVP1&2/15600/5001/SK- Typical Cross section of Road
12. Copy of drawings showing various Architectural Joints

LIST OF ATTACHMENTS

1. Report on Field Mock-Up for Ground Improvement by Replacement of Liquefiable Strata by Compacted Soil / Soil-Cement Mix (with addendum)
2. PC-E-00034-Scope of work for fabrication and erection of Critical and Important Embedded Parts (EPs) for 700 MWe Main Plant Civil Works
3. PC-E-160-Technical Specification for Manufacture of Embedded Parts
4. PP-E-2273-Technical Specification for Electrostatic Conductive Floors for KAIGA – 3&4 and RAPP- 5&6
5. PP-M-400-R1 – Technical Specification for two part Polysulphide Sealing Compounds for Containment Building
6. PP-M-1219 – Specification for Epoxy Coating for Reactor Building Internal Structure and Equipment

ANNEXURE - 1

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-103	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 25/06/2013 TO 30/06/2013
CO-ORDINATES	: N : 3257147.330, E : 561712.655	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.895m	CASING	: SX Ø Upto 52.00m Below EGL..
GROUND W. T.	: 2.73m Below EGL..	BOREHOLE DEPTH	: 52.00m.Below EGL..

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(05) 02/02/03/03					Loose, brownish, silty SAND											
2.00																				
2.50																				
3.00		3.00/ 3.50	UDS1							SM	00	68	← 32 →		15.73	← NP →			2.33 X 10⁻⁶	1.89
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(09) 03/04/05/07																
5.00																				
5.50																				
6.00		6.00/ 6.30	UDS2							ML	00	13	69	18	20.28	33	26	07	--	1.84
6.50									Stiff, greyish brown, clayey Silt of low compressibility											
7.00																				
7.50		7.50/ 8.10	SPT3	(12) 04/05/07/09																
8.00																				
8.50																				
9.00		9.00/ 9.33	UDS3							ML	00	32	57	11	21.34	27	24	03	--	1.83
9.50									Stiff, brown, clayey SILT of low compressibility											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/11.10	SPT4	(31) 07/14/17/20					Stiff, brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/12.34	UDS4							SM	00	76	24		23.39	NP			--	1.80
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(37) 09/17/20/29																
14.00																				
14.50																				
15.00		15.00/15.34	UDS5						Dense, greyish brown, silty SAND	SM	00	78	22		16.24	NP			1.58×10^{-6}	1.90
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(44) 12/20/24/37																
17.00																				
17.50																				
18.00		18.00/18.33	UDS6							SM	00	82	18		22.03	NP			--	1.84
18.50																				
19.00																				
19.50		19.50/20.10	SPT7	(60) 15/25/35/48					Very dense, greyish brown, silty SAND											
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00	SX	21.00/21.30	UDS7							SM	00	86	14		12.39	NP			--	1.91
21.50																				
22.00																				
22.50		22.50/22.83	SPT8	(>50) 20/25/52/--																
23.00																				
23.50																				
24.00		24.00/24.23	UDS8							SM	00	76	24		14.27	NP			--	1.84
24.50									Very dense, greyish brown, silty SAND											
25.00																				
25.50		25.50/25.80	SPT9	(>50) 34/52/--/--																
26.00																				
26.50																				
27.00		27.00/27.24	UDS9							SM	00	80	20		15.27	NP			--	1.86
27.50																				
28.00																				
28.50		28.50/28.74	SPT10	(>50) 35/52/--/--																
29.00																				
29.50																				
30.00		30.00/30.20	UDS10							SM	00	81	19		21.79	NP			--	1.85

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50		31.50/31.79	SPT11	(>50) 39/52/--/--					Very dense, brownish grey, silty SAND											
32.00	SX																			
32.50																				
33.00		33.00/33.30	UDS11/1							SM	00	88	← 12 →		20.27	← NP →			--	1.86
		33.34/33.64	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/34.80	SPT12	(>50) 40/52/--/--																
35.00																				
35.50																				
36.00		36.00/36.30	UDS12/1						Very dense, greyish brown, silty SAND	SM	00	81	← 19 →		19.31	← NP →			--	1.87
		36.34/36.64	UDS12/2																	
36.50																				
37.00																				
37.50		37.50/37.80	SPT13	(>50) 33/52/--/--																
38.00																				
38.50																				
39.00		39.00/39.30	UDS13/1							ML	05	18	64	13	26.31	33	25	08	--	1.83
		39.35/39.65	UDS13/2						Hard, greyish brown, clayey SILT with gravels of low compressibility											
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/40.80	SPT14	(>50) 35/52/--/--					Hard, greyish brown, clayey SILT with gravels of low compressibility											
41.00																				
41.50																				
42.00	SX	42.00/42.30	UDS14/1							SM	00	76	← 24 →		23.23	← NP →			--	1.85
		42.34/42.64	UDS14/2																	
42.50																				
43.00																				
43.50		43.50/43.79	SPT15	(>50) 37/52/--/--																
44.00																				
44.50																				
45.00		45.00/45.30	UDS15/1							SM	00	71	← 29 →		24.79	← NP →			--	1.84
		45.34/45.64	UDS15/2																	
45.50																				
46.00									Very dense, yellowish brown, silty SAND											
46.50		46.50/46.78	SPT16	(>50) 37/52/--/--																
47.00																				
47.50																				
48.00		48.00/48.30	UDS16/1							SM	00	79	← 21 →		23.13	← NP →			--	1.86
		48.34/48.64	UDS16/2																	
48.50																				
49.00																				
49.50		49.50/49.76	SPT17	(>50) 37/52/--/--																
50.00																				
49.50																				
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50	SX	51.00/51.32	UDS17/1						Very dense, yellowish brown, silty SAND											
51.00		51.36/51.66	UDS17/2							SM	00	83	← 17 →		19.06	← NP →			--	1.88
51.50									Very dense, greyish brown, silty SAND											
52.00		52.00/52.22	SPT18	(>50) 41/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-104	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 27/04/2014 TO 29/04/2014
CO-ORDINATES	: N 3257191.105, E 561697.122	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.884m	CASING	: SX mm Ø Upto 52.50m BGL.
GROUND W. T.	: 2.65m Below EGL.	BOREHOLE DEPTH	: 52.50m.Below EGL.

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/06					Loose brown, silty SAND											
2.00																				
2.50																				
3.00		3.00/	UDS1/1							SM	11	40	43	06	11.45	26	24	02	--	1.86
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(14) 04/06/08/10																
5.00																				
5.50																				
6.00		6.00/	UDS2/1						Stiff, greyish brown, clayey SILT of low compressibility with gravels	ML	07	39	48	06	12.08	27	23	04	--	1.85
		6.30/ 6.60	UDS2/2																	
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(22) 08/10/12/15																
8.00									Very stiff, brownish grey, clayey SILT											
8.50																				
9.00		9.00/	UDS3/1							ML	00	32	58	10	21.80	31	25	06	--	1.81
		9.30/ 9.60	UDS3/2						Hard, brown, clayey SILT of low compressibility											
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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BORE HOLE NO. : RBH-104 | SHEET NO. : 2 OF 6

FIELD DATA										DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS					CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %	NMC	LL%	PL%	PLASTICITY INDEX		
10.50		10.50/ 11.10	SPT4	(32) 10/15/17/21					Hard, brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/	UDS4/1																	
		12.30/ 12.60	UDS4/2							ML	00	40	52	08	15.53	28	24	04	--	1.82
12.50																				
13.00																				
13.50		13.50/ 14.10	SPT5	(39) 15/18/21/24					Hard, greyish brown, clayey SILT of low compressibility											
14.00																				
14.50																				
15.00		15.00/	UDS5/1																	
		15.30/ 15.60	UDS5/2							ML	02	38	51	09	13.66	27	23	04	--	1.84
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(40) 14/18/22/26					Hard, brownish, clayey SILT of low compressibility											
17.00																				
17.50																				
18.00		18.00/	UDS6/1																	
		18.30/ 18.60	UDS6/2							ML	02	35	55	08	13.45	29	25	04	--	1.85
18.50																				
19.00																				
19.50		19.50/ 20.10	SPT7	(38) 17/18/20/28					Hard, brownish grey, clayey SILT of low compressibility											
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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BORE HOLE NO. : RBH-104 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00	SX	21.00/	UDS7/1																	
		21.30/ 21.60	UDS7/2							ML	00	11	70	19	17.18	33	26	07	--	1.82
21.50									Hard, brownish grey, clayey SILT of low compressibility											
22.00																				
22.50		22.50/ 23.10	SPT8	(44) 15/20/24/32																
23.00																				
23.50																				
24.00		24.00/	UDS8/1							ML	02	08	65	25	18.24	34	27	07	--	1.82
		24.30/ 24.60	UDS8/2																	
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(52) 18/22/30/38																
26.00																				
26.50																				
27.00		27.00/	UDS9/1						Hard, brown, clayey SILT of low compressibility											
		27.30/ 27.60	UDS9/2							ML	02	11	71	16	17.52	32	25	07	--	1.83
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(55) 15/25/30/42																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10/1							SM	00	70	← 30 →		17.51	← NP →			--	1.84

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104 | SHEET NO. : 4 OF 6

FIELD DATA										DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
30.50		30.30/30.60	UDS10/2						Very dense, brownish grey, silty SAND	SM	00	71	29		17.62	NP			--	1.88
31.00	SX																				
31.50		31.50/32.10	SPT11	(56) 16/24/32/46																	
32.00																					
32.50																					
33.00		33.00/	UDS11/1																		
		33.30/33.60	UDS11/2																		
33.50																					
34.00																					
34.50		34.50/35.10	SPT12	(60) 17/26/34/45																	
35.00																					
35.50																					
36.00		36.00/	UDS12/1																		
		36.30/36.60	UDS12/2						Very dense, greyish brown, silty SAND	SM	00	72	29		16.09	NP			--	1.86
36.50																					
37.00																					
37.50		37.50/38.10	SPT13	(58) 15/20/38/50																	
38.00																					
38.50																					
39.00		39.00/	UDS13/1																		
		39.30/39.60	UDS13/2							SM	00	76	24		15.70	NP			--	1.89
39.50																					
40.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104 | SHEET NO. : 5 OF 6

FIELD DATA										DESCRIPTION	LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
40.50		40.50/ 41.10	SPT14	(70) 20/32/38/48																
41.00	SX																			
41.50																				
42.00		42.00/	UDS14/1																	
		42.30/ 42.60	UDS14/2								SM	00	73	← 27 →	12.52	← NP →			--	1.91
42.50										Very dense, brownish grey, silty SAND										
43.00																				
43.50		43.50/ 44.10	SPT15	(78) 18/38/40/49																
44.00																				
44.50																				
45.00		45.00/	UDS15/1																	
		45.30/ 45.60	UDS15/2								SM	00	86	← 14 →	12.53	← NP →			--	1.91
45.50																				
46.00																				
46.50		46.50/ 47.10	SPT16	(79) 20/37/42/51																
47.00										Very dense, greyish, silty SAND										
47.50																				
48.00		48.00/	UDS16/1																	
		48.30/ 48.60	UDS16/2								SM	00	72	← 28 →	14.86	← NP →			--	1.88
48.50																				
49.00																				
49.50		49.50/ 51.10	SPT17	(86) 22/39/47/49																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104 | SHEET NO. : 6 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
50.50																				
51.00	SX	51.00/	UDS17/1						Very dense, greyish brown, silty SAND	SM	00	78	← 22 →		17.25	← NP →			--	1.86
51.50		51.30/ 51.60	UDS17/2																	
52.00																				
52.50		52.50/ 53.10	SPT18	(82) 26/35/47/51																
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.50m.BELOW EGL.

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-109	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 05/09/2013 TO 10/09/2013
CO-ORDINATES	: N : 3257172.609, E : 561774.118	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.833m	CASING	: SX Ø Upto 51.60m Below EGL.
GROUND W. T.	: 2.30m Below EGL.	BOREHOLE DEPTH	: 51.60m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.50	SX	0.00	DS1						Very stiff, brownish, clayey SILT											
1.00		0.50																		
1.50																				
2.00																				
2.50																				
3.00		3.00	UDS1																	
3.50		3.50/ 4.10	SPT1	(21) 07/09/12/21					Very stiff, greyish brown, clayey SILT of low compressibility	ML	10	30	53	07	12.62	30	24	06	--	1.95
4.00																				
4.50																				
5.00																				
5.50																				
6.00		6.00/	UDS2																	
6.50		6.40/ 7.00	SPT2	(22) 09/10/12/14					Very stiff greyish brown, clayey SILT of low compressibility	ML	00	47	48	05	18.59	27	24	03	--	1.62
7.00																				
7.50																				
8.00																				
8.50																				
9.00		9.00	UDS3																	
9.50		9.45/ 10.05	SPT3	(38) 12/18/20/24					Hard, brownish grey, clayey SILT of low compressibility	ML	00	47	49	04	19.21	26	24	02	--	1.91
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50																				
11.00									Hard, brownish grey, clayey SILT of low compressibility											
11.50																				
12.00	SX	12.00	UDS4																	
		12.40/ 13.00	SPT4	(38) 11/17/21/26						ML	00	25	64	11	18.94	33	25	08	--	1.79
12.50																				
13.00									Hard brownish grey, clayey SILT of low compressibility											
13.50																				
14.00																				
14.50																				
15.00		15.00	UDS5																	
		15.42/ 16.02	SPT5	(46) 14/21/25/31						SM	00	59	38	03	18.71	27	25	02	--	1.99
15.50																				
16.00									Dense, greyish brown, silty sand											
16.50																				
17.00																				
17.50																				
18.00		18.00	UDS6																	
		18.38/ 18.98	SPT6	(71) 17/31/40/49						SM	00	82	← 18 →		21.61	← NP →			--	1.75
18.50																				
19.00									Very dense, brownish grey, silty SAND											
19.50																				
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00		21.00	UDS7																	
		21.35/ 21.95	SPT7	(72) 19/30/42/48						SM	00	81	← 19 →		23.21	← NP →			--	1.84
21.50																				
22.00	SX																			
22.50																				
23.00																				
23.50									Very dense, brownish grey, silty SAND											
24.00		24.00	UDS8																	
		24.35/ 24.93	SPT8	(78) 21/34/44/52						SM	00	75	← 25 →		14.63	← NP →			--	1.74
24.50																				
25.00																				
25.50																				
26.00																				
26.50																				
27.00		27.00	UDS9																	
		27.32/ 27.88	SPT9	(89) 20/39/50/52						SM	00	84	← 16 →		22.02	← NP →			--	1.91
27.50																				
28.00																				
28.50									Very dense, greyish brown, silty SAND											
29.00																				
29.50																				
30.00		30.00/ 30.35	UDS10																	

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50		30.35/30.85	SPT10	(81) 24/40/41/52																
31.00																				
31.50																				
32.00	SX																			
32.50																				
33.00		33.00	UDS11/1																	
		33.30	UDS11/2						Very dense, brownish grey, silty SAND	SM	00	75	←25→		21.90	--	--	--	--	1.97
33.50		33.60/34.11	SPT11	(88) 28/38/50/52																
34.00																				
34.50																				
35.00																				
35.50																				
36.00		36.00	UDS12/1																	
		36.30	UDS12/2							SM	00	78	←22→		22.39	--	--	--	--	1.89
36.50		36.60/37.05	SPT12	(>50) 31/39/52/--					Very dense, greyish brown, silty SAND											
37.00																				
37.50																				
38.00																				
38.50																				
39.00		39.00	UDS13/1																	
		39.30	UDS13/2							SM	00	73	←27→		19.21	--	--	--	--	1.86
39.50		39.60/40.12	SPT13	(89) 30/41/48/52					Very dense, brownish grey, silty SAND											
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50									Very dense, brownish grey, silty SAND											
41.00																				
41.50																				
42.00	SX	42.00	UDS14/1																	
		42.30	UDS14/2							SM	00	72	←28→		21.11	--	--	--	--	1.87
42.50		42.60/ 43.04	SPT14	(>50) 33/39/52/--																
43.00																				
43.50																				
44.00																				
44.50																				
45.00		45.00	UDS15/1																	
		45.30	UDS15/2							SM	00	74	←26→		14.60	--	--	--	--	1.79
45.50		45.60/ 46.11	SPT15	(77) 27/33/44/52					Very dense, greyish brown, silty SAND											
46.00																				
46.50																				
47.00																				
47.50																				
48.00		48.00	UDS16/1																	
		48.30	UDS16/2							SM	00	79	←21→		13.54	--	--	--	--	1.79
48.50		48.60/ 49.20	SPT16	(82) 30/34/48/52																
49.00																				
49.50																				
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00	UDS17/1						Very dense, greyish brown, silty SAND	SM	00	64	← 36 →		21.41	--	--	--	--	1.86
		51.30	UDS17/2																	
51.50		51.60/ 52.05	SPT17	(95) 37/43/52/--																
52.00																				
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 51.60m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-110	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 04/06/2013 TO 08/06/2013
CO-ORDINATES	: N : 3257191.945, E : 561760.189	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.929m	CASING	: SX Ø Upto 52.00m EGL.
GROUND W. T.	: --	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1						Loose, brownish, silty SAND											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(11) 02/05/06/06																
2.00																				
2.50																				
3.00		3.00/ 3.37	UDS1						Stiff, brownish grey, clayey SILT of low compressibility	ML	00	48	45	07	14.09	25	22	03	--	1.82
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(15) 04/07/08/10																
5.00																				
5.50																				
6.00		6.00/ 6.55	UDS2							MI	00	03	74	23	24.56	37	26	11	--	1.80
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(29) 08/12/17/22					Very stiff, greyish brown, clayey SILT of medium compressibility											
8.00																				
8.50																				
9.00		9.00/ 9.53	UDS3							ML	00	38	47	15	17.37	27	23	04	--	1.83
9.50									Very stiff, greyish brown, clayey SILT of low compressibility											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/11.10	SPT4	(32) 10/13/19/25					Very stiff, greyish brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/12.57	UDS4						Hard, greyish brown, clayey SILT of medium compressibility	MI	00	04	78	18	27.97	35	26	09	--	1.81
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(32) 10/13/19/25																
14.00									Hard, greyish brown, clayey SILT of low compressibility											
14.50																				
15.00		15.00/15.38	UDS5							ML	00	42	49	09	22.2	33	24	09	--	1.82
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(43) 06/17/26/35					Hard, greyish brown, clayey SILT of low compressibility											
17.00																				
17.50																				
18.00		18.00/18.32	UDS6							SM	00	70	← 30 →		20.79	← NP →			--	1.85
18.50																				
19.00									Dense, brownish grey, silty SAND											
19.50		19.50/20.10	SPT7	(42) 09/17/25/37																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Dense, brownish grey, silty SAND											
21.00		21.00/ 21.46	UDS7							SM	00	81	← 19 →		19.98	← NP →			--	1.83
21.50																				
22.00	SX																			
22.50		22.50/ 23.10	SPT8	(46) 11/18/28/39																
23.00									Dense, greyish brown, silty SAND											
23.50																				
24.00		24.00/ 24.30	UDS8							SM	00	84	← 16 →		25.15	← NP →			--	1.81
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(47) 13/19/28/40																
26.00																				
26.50																				
27.00		27.00/ 27.51	UDS9						Dense, brownish grey, silty SAND	SM	00	84	← 16 →		16.46	← NP →			--	1.86
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(50) 14/21/29/42																
29.00									Very dense, grey, silty SAND											
29.50																				
30.00		30.00/ 30.38	UDS10							SM	00	85	← 15 →		10.56	← NP →			--	1.92

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50									Very dense, grey, silty SAND											
31.00																				
31.50		31.50/ 32.03	SPT11	(77) 20/32/45/52																
32.00	SX																			
32.50																				
33.00		33.00/ 33.54	UDS11							MI	00	15	72	13	19.85	35	26	09	--	1.85
33.50									Hard, brownish grey, clayey SILT of medium compressibility											
34.00																				
34.50		34.50/ 34.93	SPT12	(>50) 18/39/52/--																
35.00																				
35.50																				
36.00		36.00/ 36.45	UDS12							ML	21	15	55	09	18.94	28	24	09	--	1.87
36.50																				
37.00																				
37.50		37.50/ 37.92	SPT13	(>50) 20/40/52/--					Hard, brown, clayey SILT of low compressibility											
38.00																				
38.50																				
39.00		39.00/ 39.30	UDS13							SM	00	77	← 23 →		22.28	← NP →			--	1.85
39.50									Very dense, greyish brown, silty SAND											
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 39.10m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/40.92	SPT14	(>50) 22/41/52/--					Very dense, greyish brown, silty SAND											
41.00																				
41.50																				
42.00	SX	42.00/42.30	UDS14							SM	00	70	30		22.95	NP			--	1.84
42.50																				
43.00									Very dense, greyish brown, silty SAND											
43.50		43.50/43.94	SPT15	(>50) 22/42/52/--																
44.00																				
44.50																				
45.00		45.00/45.98	UDS15							SM	01	65	34		24.30	NP			--	1.89
45.50																				
46.00									Very dense, brown, silty SAND with gravels											
46.50		46.50/46.90	SPT16	(>50) 23/43/52/--																
47.00																				
47.50																				
48.00		48.00/48.35	UDS16							SM	00	68	32		23.76	NP			--	1.86
48.50																				
49.00									Very dense, greyish brown, silty SAND											
49.50		49.50/49.88	SPT17	(>50) 26/45/52/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50	SX	51.00/ 51.25	UDS17						Very dense, greyish brown, silty SAND	SM	00	67	← 33 →		20.93	← NP →			--	1.89
51.00																				
51.50																				
52.00		52.00/ 52.35	SPT18	(>50) 28/47/52/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-111	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 23/04/2014 TO 26/04/2014
CO-ORDINATES	: N 3257214.114, E 561750.994	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.941m	CASING	: SX mm Ø Upto 52.50m BGL.
GROUND W. T.	: 2.55m Below EGL.	BOREHOLE DEPTH	: 52.50m.Below EGL.

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(06) 02/03/03/05																
2.00									Medium stiff, brown,clayey SILT of medium compressibility											
2.50																				
3.00		3.00/	UDS1/1							MI	00	04	82	14	19.10	37	28	09	--	1.85
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(22) 05/09/13/16																
5.00																				
5.50																				
6.00		6.00/	UDS2/1							MI	00	05	70	25	20.57	38	29	09	--	1.84
		6.30/ 6.60	UDS2/2																	
6.50																				
7.00									Very stiff, brown, clayey SILT of medium compressibility											
7.50		7.50/ 8.10	SPT3	(24) 08/09/15/18																
8.00																				
8.50																				
9.00		9.00/	UDS3/1							ML	01	34	57	08	20.68	34	26	08	--	1.85
		9.30/ 9.60	UDS3/2																	
9.50									Very stiff, brownish grey, clayey SILT of low compressibility											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/ 11.10	SPT4	(35) 15/16/19/21																
11.00																				
11.50																				
12.00	SX	12.00/	UDS4/1						Hard, brownish grey, clayey SILT of low compessibility	ML	00	28	61	11	14.17	32	26	06	--	1.87
		12.30/ 12.60	UDS4/2																	
12.50																				
13.00																				
13.50		13.50/ 14.10	SPT5	(36) 14/17/19/22																
14.00																				
14.50																				
15.00		15.00/	UDS5/1							MI	00	12	76	12	19.49	36	27	09	--	1.85
		15.30/ 15.60	UDS5/2																	
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(39) 12/18/21/28					Hard, brownish grey, clayey SILT of medium compressibility											
17.00																				
17.50																				
18.00		18.00/	UDS6/1							MI	00	12	75	13	27.42	41	29	12	--	1.83
		18.30/ 18.60	UDS6/2																	
18.50																				
19.00																				
19.50		19.50/ 20.10	SPT7	(42) 17/20/22/31																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00	SX	21.00/	UDS7/1																	
		21.30/ 21.60	UDS7/2							MI	00	05	79	16	24.37	40	28	12	--	1.82
21.50																				
22.00									Hard, brown, clayey SILT of medium compressibility											
22.50		22.50/ 23.10	SPT8	(50) 15/22/28/35																
23.00																				
23.50																				
24.00		24.00/	UDS8/1							SM	00	79	← 21 →		15.79	← NP →			--	1.86
		24.30/ 24.60	UDS8/2																	
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(58) 18/26/32/38																
26.00																				
26.50																				
27.00		27.00/	UDS9/1						Very dense, brownish grey, silty SAND											
		27.30/ 27.60	UDS9/2							SM	00	73	← 27 →		15.02	← NP →			--	1.87
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(66) 19/28/38/42																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10/1							SM	00	73	← 27 →		13.58	← NP →			--	1.86

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50		30.30/30.60	UDS10/2																	
31.00	SX																			
31.50		31.50/32.10	SPT11	(67) 19/29/38/44																
32.00									Very dense, brownish grey, silty SAND											
32.50																				
33.00		33.00/	UDS11/1							SM	00	86	← 14 →		23.04	← NP →			--	1.86
		33.30/33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/35.10	SPT12	(71) 20/32/39/48																
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SM	00	83	← 17 →		15.42	← NP →			--	1.87
		36.30/36.60	UDS12/2																	
36.50																				
37.00									Very dense, greyish brown, silty SAND											
37.50		37.50/38.10	SPT13	(71) 19/30/41/52																
38.00																				
38.50																				
39.00		39.00/	UDS13/1							SM	00	76	← 24 →		17.46	← NP →			--	1.88
		39.30/39.60	UDS13/2																	
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/41.10	SPT14	(70) 20/30/40/48					Very dense, brownish grey, silty SAND											
41.00	SX																			
41.50																				
42.00		42.00/	UDS14/1							SM	00	80	← 20 →		19.60	← NP →			--	1.86
		42.30/42.60	UDS14/2																	
42.50																				
43.00																				
43.50		43.50/44.00	SPT15	(74) 21/33/41/49																
44.00																				
44.50																				
45.00		45.00/	UDS15/1							SM	00	83	← 17 →		20.75	← NP →			--	1.85
		45.30/45.60	UDS15/2																	
45.50																				
46.00									Very dense, greyish brown, silty SAND											
46.50		46.50/47.10	SPT16	(77) 20/32/45/51																
47.00																				
47.50																				
48.00		48.00/	UDS16/1							SM	00	67	← 33 →		20.89	← NP →			--	1.84
		48.30/48.60	UDS16/2																	
48.50																				
49.00																				
49.50		49.50/50.03	SPT17	(82) 22/38/44/52																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/	UDS17/1						Very dense, brownish grey,SAND	SM	00	78	← 22 →		21.93	← NP →			--	1.85
51.50		51.30/ 51.60	UDS17/2																	
52.00																				
52.50		52.50/ 52.98	SPT18	(74) 20/32/42/52																
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.50m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-115	SHEET NO.	: 1 OF 5
LOCATION	: TB-1	DATE	: 06/12/2013 TO 08/12/2013
CO-ORDINATES	: N : 3257195.985, E : 561829.965	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.740m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.70m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL %	PLASTICITY INDEX		
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(06) 02/03/03/05					Medium stiff, reddish brown, clayey SILT of low compressibility											
2.00																				
2.50																				
3.00		3.00/ 3.40	UDS1							ML	00	30	61	09	12.32	34	26	08	--	1.84
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(29) 09/13/16/18																
5.00																				
5.50																				
6.00		6.00/ 6.42	UDS2						Very stiff, brownish, clayey SILT of low compressibility	ML	00	49	47	04	19.88	24	22	02	--	1.89
6.50																				
7.00		7.00/ 7.60	SPT3	(32) 12/16/16/21																
7.50																				
8.00									Hard, brownish yellow, clayey SILT of low compressibility											
8.50																				
9.00		9.00/ 9.45	UDS3							ML	00	46	48	06	18.99	31	25	06	--	1.85
9.50																				
10.00																				

ABBREVIATIONS :

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UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 2 OF 5

FIELD DATA										DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL %	PL %	PLASTICITY INDEX		
10.50		10.50/ 11.10	SPT4	(51) 16/21/30/34																
11.00																				
11.50										Hard, brownish grey, clayey SILT of low compressibility										
12.00	SX	12.00/ 12.35	UDS4								ML	00	44	49	07	21.81	27	24	03	--	1.86
12.50																				
13.00																				
13.50		13.60/ 14.20	SPT5	(65) 18/29/36/41																
14.00																				
14.50																				
15.00		15.00/ 15.34	UDS5								SM	00	70	← 30 →		23.07	← NP →			--	1.89
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(76) 20/34/42/48																
17.00										Very dense, brownish grey, silty SAND										
17.50																				
18.00																				
18.50		18.60/ 18.93	UDS6								SM	00	73	← 27 →		22.70	← NP →			--	1.89
19.00																				
19.50		19.50/ 20.08	SPT7	(>50) 24/35/45/52																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 3 OF 5

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00		21.00/ 21.32	UDS7							SM	00	78	← 22 →		24.84	← NP →			--	1.90
21.50									Very dense, brownish grey, silty SAND											
22.00	SX	22.00/ 22.45	SPT8	(>50) 23/37/52/--																
22.50																				
23.00																				
23.50																				
24.00		24.00/ 24.30	UDS8							SM	00	80	← 20 →		19.86	← NP →			--	1.89
24.50									Very dense, , brownish, silty SAND											
25.00																				
25.50		25.50/ 26.10	SPT9	(62) 10/25/37/48																
26.00																				
26.50																				
27.00		27.00/ 27.21	UDS9							SM	00	74	← 26 →		17.93	← NP →			--	1.95
27.50									Very dense, brownish grey, silty SAND											
28.00																				
28.50		28.60/ 28.90	SPT10	(>50) 35/52/--/--																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10							SM	00	82	← 18 →		--	← NP →			--	1.96

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 4 OF 5

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50									Very dense, brownish grey, silty SAND											
31.00																				
31.50	SX	31.50/31.70	SPT11	(>50) 38/52/--/--																
32.00																				
32.50																				
33.00		33.00/	UDS11/1						Very dense, greyish, silty SAND	SP	00	96	← 04 →		--	--	--	--	--	1.98
		33.30/33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/34.75	SPT12	(>50) 40/52/--/--																
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SM	00	74	← 26 →		15.50	← NP →			--	1.89
		36.30/36.60	UDS12/2																	
36.50																				
37.00									Very dense, brownish grey, silty SAND											
37.50		37.50/37.74	SPT13	(>50) 44/52/--/--																
38.00																				
38.50																				
39.00		39.00/	UDS13/1							SM	00	83	← 17 →		20.00	← NP →			--	1.92
		39.30/39.60	UDS13/2																	
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 5 OF 5

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50	SX	40.50/40.80	SPT14	(>50) 34/52/--/--					Very dense, greyish, silty SAND											
41.00																				
41.50																				
42.00		42.00/	UDS14/1							SM	00	75	25		23.43	NP			--	1.92
		42.30/42.60	UDS14/2																	
42.50																				
43.00																				
43.50		43.50/43.95	SPT15	(>50) 25/38/52/--																
44.00																				
44.50																				
45.00		45.00/	UDS15/1							SM	00	88	12		--	NP			--	1.89
		45.30/45.60	UDS15/2																	
45.50																				
46.00																				
46.50		46.50/46.95	SPT16	(>50) 25/42/52/--																
47.00																				
47.50																				
48.00		48.00/	UDS16/1							SM	00	85	15		16.52	NP			--	1.94
		48.30/48.60	UDS16/2																	
48.50																				
49.00																				
49.50		49.50/49.91	SPT17	(>50) 31/46/52/--																
50.00																				
49.50																				
51.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 6 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL %	PLASTICITY INDEX		
50.50																				
51.00	SX	51.00/ 51.30	UDS17/1 UDS16/2						Very dense, brownish, silty SAND	SM	00	76	24		22.35	NP			--	1.97
51.50		51.60																		
52.00		52.00/ 52.35	SPT18	(>50) 28/35/52/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-116	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 05/06/2013 TO 10/06/2013
CO-ORDINATES	: N : 3257239.399, E : 561811.959	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.939m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.70m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.50	SX	0.00 0.50	DS1						Brownish, clayey SILT											
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/05																
2.00																				
2.50									Medium stiff, greyish brown, clayey SILT of low compressibility											
3.00		3.00/ 3.39	UDS1							ML	00	43	51	06	11.01	30	25	05	--	1.88
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(18) 05/07/11/13																
5.00																				
5.50									Very stiff, brownish, clayey SILT of low compressibility											
6.00		6.00/ 6.42	UDS2							ML	03	41	51	05	11.81	32	25	07	--	1.87
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(17) 06/07/10/14																
8.00																				
8.50									Very stiff, greyish brown, clayey SILT of low compressibility											
9.00		9.00/ 9.45	UDS3							ML	00	47	47	06	12.90	28	24	04	--	1.86
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 2 OF 6

FIELD DATA										DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
10.50		10.50/ 11.10	SPT4	(61) 16/26/35/41																	
11.00																					
11.50																					
12.00	SX	12.00/ 12.18	UDS4								ML	00	49	47	06	17.85	27	24	03	--	1.85
12.50										Hard, greyish brown, clayey SILT of low compressibility											
13.00																					
13.50		13.50/ 14.10	SPT5	(61) 17/25/36/41																	
14.00																					
14.50																					
15.00		15.00/ 15.37	UDS5								ML	00	41	49	10	19.70	33	26	07	--	1.84
15.50										Hard, brownish, clayey SILT of low compressibility											
16.00																					
16.50		16.50/ 17.10	SPT6	(54) 20/25/29/31																	
17.00																					
17.50																					
18.00		18.00/ 18.33	UDS6							Very dense, brownish grey, silty SAND	SM	00	81	← 19 →		15.67	← NP →			--	1.87
18.50																					
19.00																					
19.50		19.50/ 20.10	SPT7	(38) 11/15/23/34																	
20.00										Dense, brownish grey, silty SAND											

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Dense, greyish brown, silty SAND											
21.00		21.00/ 21.30	UDS7							SM	00	75	← 25 →		18.03	← NP →			--	1.86
21.50																				
22.00	SX								Very dense, brownish grey, silty SAND											
22.50		22.50/ 23.10	SPT8	(57) 17/24/33/35																
23.00																				
23.50																				
24.00		24.00/ 24.25	UDS8							SM	00	72	← 28 →		19.26	← NP →			--	1.85
24.50									Very dense, greyish brown, silty SAND											
25.00																				
25.50		25.50/ 26.10	SPT9	(61) 16/29/32/33																
26.00																				
26.50																				
27.00		27.00/ 27.30	UDS9							ML	00	19	67	14	20.65	34	26	08	--	1.84
27.50									Hard, greyish brown, clayey SILT of low compressibility											
28.00																				
28.50		28.50/ 28.95	SPT10	(99) 14/27/52/--																
29.00									Very dense, greyish brown, silty SAND											
29.50																				
30.00		30.00/ 30.30	UDS10							SM	00	72	← 28 →		21.50	← NP →			--	1.83

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50	SX	31.50/31.90	SPT11	(80) 15/30/50/--					Very dense, brownish grey, silty SAND											
32.00																				
32.50																				
33.00		33.00/33.30	UDS11							SP-SM	00	92	← 08 →		11.29	--	--	--	--	1.91
33.50																				
34.00																				
34.50		34.50/34.85	SPT12	(82) 17/31/51/--																
35.00																				
35.50																				
36.00		36.00/36.32	UDS12						Very dense, greyish brown, silty SAND	SP-SM	00	93	← 07 →		13.35	--	--	--	--	1.88
36.50																				
37.00																				
37.50		37.50/37.90	SPT13	(89) 19/39/50/--																
38.00																				
38.50																				
39.00		39.00/39.33	UDS13							SM	08	71	← 21 →		17.12	← NP →			--	1.86
39.50									Very dense, greyish brown, silty SAND											
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/40.86	SPT14	(>50) 27/37/52/--					Very dense, brownish grey, silty SAND											
41.00																				
41.50																				
42.00	SX	42.00/42.30	UDS14							SM	00	79	← 21 →		13.89	← NP →			--	1.87
42.50																				
43.00																				
43.50		43.50/43.84	SPT15	(>50) 27/45/52/--																
44.00																				
44.50																				
45.00		45.00/45.32	UDS15							SM	00	81	← 19 →		17.82	← NP →			--	1.86
45.50																				
46.00																				
46.50		46.50/46.77	SPT16	(>50) 34/52/--/--					Very dense, greyish brown, silty SAND											
47.00																				
47.50																				
48.00		48.00/48.40	UDS16							SM	00	84	← 16 →		16.99	← NP →			--	1.88
48.50																				
49.00																				
49.50		49.50/49.65	SPT17	(>50) 62/--/--/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/ 51.24	UDS17						Very dense, brownish grey, silty SAND	SM	00	78	← 22 →		19.86	← NP →			--	1.66
51.50																				
52.00		52.00/ 52.27	SPT18	(>50) 23/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-107	SHEET NO.	: 1 OF 2
LOCATION	: GT Area-1	DATE	: 27/04/2014 TO 28/04/2014
CO-ORDINATES	: N 3257119.883, E 561811.178	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.709m	CASING	: SX mm Ø Upto 18.00m BGL.
GROUND W. T.	: 2.65m Below EGL.	BOREHOLE DEPTH	: 18.00m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL %	PL%	PLASTICITY INDEX		
0.50	SX	0.00 0.50	DS1						Medium stiff, brownish yellow, clayey SILT											
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/06																
2.00																				
2.50									Medium stiff, brownish grey, clayey SILT of low compressibility											
3.00		3.00/	UDS1/1							ML	00	45	49	06	12.28	28	24	04	--	1.86
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(14) 05/06/08/11																
5.00									Stiff, brownish grey, clayey SILT											
5.50																				
6.00		6.00/	UDS2/1							ML	01	46	48	05	16.25	28	25	03	--	1.84
		6.30/ 6.60	UDS2/2																	
6.50									Stiff, greyish brown, clayey SILT of low compressibility											
7.00																				
7.50		7.50/ 8.10	SPT3	(23) 08/11/12/15																
8.00																				
8.50									Very stiff, brownish, clayey SILT of low compressibility											
9.00		9.00/	UDS3/1							ML	00	48	48	04	14.63	27	24	03	--	1.85
		9.30/ 9.60	UDS3/2																	
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-107 | SHEET NO. : 2 OF 2

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(30) 12/14/16/22																
11.00																				
11.50																				
12.00		12.00/	UDS4/1							ML	00	45	49	06	17.42	27	24	03	--	1.82
		12.30/12.60	UDS4/2																	
12.50																				
13.00									Hard, brownish, clayey SILT of low compressibility											
13.50		13.50/14.10	SPT5	(40) 15/19/21/28																
14.00																				
14.50																				
15.00		15.00/	UDS5/1							ML	00	47	49	04	19.36	26	23	03	5.34×10^{-6}	1.82
		15.30/15.60	UDS5/2																	
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(46) 18/22/24/31																
17.00																				
17.50									Dense, grey, silty SAND											
18.00		18.00/	UDS6/1							SM	00	74	← 26 →		21.90	← NP →			--	1.85
		18.30/18.60	UDS6/2																	
18.50																				
19.00																				
19.50																				
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 18.60m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-105	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 27/03/2013 TO 06/04/2013
CO-ORDINATES	: N : 3257237.853 , E : 561675.110	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.800m	CASING	: SX Ø Upto 52.00m BGL.
GROUND W. T.	: 3.00m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL..

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1						Medium stiff, brownish, clayey SILT											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(04) 02/02/02/03					Medium stiff, greyish yellow, clayey SILT											
2.00																				
2.50																				
3.00		3.00/ 3.42	UDS1						Medium stiff, greyish brown, clayey SILT of low compressibility	ML	29	14	50	07	18.32	31	25	06	2.86 X 10⁻⁶	1.87
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(31) 07/13/18/19					Hard, clayey SILT of low compressibility											
5.00																				
5.50																				
6.00		6.00/ 6.30	UDS2						Hard, yellowish grey, clayey SILT of low compressibility	ML	00	24	61	15	15.52	33	25	08	--	1.91
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(31) 10/20/11/21																
8.00																				
8.50																				
9.00		9.00/ 9.50	UDS3						Hard, yellowish grey, clayey SILT of low compressibility	ML	00	34	57	09	18.66	31	26	05	2.38 X 10⁻⁶	1.88
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/ 11.10	SPT4	(24) 07/08/16/24					Hard, yellowish grey, clayey SILT of low compressibility											
11.00									Very stiff, yellowish grey, clayey SILT											
11.50																				
12.00	SX	12.00/ 12.54	UDS4							MI	01	02	64	33	27.08	40	28	12	2.26×10^{-6}	1.78
12.50									Hard, greyish brown, clayey SILT of medium compressibility											
13.00																				
13.50		13.50/ 13.73	SPT5	(>50) 14/52/--/--																
14.00																				
14.50																				
15.00		15.00/ 15.60	SPT6	(45) 11/20/25/35					Hard, greyish brown, clayey SILT											
15.50																				
16.00																				
16.50		16.50/ 16.74	SPT7	(>50) 27/52/--/--																
17.00									Hard, brownish, clayey SILT											
17.50																				
18.00		18.00/ 18.39	SPT8	(>50) 19/32/52/--																
18.50									Hard, greyish brown, clayey SILT											
19.00																				
19.50		19.50/ 19.91	SPT9	(>50) 19/40/52/--					Very dense, greyish, silty SAND											
20.00																				

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00		21.00/ 21.37	SPT10	(>50) 33/42/52/--																
21.50																				
22.00	SX								Very dense, greyish, silty SAND											
22.50		22.50/ 22.78	SPT11	(>50) 31/52/--/--																
23.00																				
23.50																				
24.00		24.00/ 24.23	SPT12	(>50) 35/52/--/--																
24.50									Hard, greyish, clayey SILT											
25.00																				
25.50		25.50/ 26.10	SPT13	(45) 12/21/24/40																
26.00									Hard, brownish, clayey SILT											
26.50																				
27.00		27.00/ 27.28	SPT14	(>50) 35/52/--/--																
27.50									Very dense, greyish brown, silty SAND											
28.00																				
28.50		28.50/ 28.90	SPT15	(>50) 40/45/52/--																
29.00									Hard, greyish brown, clayey SILT											
29.50																				
30.00		30.00/ 30.12	SPT16	(>50) 30/40/52/--																

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50									Very dense, greyish, SAND											
32.00	SX																			
32.50																				
33.00		33.00/ 33.37	SPT17	(>50) 24/38/52/--																
33.50																				
34.00																				
34.50																				
35.00																				
35.50																				
36.00		36.00/ 36.29	SPT18	(>50) 28/52/--/--					Hard, brownish, clayey SILT with gravels											
36.50																				
37.00																				
37.50																				
38.00																				
38.50																				
39.00		39.00/ 39.21	SPT19	(>50) 37/52/--/--																
39.50									Hard, greyish brown, clayey SILT with gravels											
40.00																				

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 39.10m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 5 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
40.50																				
41.00									Hard, greyish brown, clayey SILT with gravels											
41.50																				
42.00	SX	42.00/ 42.10	SPT20	(>50) 52/--/--/--																
42.50																				
43.00									Hard, brownish grey, clayey SILT with gravels											
43.50																				
44.00																				
44.50																				
45.00		45.00/ 45.14	SPT21	(>50) 52/--/--/--																
45.50																				
46.00									Hard, brownish, clayey SILT											
46.50																				
47.00																				
47.50																				
48.00		48.00/ 48.25	SPT22	(>50) 38/52/--/--																
48.50																				
49.00									Hard, brownish, clayey SILT											
49.50																				
50.00																				

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50									Hard, brownish, clayey SILT											
51.00		51.00/ 51.14	SPT23	(>50) 52/--/--/--																
51.50									Hard, greyish brown, clayey SILT with gravels											
52.00	SX	52.00/ 52.20	SPT24	(>50) 42/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-106	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 26/03/2013 TO 30/04/2013
CO-ORDINATES	: N : 3257282.191, E : 561656.720	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.994m	CASING	: SX Ø Upto 52.00m BGL.
GROUND W. T.	: 2.60m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL..

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1						Loose, brownish, silty SAND											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(05) 02/02/03/04																
2.00																				
2.50									Loose, greyish yellow, silty SAND											
3.00		3.00/ 3.40	UDS1							SM	00	68	← 32 →		19.49				--	1.86
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(30) 08/13/17/20																
5.00																				
5.50																				
6.00		6.00/ 6.42	UDS2							SM	00	57	38	05	18.96	26	23	03	--	1.83
6.50																				
7.00									Dense, greyish yellow, silty SAND											
7.50		7.50/ 8.10	SPT3	(47) 14/20/27/33																
8.00																				
8.50																				
9.00																				
9.50		9.60/ 9.92	UDS3							SM	00	70	← 30 →		19.12				--	1.86
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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Checked By : Prajit Nagrale

Drawn By: Jitin More

SCALE : 1: 50
JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(47) 14/20/27/33					Dense, greyish yellow, silty SAND											
11.00																				
11.50																				
12.00																				
12.50		12.60/12.90	UDS4						Hard, brownish, clayey SILT of medium compressibility	MI	00	03	74	23	27.14	37	27	10	--	1.86
13.00		13.00/13.60	SPT5	(56) 17/24/32/39																
13.50																				
14.00																				
14.50																				
15.00																				
15.50		15.60/15.90	UDS5							SM	00	80	← 20 →		24.79	← NP →			--	1.87
16.00																				
16.50		16.50/17.10	SPT6	(48) 14/21/27/34					Dense, brownish, silty SAND											
17.00																				
17.50																				
18.00		18.00/18.32	UDS6							SM	00	85	← 15 →		20.37	← NP →			--	1.89
18.50																				
19.00																				
19.50		19.50/20.10	SPT7	(65) 23/27/38/45					Very dense, brownish, silty SAND											
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 3 OF 6

FIELD DATA										DESCRIPTION	LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
20.50																				
21.00																				
21.50		21.00/ 21.90	UDS7																	
22.00	SX									Very dense, brownish grey, silty SAND	SM	00	88	← 12 →	20.46	← NP →			--	1.88
22.50		22.50/ 22.95	SPT8	(>50) 26/34/52/--																
23.00																				
23.50																				
24.00																				
24.50		24.60/ 24.90	UDS8								SM	00	80	← 20 →	21.34	← NP →			--	1.84
25.00																				
25.50		25.50/ 25.90	SPT9	(>50) 29/42/52/--																
26.00																				
26.50																				
27.00																				
27.50		27.50/ 27.90	UDS9							Very dense, brownish grey, silty SAND	SM	00	86	← 14 →	18.78	← NP →			--	1.89
28.00		28.00/ 28.42	SPT10	(>50) 33/48/52/--																
28.50																				
29.00																				
29.50																				
30.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50		30.60/	UDS10/1																	
		30.90/ 31.20	UDS10/2							SM	00	85	← 15 →		22.20	← NP →			--	1.91
31.00																				
31.50		31.50/ 31.85	SPT11	(>50) 39/40/52/--																
32.00	SX																			
32.50																				
33.00									Very dense, greyish, brown, silty SAND											
33.50		33.60/	UDS11/1																	
		33.90/ 31.20	UDS11/2							SM	00	82	← 18 →		16.97	← NP →			--	1.89
34.00																				
34.50		34.50/ 35.10	SPT12	(66) 16/28/38/50																
35.00																				
35.50																				
36.00																				
36.50		36.60/	UDS12/1																	
		36.90/ 37.20	UDS12/2							ML	00	21	67	12	22.81	31	25	06	--	1.82
37.00									Hard, brownish, clayey SILT of low compressibility											
37.50		37.50/ 37.85	SPT13	(>50) 20/34/52/--																
38.00																				
38.50																				
39.00																				
39.50		39.60/	UDS13/1																	
		39.90/ 40.20	UDS13/2						Hard, greyish brown, clayey SILT with gravels	ML	08	39	46	07	19.93	28	25	03	--	1.84
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50	SX	40.50/40.90	SPT14	(>50) 25/39/52/--					Hard, greyish brown, clayey SILT with gravels											
41.00																				
41.50																				
42.00																				
42.50		42.60/	UDS14/1																	
		42.90/43.20	UDS14/2																	
43.00										SM	00	82	← 18 →		16.97	← NP →			--	1.89
43.50		43.50/43.88	SPT15	(>50) 29/40/52/--																
44.00																				
44.50																				
45.00																				
45.50		45.60/	UDS15/1																	
		45.90/46.20	UDS15/2																	
46.00										SM	00	82	← 18 →		16.97	← NP →			--	1.89
46.50		46.50/46.85	SPT16	(>50) 32/45/52/--					Very dense, silty SAND											
47.00																				
47.50																				
48.00																				
48.50		48.60/	UDS16/1																	
		48.90/49.20	UDS16/2																	
49.00										SM	00	82	← 18 →		16.97	← NP →			--	1.89
49.50		49.50/49.85	SPT17	(>50) 37/48/52/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00									Very dense, silty SAND											
51.50		51.60/	UDS17/1																	
52.00	SX	51.90/ 52.20	UDS17/2							SM	00	74	← 26 →		19.42	← NP →			--	1.89
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-112	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 22/04/2014 TO 25/04/2014
CO-ORDINATES	: N 3257262.915, E 561733.438	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.998m	CASING	: SX mm Ø Upto 54.00m BGL.
GROUND W. T.	: 2.55m Below EGL.	BOREHOLE DEPTH	: 54.00m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN)	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL %	PL %	PLASTICITY INDEX		
0.50	SX	0.00	DS1						Medium stiff, brownish,clayey SILT of low compressibility											
		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(06) 02/03/03/05																
2.00																				
2.50																				
3.00		3.00/	UDS1/1							ML	01	42	51	06	12.49	28	24	04	--	1.86
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(20) 04/08/12/14																
5.00									Very stiff, brownish, clayey SILT											
5.50																				
6.00		6.00/	UDS2/1							ML	00	34	58	08	11.06	30	25	05	--	1.86
		6.30/ 6.60	UDS2/2																	
6.50									Very stiff, brownish grey, clayey SILT of low compressibility											
7.00																				
7.50		7.50/ 8.10	SPT3	(49) 08/21/28/38																
8.00																				
8.50									Hard, brownish grey, clayey SILT of low compressibility											
9.00		9.00/	UDS3/1							ML	01	32	57	10	13.96	31	25	06	--	1.85
		9.30/ 9.60	UDS3/2																	
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(47) 14/20/27/33																
11.00																				
11.50																				
12.00		12.00/	UDS4/1						Hard, brownish grey, clayey SILT of low compressibility	ML	00	35	57	08	15.41	30	25	05	--	1.86
		12.30/12.60	UDS4/2																	
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(56) 17/24/32/39																
14.00									Hard, greyish brown, clayey SILT											
14.50																				
15.00		15.00/	UDS5/1							SM	00	79	← 21 →		17.52	← NP →			--	1.84
		15.30/15.60	UDS5/2																	
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(48) 14/21/27/34																
17.00									Dense, brownish grey, silty SAND											
17.50																				
18.00		18.00/	UDS6/1							SM	00	86	← 14 →		17.01	← NP →			--	1.84
		18.30/18.60	UDS6/2																	
18.50																				
19.00																				
19.50		19.50/20.10	SPT7	(62) 23/27/35/45																
20.00									Very dense,brownish grey,silty SAND											

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00	SX	21.00/	UDS7/1																	
		21.30/ 21.60	UDS7/2							SM	00	68	← 32 →		15.89	← NP →			--	1.86
21.50																				
22.00									Dense, brownish grey, silty SAND											
22.50		22.50/ 23.10	SPT8	(48) 18/20/28/38																
23.00																				
23.50																				
24.00		24.00/	UDS8/1							SM	00	85	← 15 →		13.46	← NP →			--	1.88
		24.30/ 24.60	UDS8/2																	
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(55) 18/22/33/42																
26.00																				
26.50																				
27.00		27.00/	UDS9/1						Very dense, greyish brown, silty SAND											
		27.30/ 27.60	UDS9/2							SM	00	77	← 23 →		14.36	← NP →			--	1.87
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(55) 17/24/31/38																
29.00																				
29.50																				
30.00		30.00/																		
		30.30	UDS10/1							ML	00	31	60	09	12.72	32	26	06	--	1.88

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50		30.30/ 30.60	UDS10/2						Hard, brownish grey, clayey SILT of low compressibility											
31.00	SX																			
31.50		31.50/ 32.10	SPT11	(51) 16/21/30/34																
32.00																				
32.50																				
33.00		33.00/	UDS11/1							SM	00	80	← 20 →		18.76	← NP →			--	1.84
		33.30/ 33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/ 35.10	SPT12	(65) 18/29/36/45					Very dense, brownish grey, silty SAND											
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SM	00	81	← 19 →		15.61	← NP →			--	1.86
		36.30/ 36.60	UDS12/2																	
36.50																				
37.00																				
37.50		37.50/ 37.95	SPT13	(>50) 23/37/52/--																
38.00																				
38.50									Hard, brownish, clayey SILT of low compressibility											
39.00		39.00/	UDS13/1							ML	00	42	51	07	18.82	28	24	04	--	1.83
		39.30/ 39.60	UDS13/2																	
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/40.98	SPT14	(87) 23/38/49/52																
41.00	SX																			
41.50																				
42.00		42.00/	UDS14/1							MI	05	04	77	14	23.38	36	27	09	--	1.83
		42.30/42.60	UDS14/2						Hard, brownish grey, clayey SILT of medium compressibility											
42.50																				
43.00																				
43.50		43.50/43.95	SPT15	(95) 28/43/52/--																
44.00																				
44.50																				
45.00		45.00/	UDS15/1							ML	00	33	59	08	13.38	31	25	06	--	1.87
		45.30/45.60	UDS15/2																	
45.50																				
46.00																				
46.50		46.50/46.98	SPT16	(73) 21/31/42/52					Hard, brownish, clayey SILT of low compressibility											
47.00																				
47.50																				
48.00		48.00/	UDS16/1							SM	00	76	← 24 →		18.56	← NP →			--	1.85
		48.30/48.60	UDS16/2																	
48.50																				
49.00									Very dense, brownish grey, silty SAND											
49.50		49.50/50.00	SPT17	(65) 19/27/38/52																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50									Very dense, brownish grey, silty SAND											
51.00		51.00/	UDS17/1							SM	00	82	← 18 →		18.16	← NP →			--	1.84
		51.30/ 51.60	UDS17/2																	
51.50	SX																			
52.00																				
52.50		52.50/ 52.45	SPT17	(86) 21/34/52/--					Very dense, brown,silty SAND											
53.00																				
53.50																				
54.00		54.00/	UDS18/1							SM	00	73	← 27 →		11.88	← NP →			--	1.87
		54.30/ 54.60	UDS18/2																	
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 54.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-113	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 10/03/2013 TO 13/03/2013
CO-ORDINATES	: N : 3257283.392, E : 561722.261	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.093m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.71m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																		
0.50		0.50																			
1.00																					
1.50		1.50/ 2.10	SPT1	(05) 02/02/03/04					Medium stiff, brownish, clayey SILT of low compressibility												
2.00																					
2.50																					
3.00		3.00/ 3.50	UDS1							ML	0	35	57	08	13.64	26	23	03	--	1.88
3.50																					
4.00																					
4.50		4.50/ 5.10	SPT2	(09) 03/04/05/07																	
5.00																					
5.50																					
6.00		6.00/ 6.50	UDS2						Stiff, brown, clayey SILT of low compressibility	ML	0	39	53	08	17.91	28	24	04	--	1.87
6.50																					
7.00																					
7.50		7.50/ 8.10	SPT3	(20) 06/08/12/15																	
8.00																					
8.50									Very stiff, greyish brown, clayey SILT of low compressibility												
9.00		9.00/ 9.50	UDS3							ML	0	27	61	12	11.86	32	25	07	--	1.89
9.50																					
10.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/11.10	SPT4	(30) 09/12/18/21					Hard, greyish brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/12.50	UDS4							MI	0	04	80	16	25.86	37	26	11	--	1.84
12.50									Hard, greyish brown, clayey SILT of medium compressibility											
13.00																				
13.50		13.50/14.10	SPT5	(34) 08/13/21/26																
14.00																				
14.50																				
15.00		15.00/15.36	UDS5						Dense, greyish brown, silty SAND	SM	00	65	← 35 →		18.74	← NP →			--	1.89
15.50																				
16.00																				
16.50		16.50/17.00	SPT6	(47) 09/19/28/52																
17.00																				
17.50																				
18.00		18.00/18.31	UDS6						Dense, brown, silty SAND	SM	00	68	← 32 →		18.94	← NP →			--	1.86
18.50																				
19.00																				
19.50		19.50/19.90	SPT7	(>50) 12/26/52/--																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Very dense, brownish grey, silty SAND											
21.00		21.00/ 21.40	UDS7							SM	00	86	← 14 →		24.98	← NP →			--	1.88
21.50																				
22.00	SX																			
22.50		22.50/ 22.90	SPT8	(>50) 12/21/52/--					Very dense, brownish grey, silty SAND											
23.00																				
23.50																				
24.00		24.00/ 24.32	UDS8							SM	00	84	← 16 →		22.64	← NP →			--	1.91
24.50																				
25.00																				
25.50		25.50/ 25.94	SPT9	(>50) 15/28/52/--																
26.00																				
26.50																				
27.00		27.00/ 27.31	UDS9						Very dense, brownish grey, silty SAND	SM	00	86	← 14 →		22.87	← NP →			--	1.54
27.50																				
28.00																				
28.50		28.50/ 28.88	SPT10	(>50) 18/28/52/--																
29.00																				
29.50																				
30.00		30.00/ 30.31	UDS10							SM	00	85	← 15 →		21.63	← NP →			--	1.90

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50		31.50/ 31.86	SPT11	(>50) 19/41/52/--																
32.00	SX																			
32.50																				
33.00		33.00/ 33.30	UDS11							SM	00	86	← 14 →		19.89	← NP →			--	1.86
33.50																				
34.00																				
34.50		34.50/ 34.92	SPT12	(>50) 25/28/52/--					Very dense, greyish brown, silty SAND											
35.00																				
35.50																				
36.00		36.00/ 36.35	UDS12							SM	00	82	← 18 →		19.73	← NP →			--	1.85
36.50																				
37.00		37.00/ 37.96	SPT13	(49) 17/21/28/52																
37.50																				
38.00																				
38.50																				
39.00		39.00/ 39.28	UDS13							SM	00	62	← 38 →		30.15	← NP →			--	1.82
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX (%)	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/ 40.85	SPT14	(>50) 2144/52/--					Very dense, greyish brown, silty SAND										
41.00																			
41.50																			
42.00	SX	42.00/ 42.20	UDS14							SM	00	83	← 17 →		20.95	← NP →			--	1.83
42.50																			
43.00																			
43.50		43.50/ 43.84	SPT15	(>50) 26/46/52/--															
44.00																			
44.50																			
45.00		45.00/ 45.28	UDS15						Hard, greyish brown, clayey SILT of low compresibility	ML	18	10	61	11	25.17	← NP →			--	1.81
45.50																			
46.00																			
46.50		46.50/ 46.90	SPT16	(>50) 28/46/52/--															
47.00																			
47.50																			
48.00		48.00/ 48.35	UDS16							SM	13	50	← 37 →		20.58	← NP →			--	1.80
48.50									Very dense, greyish brown, silty SAND with gravels										
49.00																			
49.50		49.50/ 49.82	SPT17	(>50) 31/41/52/--															
50.00																			

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/ 51.26	UDS17						Very dense, greyish brown, silty SAND	SM	00	82	← 18 →		20.68	← NP →			--	1.85
51.50																				
52.00		52.00/ 52.30	SPT18	(>50) 40/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-114	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 18/04/2014 TO 02/04/2014
CO-ORDINATES	: N 3257306.490, E 561715.377	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.415m	CASING	: SX mm Ø Upto 53.00m BGL.
GROUND W. T.	: 2.93m Below EGL.	BOREHOLE DEPTH	: 53.00m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.50	SX	0.00 0.50	DS1						Medium stiff, brown,clayey SILT of low compressibility											
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/04																
2.00																				
2.50																				
3.00		3.00/	UDS1/1							ML	00	35	58	07	11.38	31	25	06	--	1.87
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2																	
5.00									Medium stiff, brownish grey, clayey SILT											
5.50																				
6.00		6.00/	UDS2/1							ML	01	12	72	15	22.73	34	26	08	--	1.84
		6.30/ 6.60	UDS2/2																	
6.50																				
7.00									Brownish, clayey SILT of low compressibility											
7.50		7.50/ 8.10	SPT3	(13) 03/06/07/10																
8.00																				
8.50																				
9.00		9.00/	UDS3/1						Stiff, brownish grey, clayey SILT of low compressibility	ML	00	30	62	08	14.96	32	25	07	--	1.86
		9.30/ 9.60	UDS3/2																	
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(16) 04/08/08/09					Very stiff, brownish grey, clayey SILT											
11.00																				
11.50																				
12.00		12.00/	UDS4/1							ML	00	35	58	07	14.09	30	25	05	--	1.85
		12.30/12.60	UDS4/2																	
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(16) 05/07/09/11					Very stiff, brownish, clayey SILT of low compressibility											
14.00																				
14.50																				
15.00		15.00/	UDS5/1							SM	00	88	← 12 →		20.48	← NP →			--	1.83
		15.30/15.60	UDS5/2																	
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(38) 06/18/20/22					Dense, brownish grey, silty SAND											
17.00																				
17.50																				
18.00		18.00/	UDS6/1							SM	00	77	← 23 →		18.41	← NP →			--	1.85
		18.30/18.60	UDS6/2																	
18.50																				
19.00																				
19.50		19.50/20.10	SPT7	(49) 08/21/28/38																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00	SX	21.00/	UDS7/1						Dense, brownish grey, silty SAND	SM	00	87	← 13 →		12.17	← NP →			--	1.86
		21.30/ 21.60	UDS7/2																	
21.50																				
22.00																				
22.50		22.50/ 23.10	SPT8	(52) 09/23/29/32																
23.00																				
23.50																				
24.00		24.00/	UDS8/1							SM	00	81	← 19 →		20.83	← NP →			--	1.83
		24.30/ 24.60	UDS8/2																	
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(54) 20/22/32/37																
26.00									Very dense, brownish grey, silty SAND											
26.50																				
27.00		27.00/	UDS9/1							SM	00	85	← 15 →		22.35	← NP →			--	1.83
		27.30/ 27.60	UDS9/2																	
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(58) 14/27/31/38																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10/1							SM	00	81	← 19 →		11.15	← NP →			--	1.87

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50		30.30/30.60	UDS10/2																	
31.00	SX																			
31.50		31.50/32.10	SPT11	(59) 16/28/31/42					Very dense, brownish grey, silty SAND											
32.00																				
32.50																				
33.00		33.00/	UDS11/1							SM	00	88	← 12 →		11.41	← NP →			--	1.87
		33.30/33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/35.10	SPT12	(77) 22/33/44/51																
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SP-SM	00	92	← 08 →		19.14	--	--	--	--	1.86
		36.30/36.60	UDS12/2																	
36.50																				
37.00																				
37.50		37.50/38.10	SPT13	(67) 19/28/39/45					Very dense, brownish grey, silty SAND											
38.00																				
38.50																				
39.00		39.00/	UDS13/1							SP-SM	00	90	← 10 →		11.97	--	--	--	--	1.87
		39.30/39.60	UDS13/2						Very dense, grey, silty SAND											
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 5 OF 6

FIELD DATA										DESCRIPTION	LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL %	PL %	PLASTICITY INDEX		
40.50		40.50/41.00	SPT14	(78) 22/33/45/52																
41.00	SX																			
41.50																				
42.00		42.00/	UDS14/1																	
		42.30/42.60	UDS14/2							SM	00	87	← 13 →		16.13	← NP →			--	1.86
42.50																				
43.00																				
43.50		43.50/44.00	SPT15	(86) 24/38/48/52																
44.00																				
44.50																				
45.00		45.00/	UDS15/1																	
		45.30/45.60	UDS15/2							Very dense, brownish grey, silty SAND	SM	00	85	← 15 →	12.30	← NP →			--	1.88
45.50																				
46.00																				
46.50		46.50/46.90	SPT16	(>50) 22/35/52/--																
47.00																				
47.50																				
48.00		48.00/	UDS16/1																	
		48.30/48.60	UDS16/2							SM	00	89	← 11 →		11.84	← NP →			--	1.86
48.50																				
49.00																				
49.50		49.50/49.85	SPT17	(>50) 21/37/52/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																					
51.00		51.00/	UDS17/1																		
		51.30/ 51.60	UDS17/2						Very dense, brownish grey, silty SAND	SM	00	89	← 11 →		11.64	--	--	--	--	1.86
51.50	SX																				
52.00																					
52.50		52.50/ 52.80	SPT18	(>50) 28/52/--/--																	
53.00		53.00/																			
		53.30/ 53.60	UDS18/1 UDS18/2							SM	00	55	41	04	20.37	27	24	03	--	1.84
53.50																					
54.00																					
54.50																					
55.00																					
55.50																					
56.00																					
56.50																					
57.00																					
57.50																					
58.00																					
58.50																					
59.00																					
59.50																					
60.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 53.00m.BELOW EGL.

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-117	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 05/06/2013 TO 11/06/2013
CO-ORDINATES	: N : 3257286.508, E : 561792.420	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.036m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.70m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/05					Medium stiff, brownish, clayey SILT											
2.00																				
2.50																				
3.00		3.00/ 3.35	UDS1							ML	00	40	54	06	12.03	33	26	07	--	1.83
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(17) 06/07/10/14																
5.00																				
5.50																				
6.00		6.00/ 6.34	UDS2						Very stiff, greyish brown, clayey SILT of low compressibility	ML	00	23	66	11	18.13	34	26	08	--	1.81
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(18) 06/08/10/11																
8.00																				
8.50																				
9.00		9.00/ 9.32	UDS3							SM	00	69	← 31 →		15.80	← NP →			--	1.86
9.50									Medium dense, greyish brown, silty SAND											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(25) 10/12/13/18					Medium dense, greyish brown, silty SAND											
11.00																				
11.50																				
12.00		12.00/12.30	UDS4							SM	00	68	← 32 →		13.87	← NP →			--	1.87
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(30) 12/14/16/21					Dense, greyish brown, silty SAND											
14.00																				
14.50																				
15.00		15.00/15.36	UDS5							SM	00	80	← 20 →		17.12	← NP →			--	1.88
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(39) 13/18/21/28					Dense, brownish grey, silty SAND											
17.00																				
17.50																				
18.00		18.00/18.21	UDS6							MI	00	16	66	18	27.19	36	27	09	--	1.81
18.50																				
19.00									Hard, brownish grey, clayey SILT of medium compressibility											
19.50		19.50/20.10	SPT7	(40) 16/19/21/28																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Hard, brownish grey, clayey SILT of medium compressibility											
21.00		21.00/ 21.27	UDS7							SM	00	51	43	06	19.24	26	23	03	--	1.86
21.50																				
22.00	SX																			
22.50		22.50/ 23.10	SPT8	(45) 19/22/23/26					Dense brownish grey, silty SAND											
23.00																				
23.50																				
24.00		24.00/ 24.27	UDS8							SM	00	80	← 20 →		19.55	← NP →			--	1.85
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(60) 13/26/34/39																
26.00																				
26.50																				
27.00		27.00/ 27.30	UDS9							SM	00	89	← 12 →		17.05	← NP →			--	1.89
27.50									Very dense, greyish brown, silty SAND											
28.00																				
28.50		28.50/ 29.10	SPT10	(67) 19/30/37/41																
29.00																				
29.50																				
30.00		30.00/ 30.25	UDS10							SM	04	15	← 81 →		16.90	← NP →			--	1.82

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50		31.50/ 32.10	SPT11	(74) 23/32/42/52																
32.00	SX																			
32.50																				
33.00		33.00/ 33.34	UDS11						Very dense, greyish brown, silty SAND	SM	00	79	← 21 →		13.16	← NP →		--	1.85
33.50																				
34.00																				
34.50		34.50/ 35.05	SPT12	(81) 26/35/46/52																
35.00																				
35.50																				
36.00		36.00/ 36.35	UDS12							SM	00	71	← 29 →		10.22	← NP →		--	1.93
36.50																				
37.00																				
37.50		37.50/ 37.95	SPT13	(>50) 32/48/52/--					Very dense, brown, silty SAND											
38.00																				
38.50																				
39.00		39.00/ 39.39	UDS13							SM	00	74	← 26 →		20.22	← NP →		--	1.86
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50	SX	40.50/40.68	SPT14	(>50) 44/52/--/--					Very dense, brownish grey, silty SAND											
41.00																				
41.50																				
42.00		42.00/42.26	UDS14							SM	00	73	← 27 →		19.93	← NP →			--	1.84
42.50																				
43.00																				
43.50		43.50/43.75	SPT15	(>50) 40/52/--/--																
44.00																				
44.50																				
45.00		45.00/45.23	UDS15							SM	00	73	← 27 →		18.38	← NP →			--	1.87
45.50																				
46.00																				
46.50		46.50/46.82	SPT16	(>50) 24/35/52/--																
47.00																				
47.50																				
48.00		48.00/48.25	UDS16							SM	00	75	← 25 →		20.27	← NP →			--	1.85
48.50																				
49.00									Very dense, greyish brown, silty SAND											
49.50		49.50/49.95	SPT17	(>50) 28/42/52/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/ 51.27	UDS17						Very dense, greyish brown, silty SAND	SM	00	85	← 15 →		20.36	← NP →			--	1.89
51.50																				
52.00		52.00/ 52.13	SPT18	(>50) 52/--/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-118	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 08/09/2013 TO 12/09/2013
CO-ORDINATES	: N : 3257328.963, E : 561770.526	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.930m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.50m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1						Medium stiff, brownish, clayey SILT										
0.50		0.50																	
1.00																			
1.50																			
2.00																			
2.50																			
3.00		3.00	UDS1							ML	00	44	51	05	16.35	29	25	04	--	1.95
3.50		3.50/ 4.10	SPT1	(09) 02/03/06/09					Stiff, brownish, clayey SILT of low compressibility										
4.00																			
4.50																			
5.00																			
5.50																			
6.00		6.00/	UDS2							ML	00	40	55	05	18.73	26	23	03	--	1.89
6.50		6.40/ 7.00	SPT2	(26) 06/12/14/16					Very stiff, brownish grey, clayey SILT of low compressibility										
7.00																			
7.50																			
8.00																			
8.50																			
9.00		9.00/	UDS3							ML	02	45	49	04	23.36	27	23	04	--	1.87
9.50		9.37/ 9.97	SPT3	(21) 07/09/12/14															
10.00																			

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 2 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50																				
11.00									Very stiff, brownish grey, clayey SILT of low compressibility											
11.50																				
12.00	SX	12.00	UDS4																	
		12.40/ 13.00	SPT4	(58) 10/23/35/43						ML	06	24	62	08	22.66	29	24	05	--	1.93
12.50																				
13.00																				
13.50																				
14.00																				
14.50									Hard, brownish grey, clayey SILT of low compressibility											
15.00		15.00	UDS5																	
		15.30/ 15.90	SPT5	(61) 12/24/37/42						ML	01	06	71	22	17.31	34	26	08	--	1.89
15.50																				
16.00																				
16.50																				
17.00																				
17.50																				
18.00		18.00	UDS6																	
		18.35/ 18.80	SPT6	(39) 14/17/22/31						SM	00	70	← 30 →		19.56	← NP →			--	1.98
18.50																				
19.00									Dense, greyish brown, silty SAND											
19.50																				
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Dense, greyish brown, silty SAND											
21.00		21.00	UDS7																	
		21.24/ 21.82	SPT7	(75) 18/34/41/52						SM	00	78	← 22 →		20.47	← NP →			--	1.99
21.50																				
22.00	SX								Very dense, brownish grey, silty SAND											
22.50																				
23.00																				
23.50																				
24.00		24.00	UDS8																	
		24.30/ 24.80	SPT8	(71) 17/28/43/52						SM	00	84	← 16 →		23.10	← NP →			--	1.93
24.50																				
25.00									Very dense, greyish brown, silty SAND											
25.50																				
26.00																				
26.50																				
27.00		27.00	UDS9																	
		27.28/ 27.88	SPT9	(53) 19/26/27/41						SM	00	74	← 26 →		21.41	← NP →			--	1.87
27.50																				
28.00									Very dense, brownish grey, silty SAND											
28.50																				
29.00																				
29.50																				
30.00		30.00/ 30.24	UDS10							SM	00	85	← 15 →		21.13	← NP →			--	1.97

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50	SX	30.24/ 30.84	SPT10	(62) 17/24/38/47					Very dense, brownish grey, silty SAND											
31.00																				
31.50																				
32.00																				
32.50																				
33.00		33.00	UDS11/1							SM	00	79	← 21 →		20.04	← NP →			--	1.98
		33.30	UDS11/2																	
33.50		33.60/ 34.20	SPT11	(70) 19/28/42/52																
34.00									Very dense, brownish yellow, silty SAND											
34.50																				
35.00																				
35.50																				
36.00		36.00	UDS12/1							SM	00	69	← 31 →		19.37	← NP →			--	1.84
		36.30	UDS12/2																	
36.50		36.60/ 37.20	SPT12	(42) 12/20/22/44																
37.00									Very dense, greyish brown, SAND											
37.50																				
38.00																				
38.50																				
39.00		39.00	UDS13/1							SM	00	67	← 33 →		20.78	← NP →			--	1.93
		39.30	UDS13/2																	
39.50		39.60/ 40.00	SPT13	(>50) 28/42/52/--																
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50																				
41.00																				
41.50																				
42.00	SX	42.00	UDS14/1																	
		42.30	UDS14/2							SM	00	63	← 37 →		17.76	← NP →			--	1.84
42.50		42.60/ 42.95	SPT14	(>50) 36/43/52/--																
43.00																				
43.50									Very dense, greyish brown, SAND											
44.00																				
44.50																				
45.00		45.00	UDS15/1																	
		45.30	UDS15/2							SM	00	78	← 22 →		16.82	← NP →			--	1.86
45.50		45.60/ 45.80	SPT15	(>50) 42/52/--/--																
46.00																				
46.50																				
47.00																				
47.50																				
48.00		48.00	UDS16/1																	
		48.30	UDS16/2							SM	00	68	← 32 →		19.38	← NP →			--	1.86
48.50		48.60/ 48.78	SPT16	(>50) 48/52/--/--																
49.00									Very dense, brownish grey, silty SAND											
49.50																				
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00	UDS17/1						Very dense, brownish grey, silty SAND	SM	00	83	← 17 →		18.90	← NP →			--	1.90
		51.30	UDS17/2																	
51.50		51.60/ 51.72	SPT17	(>50) 52/--/--/--																
52.00		52.00/ 52.28	SPT18	(>50) 49/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-108	SHEET NO.	: 1 OF 2
LOCATION	: GT Area-2	DATE	: 25/04/2014 TO 26/04/2014
CO-ORDINATES	: N 3257361.084, E 561698.594	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.046m	CASING	: SX mm Ø Upto 18.00m BGL.
GROUND W. T.	: 2.85m Below EGL.	BOREHOLE DEPTH	: 18.00m.Below EGL.

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/05																
2.00									Medium stiff, brown, clayey SILT of low compressibility											
2.50																				
3.00		3.00/	UDS1/1							ML	00	32	59	09	11.24	32	25	07	--	1.87
3.50		3.30/ 3.60	UDS1/2																	
4.00																				
4.50		4.50/ 5.10	SPT2	(25) 07/11/14/19																
5.00									Very stiff, brown, clayey SILT											
5.50																				
6.00		6.00/	UDS2/1							ML	00	49	46	05	12.84	26	24	02	--	1.91
6.50		6.30/ 6.60	UDS2/2																	
7.00																				
7.50		7.50/ 8.10	SPT3	(67) 11/29/38/42					Hard, brownish grey, clayey SILT of low compressibility											
8.00																				
8.50																				
9.00		9.00/	UDS3/1							ML	01	39	54	06	14.33	30	25	05	3.38×10^{-6}	1.88
9.50		9.30/ 9.60	UDS3/2																	
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

DBM GEOTECHNICS AND CONSTRUCTIONS PVT. LTD. MUMBAI.
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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-108 | SHEET NO. : 2 OF 2

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/ 11.10	SPT4	(31) 05/13/18/22																	
11.00																					
11.50																					
12.00	SX	12.00/	UDS4/1																		
		12.30/ 12.60	UDS4/2						Hard, brownish grey, clayey SILT of low compressibility	ML	01	25	64	10	16.06	33	26	07	--	1.87
12.50																					
13.00																					
13.50		13.50/ 14.10	SPT5	(41) 08/19/22/31																	
14.00																					
14.50																					
15.00		15.00/	UDS5/1																		
		15.30/ 15.60	UDS5/2						Hard, brownish grey, clayey SILT of low compressibility with gravels	ML	13	32	48	07	12.38	28	24	04	--	1.88
15.50																					
16.00																					
16.50		16.50/ 17.10	SPT6	(45) 19/21/24/33																	
17.00																					
17.50									Hard, greyish brown, clayey SILT of low compressibility												
18.00		18.00/	UDS6/1																		
		18.30/ 18.60	UDS6/2							ML	02	39	53	06	11.92	29	24	05	--	1.89
18.50																					
19.00																					
19.50																					
20.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 18.60m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

1. Geotechnical Properties of Natural Soil

1.1 Turbine Building -1:

1.1.1 Static Young's modulus (Es)

Structure	Test Depth Below Existing Ground Level	E_s	Gs
		MPa	MPa
Turbine Building, TB-1	3.6m	16.24	6.01
	8.6m	20.22	7.49
	13.6m	29.86	11.06
	18.6m	48.86	18.1
	23.6m	220.68	81.73
	28.6m	284.06	105.21
	29.4m	229.06	84.84
	34.4m	147.84	54.75
	39.4m	106.57	53.36
	44.4m	277.53	102.79
	49.4m	213.07	78.91
	59.4m	196.62	72.83
	69.4m	352.96	130.72
	79.4m	377.76	139.91

1.1.2 Angle of Internal Friction (ϕ)

Depth below FGL		Depth below EGL		Avg. Density	Angle of Internal Friction based on Corrected SPT, Φ in Degrees
From	To	From	To		
5.4m	8.4m	0.0m	3.0m	1.87	29
8.4m	11.4m	3.0m	6.0m	1.87	32
11.4m	14.4m	6.0m	9.0m	1.85	32
14.4m	17.4m	9.0m	12.0m	1.83	35
17.4m	20.4m	12.0m	15.0m	1.88	35
20.4m	23.4m	15.0m	18.0m	1.84	35
23.4 m	26.4m	18.0m	21.0m	1.85	35
26.4 m	29.4m	21.0m	24.0m	1.83	35
29.4m	32.4m	24.0m	27.0m	1.87	36
32.4m	35.4m	27.0m	30.0m	1.88	36
35.4m	38.4m	30.0m	33.0m	1.90	36
38.4m	41.4m	33.0m	36.0m	1.88	37
41.4m	44.4m	36.0m	39.0m	1.87	36
44.4m	47.4m	39.0m	42.0m	1.87	37
47.4m	50.4m	42.0m	45.0m	1.86	37
50.4m	53.4m	45.0m	48.0m	1.86	36
53.4m	56.4m	48.0m	51.0m	1.88	36

56.4m	59.4m	51.0m	54.0m	1.86	36
59.4m	62.4m	54.0m	57.0m	1.85	37
62.4m	65.4m	57.0m	60.0m	1.89	37
65.4m	71.4m	60.0m	66.0m	1.88	37
71.4m	77.4m	66.0m	72.0m	1.88	37
77.4m	83.4m	72.0m	78.0m	1.89	37
83.4m	89.4m	78.0m	84.0m	1.88	37
89.4m	95.4m	84.0m	90.0m	1.89	38
95.4m	101.4m	90.0m	96.0m	1.87	38
101.4m	107.4m	96.0m	102.0m	1.87	38

1.2 Turbine Building -2:

1.2.1 Static Young's modulus (Es)

Structure	Test Depth Below Existing Ground Level	E_s	G_s
		MPa	MPa
Turbine Building, TB-2	4.5m	24.5	9.07
	9.5m	19.94	7.39
	14.5m	46.2	17.11
	19.5m	94.1	34.85
	24.5m	190.48	70.55
	29.5m	96.9	35.89
	34.4m	147.84	54.75
	39.4m	106.57	53.36
	44.4m	277.53	102.79
	49.4m	213.07	78.91
	59.4m	196.62	72.83
	69.4m	352.96	130.72
	79.4m	377.76	139.91

1.2.2 Angle of Internal Friction (ϕ)

Depth below FGL		Depth below EGL		Avg. Density	Angle of Internal Friction based on Corrected SPT, Φ in Degrees
From	To	From	To		
5.4m	8.4m	0.0m	3.0m	1.87	29
8.4m	11.4m	3.0m	6.0m	1.86	32
11.4m	14.4m	6.0m	9.0m	1.87	33
14.4m	17.4m	9.0m	12.0m	1.85	34
17.4m	20.4m	12.0m	15.0m	1.87	34
20.4m	23.4m	15.0m	18.0m	1.87	34
23.4 m	26.4m	18.0m	21.0m	1.89	37
26.4 m	29.4m	21.0m	24.0m	1.87	36
29.4m	32.4m	24.0m	27.0m	1.87	35
32.4m	35.4m	27.0m	30.0m	1.89	35

35.4m	38.4m	30.0m	33.0m	1.88	37
38.4m	41.4m	33.0m	36.0m	1.86	35
41.4m	44.4m	36.0m	39.0m	1.86	37
44.4m	47.4m	39.0m	42.0m	1.84	38
47.4m	50.4m	42.0m	45.0m	1.86	39
50.4m	53.4m	45.0m	48.0m	1.86	38
53.4m	56.4m	48.0m	51.0m	1.87	37
56.4m	59.4m	51.0m	54.0m	1.86	36
59.4m	62.4m	54.0m	57.0m	1.85	37
62.4m	65.4m	57.0m	60.0m	1.89	37
65.4m	71.4m	60.0m	66.0m	1.88	37
71.4m	77.4m	66.0m	72.0m	1.88	37
77.4m	83.4m	72.0m	78.0m	1.89	37
83.4m	89.4m	78.0m	84.0m	1.88	37
89.4m	95.4m	84.0m	90.0m	1.89	38
95.4m	101.4m	90.0m	96.0m	1.87	38
101.4m	107.4m	96.0m	102.0m	1.87	38

1.3 Turbine Building -1&2

1.3.1 Density (ρ), Poisson's Ratio (μ), Dynamic Young's modulus (E_d)

Depth(m)	Average velocity		Vp/Vs	Density (Kg/m^3)	Poisson's Ratio	E_d(MPa)	G_d(MPa)
	Vs	Vp					
1.5	250.81	479.68	1.91	1850	0.31	310	120
3	261.14	521.11	2.00	1850	0.33	340	130
4.5	266.56	547.61	2.05	1850	0.34	350	130
6	287.08	577.76	2.01	1835	0.34	400	150
7.5	296.29	604.08	2.04	1835	0.34	430	160
9	309.46	632.66	2.04	1860	0.34	480	180
10.5	331.59	661.69	2.00	1860	0.33	540	200
12	358.68	711.46	1.98	1825	0.33	620	230
13.5	390.10	770.10	1.97	1825	0.33	740	280
15	419.73	807.18	1.92	1855	0.31	860	330
16.5	403.31	759.56	1.88	1855	0.30	790	300
18	389.58	726.98	1.87	1855	0.30	730	280
19.5	393.48	724.75	1.84	1855	0.29	740	290
21	405.04	746.56	1.84	1855	0.29	790	300
22.5	404.34	732.55	1.81	1855	0.28	780	300
24	404.29	746.16	1.85	1860	0.29	790	300
25.5	399.54	739.90	1.85	1860	0.29	770	300
27	412.10	758.19	1.84	1875	0.29	820	320
28.5	424.58	786.90	1.85	1875	0.29	880	340
30	467.65	873.70	1.87	1910	0.30	1090	420

31.5	460.85	866.90	1.88	1910	0.30	1060	410
33	469.60	892.16	1.90	1855	0.31	1070	410
34.5	478.15	901.95	1.89	1855	0.30	1110	420
36	459.23	848.86	1.85	1860	0.29	1010	390
37.5	489.63	896.43	1.83	1860	0.29	1150	450
39	513.53	945.45	1.84	1835	0.29	1250	480
40.5	545.79	996.24	1.83	1835	0.29	1410	550
42	569.35	1045.34	1.84	1835	0.29	1530	590
43.5	583.95	1074.66	1.84	1835	0.29	1620	630
45	591.89	1119.08	1.89	1850	0.31	1690	650
46.5	582.78	1098.14	1.88	1850	0.30	1640	630
47	535.69	1010.04	1.89	1854.375	0.29	1380	530
48.5	535.13	1004.80	1.88	1874.286	0.29	1380	540
50	487.30	926.65	1.90	1837.5	0.31	1140	440
51.5	498.09	920.75	1.85	1796.25	0.29	1150	450
53	484.14	918.17	1.90	1788.125	0.30	1090	420
54.5	486.54	922.97	1.90	1794.065	0.30	1110	420
56	484.79	923.98	1.91	1792.03	0.31	1100	420
57.5	489.43	946.48	1.93	1830	0.31	1150	440
59	497.16	933.68	1.88	1885	0.30	1210	470
60.5	496.38	974.97	1.96	1922.5	0.32	1250	470
62	492.79	954.68	1.94	1936.25	0.31	1240	470
63.5	513.86	955.98	1.86	1943.125	0.29	1330	510
65	529.58	996.27	1.88	1946.565	0.31	1430	550
66.5	526.01	1007.93	1.92	1940	0.32	1410	540
68	541.58	1017.65	1.88	1962.5	0.30	1500	580
69.5	531.00	1023.92	1.93	1973.75	0.32	1470	560
71	539.60	1047.20	1.94	1979.375	0.32	1520	580
72.5	542.85	1056.60	1.95	1967.19	0.32	1520	580
74	550.05	1094.62	1.99	1968.595	0.32	1580	600
75.5	528.95	1046.02	1.98	1969.295	0.32	1460	550
77	545.09	1043.02	1.91	1969.65	0.31	1540	590
78.5	553.38	1055.38	1.91	1975	0.31	1590	600
80	547.84	1036.38	1.89	1950	0.31	1530	590
81.5	546.56	1059.77	1.94	1937.5	0.32	1530	580
83	583.91	1094.00	1.87	1931.25	0.31	1720	660
84.5	577.33	1075.53	1.86	1943.125	0.30	1680	650
86	573.29	1090.50	1.90	1941.565	0.31	1670	640
87.5	575.86	1092.52	1.90	1940.78	0.31	1680	640
89	581.85	1116.78	1.92	1940.39	0.31	1720	660
90.5	569.14	1116.10	1.96	1910	0.32	1630	620
92	563.89	1106.53	1.96	1890	0.32	1590	600

93.5	571.15	1164.05	2.04	1880	0.33	1640	610
95	580.45	1186.12	2.04	1875	0.34	1690	630
96.5	606.61	1215.18	2.00	1902.5	0.33	1860	700
98	596.35	1233.37	2.07	1901.25	0.34	1810	680
99.5	601.71	1263.48	2.10	1900.625	0.35	1860	690
101	593.94	1273.63	2.14	1900.315	0.35	1810	670
102.5	595.15	1269.00	2.13	1870	0.35	1790	660
104	582.05	1258.75	2.16	1902.5	0.35	1740	640
105.5	595.75	1263.33	2.12	1918.75	0.34	1830	680
107	600.63	1278.40	2.13	1926.875	0.35	1870	700
108.5	622.53	1341.52	2.15	1945.94	0.35	2040	750
109.5	625.41	1331.37	2.13	1950	0.35	2050	760

1.4 Cohesion (C_u):

Soil is considered cohesion-less for analysis. However, for the stability in the software application, a minimum value of cohesion may be used.

ANNEXURE - 1A

1. Geotechnical Properties of Improved Soil (Soil – Cement Mix)

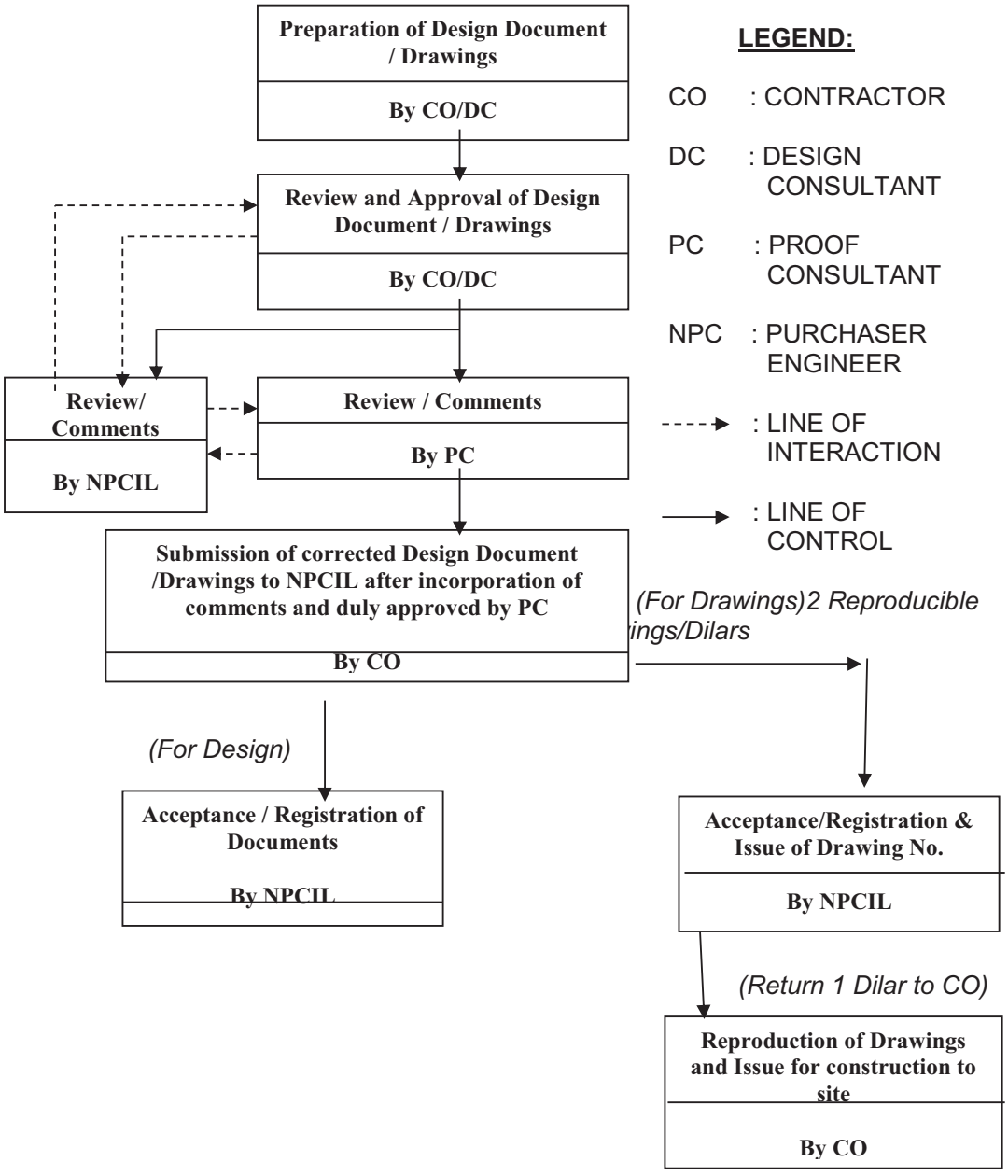
Sr. No.	Properties	Values	Unit	Remark
1	Static Modulus of Elasticity (Es)	777	MPa	
2	Improved Bulk Density, ρ	2	T/m^2	
3	Poisson's Ratio, μ, (Static/Dynamic)	0.38	-	
4	Cohesion, C	1.82	Kg/cm^2	For Static analysis
		3.44	Kg/cm^2	For Dynamic analysis
5	Angle of Internal Friction, ϕ	51.01	Degrees	For Static analysis
		47.37	Degrees	For Dynamic analysis
6	Dilation Angle, ψ = ϕ - 30	21.01	Degrees	For Static analysis
		17.37	Degrees	For Dynamic analysis
7	Shear Wave Velocity, Vs	1157	m/sec	
8	G/Gmax correction	0.4	-	

Note 1 - Reduction factor of 0.75 (this factor is applied to cohesion and tanΦ) shall be multiplied as per Euro Code-7 to take care of the spatial variation.

Note 2 - To take care of tension effect in soil-cement, a tension cut-off value of $2C_u*\cot\alpha$ (where $\alpha=45+\Phi/2$) shall be considered in the analysis.

ANNEXURE - 2

FLOW CHART FOR ISSUE OF CIVIL DESIGN DOCUMENT/DRAWING



ANNEXURE - 3

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
0.100	0.029	0.023	0.016	0.013	0.012	0.011	0.010	0.008	0.006
0.105	0.032	0.025	0.018	0.015	0.013	0.012	0.011	0.009	0.006
0.110	0.035	0.028	0.020	0.016	0.014	0.013	0.012	0.009	0.007
0.116	0.039	0.031	0.022	0.018	0.016	0.015	0.013	0.010	0.008
0.122	0.043	0.034	0.025	0.020	0.018	0.016	0.014	0.011	0.008
0.128	0.047	0.037	0.027	0.022	0.020	0.018	0.016	0.013	0.009
0.134	0.052	0.041	0.030	0.024	0.022	0.020	0.017	0.014	0.010
0.141	0.058	0.045	0.033	0.027	0.024	0.022	0.019	0.015	0.011
0.148	0.064	0.050	0.036	0.030	0.026	0.024	0.021	0.017	0.012
0.155	0.070	0.055	0.040	0.033	0.029	0.026	0.023	0.019	0.013
0.163	0.077	0.060	0.044	0.036	0.032	0.029	0.026	0.021	0.015
0.171	0.085	0.067	0.049	0.040	0.036	0.032	0.028	0.023	0.016
0.180	0.094	0.074	0.054	0.044	0.040	0.035	0.031	0.025	0.018
0.189	0.104	0.081	0.060	0.049	0.044	0.039	0.034	0.028	0.020
0.198	0.115	0.089	0.066	0.053	0.048	0.043	0.038	0.030	0.022
0.208	0.127	0.099	0.073	0.059	0.053	0.047	0.042	0.033	0.024
0.218	0.139	0.108	0.080	0.065	0.059	0.052	0.046	0.037	0.026
0.229	0.154	0.119	0.089	0.072	0.065	0.057	0.050	0.041	0.029
0.241	0.170	0.132	0.098	0.079	0.072	0.063	0.056	0.045	0.032
0.253	0.188	0.146	0.109	0.088	0.079	0.070	0.062	0.049	0.036
0.265	0.206	0.160	0.119	0.096	0.087	0.077	0.068	0.054	0.039
0.279	0.229	0.178	0.132	0.107	0.097	0.085	0.075	0.060	0.043
0.293	0.252	0.196	0.146	0.118	0.107	0.094	0.083	0.066	0.048
0.307	0.277	0.216	0.160	0.130	0.117	0.104	0.091	0.073	0.053
0.323	0.307	0.239	0.178	0.144	0.130	0.115	0.100	0.081	0.058
0.339	0.339	0.263	0.196	0.159	0.143	0.127	0.111	0.089	0.064
0.356	0.374	0.291	0.216	0.176	0.157	0.141	0.122	0.098	0.071
0.373	0.410	0.319	0.237	0.194	0.173	0.155	0.134	0.108	0.078
0.392	0.453	0.353	0.262	0.214	0.191	0.171	0.148	0.119	0.086
0.412	0.501	0.390	0.290	0.237	0.211	0.190	0.164	0.132	0.095
0.432	0.525	0.409	0.304	0.249	0.221	0.199	0.172	0.138	0.100
0.454	0.552	0.430	0.320	0.262	0.233	0.209	0.180	0.145	0.105
0.476	0.579	0.451	0.335	0.274	0.244	0.219	0.189	0.152	0.110
0.500	0.608	0.474	0.352	0.288	0.256	0.231	0.199	0.160	0.115
0.525	0.639	0.497	0.370	0.303	0.269	0.242	0.208	0.168	0.121
0.552	0.671	0.523	0.389	0.318	0.283	0.254	0.219	0.177	0.127
0.579	0.704	0.549	0.408	0.334	0.297	0.267	0.230	0.185	0.133
0.608	0.740	0.576	0.428	0.350	0.311	0.280	0.241	0.195	0.140
0.639	0.777	0.605	0.450	0.368	0.327	0.295	0.254	0.205	0.147

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
0.670	0.815	0.635	0.472	0.386	0.343	0.309	0.266	0.215	0.154
0.704	0.856	0.667	0.496	0.406	0.361	0.325	0.279	0.225	0.162
0.739	0.899	0.700	0.520	0.426	0.379	0.341	0.293	0.237	0.170
0.776	0.944	0.735	0.546	0.447	0.397	0.358	0.308	0.248	0.179
0.815	0.991	0.772	0.574	0.470	0.417	0.376	0.324	0.261	0.188
0.856	1.018	0.791	0.588	0.481	0.428	0.385	0.331	0.268	0.193
0.899	1.046	0.811	0.602	0.494	0.438	0.395	0.339	0.274	0.198
0.943	1.073	0.831	0.616	0.506	0.449	0.404	0.347	0.281	0.203
0.991	1.103	0.851	0.631	0.519	0.460	0.414	0.356	0.288	0.208
1.040	1.132	0.872	0.646	0.531	0.471	0.425	0.364	0.296	0.213
1.092	1.163	0.894	0.661	0.545	0.483	0.435	0.373	0.303	0.219
1.147	1.194	0.916	0.677	0.559	0.495	0.446	0.382	0.311	0.224
1.204	1.226	0.938	0.693	0.572	0.507	0.457	0.391	0.319	0.230
1.264	1.259	0.962	0.709	0.587	0.519	0.468	0.400	0.327	0.236
1.327	1.293	0.985	0.726	0.601	0.532	0.480	0.410	0.335	0.242
1.394	1.328	1.010	0.743	0.617	0.545	0.492	0.420	0.344	0.248
1.464	1.364	1.035	0.761	0.632	0.558	0.504	0.430	0.352	0.255
1.537	1.401	1.060	0.779	0.648	0.572	0.517	0.440	0.361	0.261
1.614	1.438	1.086	0.798	0.664	0.586	0.529	0.451	0.371	0.268
1.694	1.477	1.113	0.817	0.681	0.600	0.542	0.461	0.380	0.275
1.779	1.517	1.141	0.836	0.698	0.615	0.556	0.472	0.389	0.282
1.868	1.558	1.169	0.856	0.715	0.630	0.570	0.484	0.399	0.289
1.961	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.059	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.162	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.270	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.384	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.503	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.628	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.760	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.898	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.043	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.195	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.355	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.522	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.698	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.883	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.077	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.281	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
4.495	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.720	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.956	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
5.204	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
5.464	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
5.737	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
6.024	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
6.325	1.500	1.130	0.840	0.705	0.622	0.564	0.480	0.400	0.291
6.642	1.407	1.066	0.804	0.678	0.599	0.544	0.466	0.391	0.286
6.974	1.320	1.006	0.771	0.653	0.577	0.525	0.452	0.382	0.281
7.322	1.238	0.950	0.739	0.628	0.556	0.507	0.439	0.373	0.276
7.689	1.162	0.896	0.708	0.604	0.536	0.489	0.426	0.364	0.271
8.073	1.090	0.846	0.678	0.581	0.516	0.472	0.413	0.356	0.267
8.477	1.022	0.798	0.650	0.559	0.497	0.456	0.401	0.348	0.262
8.901	0.959	0.753	0.622	0.537	0.479	0.440	0.389	0.340	0.257
9.346	0.899	0.711	0.596	0.517	0.462	0.425	0.377	0.332	0.253
9.813	0.844	0.671	0.571	0.497	0.445	0.410	0.366	0.324	0.248
10.303	0.792	0.633	0.547	0.478	0.429	0.396	0.355	0.317	0.244
10.819	0.751	0.606	0.526	0.461	0.414	0.383	0.345	0.309	0.240
11.360	0.712	0.579	0.506	0.445	0.399	0.370	0.335	0.301	0.236
11.928	0.676	0.554	0.486	0.429	0.386	0.358	0.325	0.293	0.232
12.524	0.641	0.530	0.467	0.413	0.372	0.346	0.315	0.286	0.227
13.150	0.608	0.507	0.449	0.399	0.359	0.335	0.306	0.279	0.223
13.808	0.577	0.485	0.431	0.384	0.347	0.324	0.297	0.272	0.220
14.498	0.548	0.464	0.414	0.371	0.335	0.313	0.289	0.265	0.216
15.223	0.519	0.444	0.398	0.357	0.323	0.303	0.280	0.259	0.212
15.984	0.493	0.424	0.383	0.345	0.312	0.293	0.272	0.252	0.208
16.783	0.468	0.406	0.368	0.332	0.301	0.284	0.264	0.246	0.205
17.622	0.444	0.388	0.353	0.320	0.290	0.274	0.257	0.240	0.201
18.504	0.421	0.371	0.339	0.309	0.280	0.265	0.249	0.234	0.198
19.429	0.399	0.355	0.326	0.298	0.271	0.257	0.242	0.228	0.194
20.400	0.379	0.340	0.313	0.287	0.261	0.248	0.235	0.222	0.191
21.420	0.362	0.326	0.302	0.278	0.254	0.242	0.230	0.218	0.189
22.491	0.345	0.313	0.291	0.269	0.247	0.236	0.225	0.214	0.187
23.616	0.330	0.300	0.281	0.260	0.241	0.231	0.220	0.210	0.185
24.797	0.315	0.288	0.271	0.252	0.234	0.225	0.216	0.206	0.183
26.036	0.300	0.276	0.261	0.243	0.228	0.219	0.211	0.202	0.182
27.338	0.287	0.265	0.252	0.236	0.222	0.214	0.206	0.199	0.180
28.705	0.274	0.254	0.243	0.228	0.216	0.209	0.202	0.195	0.178

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
30.140	0.261	0.244	0.234	0.220	0.210	0.204	0.198	0.191	0.176
31.647	0.250	0.234	0.226	0.213	0.204	0.199	0.193	0.188	0.175
33.230	0.238	0.225	0.218	0.206	0.199	0.194	0.189	0.184	0.173
34.000	0.233	0.220	0.214	0.203	0.196	0.192	0.187	0.183	0.172
37.000	0.215	0.205	0.201	0.192	0.187	0.184	0.180	0.177	0.169
40.000	0.200	0.192	0.190	0.182	0.179	0.177	0.174	0.172	0.166
45.000	0.181	0.177	0.175	0.172	0.170	0.169	0.168	0.167	0.164
50.000	0.166	0.165	0.163	0.163	0.163	0.163	0.163	0.162	0.162
60.000	0.165	0.164	0.163	0.162	0.162	0.162	0.162	0.162	0.162
70.000	0.163	0.163	0.162	0.162	0.162	0.161	0.161	0.161	0.161
80.000	0.162	0.162	0.161	0.161	0.161	0.161	0.161	0.161	0.161
90.000	0.161	0.161	0.161	0.161	0.160	0.160	0.160	0.160	0.160
100.000	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160

ANNEXURE - 4

INFORMATION TO BE SUBMITTED ALONGWITH THE BID FOR THE PROPOSED AGENCY FOR CIVIL WORKS

The proposed agency for civil design and construction shall meet the qualification criteria specified in the relevant section of the tender. The following information shall be supplied along with the bid:

1. The name of the proposed agency to execute the Civil works alongwith its credentials & capability to execute the works, within the scope of this tender. The proposed agencies for civil works are given below:

a) Larson & Turbo Ltd.

b) Hindustan Construction Company

c) Simplex Infrastructures Ltd

d) AFCONS Infrastructures Ltd

Any other agency may also be accepted subjected to meeting the "qualification criteria for agency for civil works" specified in the relevant clause of the tender.

The proposed agency for civil should meet the relevant mandatory qualification criteria . The bidder shall submit the credential of the proposed agency to establish, the civil work executing agency's competence to successfully complete the scope of job within this contract as per the terms & conditions stipulated in the tender.

2. Reference list of similar works carried out along with year of award, year of completion & value of work .(Specific details of works related to design & construction of turbine building & TG Deck considering seismic effects in soil sites shall be provided) .

3. Detailed credentials of prospective Design Consultant along with supporting documents of his earlier experience for designing the Turbine Building with Turbogenerator foundation for a power plant of minimum 500 MWe capacity in soil sites .

4. Detailed credentials of Proof Consultant having experience in design & review of machine foundation & framed structures.

5. Drawing showing G.A. of all the structures & allied works within the scope of this tender.

6. Drawings showing longitudinal and transverse sections, architectural elevation of above structures including foundation details.

7. Details of fire protection measures to be adopted for steel structures. Bidder shall also submit the details of agency and his experience to carry out the similar job to protect the steel structure for fire rating as specified in the tender specifications.

8. The Technical , Financial & Other data as per annexure-5 TO 7 for the proposed agency for executing the civil works. It may be noted that, only some of the important information about civil works is sought , under the following Annexure 5 TO 7. For

detail scope of work , technical specifications of civil works the complete Section C-2-1 shall be applicable.

9. Schedule of work

10. Resources proposed

ANNEXURE - 5

1. DETAILS OF COMPANY:

A. STRUCTURE AND ORGANISATION:

a) Name of company:

Previous Business Name:

(under present management since….)

Address in full:

Telephone Number

Registered office address: Fax No.

Gram

e-mail

ii Description of Company (for example, General Civil Engineering Contractor) or specialist in any particular field:

Please mention the registration No. & Class with CPWD, NPCIL, BHAVINI, Railways, etc.

iii) Number of years of experience as a main Contractor:

In India:

Abroad:

iv) Number of years of experience as a Sub Contractor:
(Furnish the Main contractors name, and address)

In India:

Abroad:

v) Name and addresses of associated Companies who will be involved in the project and whether parent/subsidiary/other category:-

vi) If the company is subsidiary, what involvement, will the parent Company have in the project?

vii) Does the company belong to Individual/Partnership/Limited Company/Public Sector Undertaking/Corporation?

viii) Please indicate here or attach an organisation chart showing the Company structure including the positions of directors and key personnel.

ix) Registration No., Legal deed, Responsibilities & financial involvement of the consortium or partners of joint venture, power of attorney, etc.

x) Penalty provision in case a partner abandons his responsibility in between the execution of contract.

xi) Whether the firm is registered under Employees Provident Fund?

xii) Whether the firm or any of its partners/ shareholders have been black listed/banned/suspended from doing business earlier?

xiii) In case of Corporation(s), please indicate whether the firm was referred to NPCIL in the past. If so, please furnish full details thereof.

B. STRUCTURE AND ORGANISATION:

Name and address of any associates the company has in India in the procedure of customs, immigration etc.

Please indicate here or attach an organisation chart showing the Company structure the position of directors and key personnel, as relevant.

C. FINANCIAL STATEMENT:

(Note:1. Bidders are requested to furnish the last four years printed annual reports. The report shall include balance sheet, profit & loss account, schedules, Directors report, Auditors report etc.

Note2. The Bidders should submit the latest Income Tax clearance certificate in the approved format along with the tender

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(i) Capital:

Authorised :

Issued :

(ii) Annual value of construction work undertaken for each of the last four years and projected for current year: (Rs. in Lakhs)

Year	Current 1	2	3	4	5
Home Abroad					

(iii) Approximate value of work in hand

(iv) Please attach copies of the Company's previous four years accounts. (Profit/loss/assets/liabilities) and other financial data along with audited annual report.

List all attachments below:

(v) Name and full address of Bankers from whom references can be obtained.

(vi) Please furnish information on:

(vii) Bank guarantee limits available on the date of submission of the tender.

(viii) Solvency Certificate from the banker.

(ix) Financial arrangement (own resources + bank credit)

(x) Financial arrangement (Cash + Current Assets – Current Liabilities)

(xi) Financial status (Average Annual Turnover)

(xii) Details of assets and balance sheets.

Note: Please furnish data for points ix,x,xi &xii relevant for the last Five financial years.

D. Joint venture:

(i) If the Company intends to enter into a Joint Venture for the project, please give the following information, otherwise state “not applicable”.

(ii) Name and address of Joint Venture Partners:

(iii) Name of Company leading the Joint Venture:

(iv) Name and address of Bankers to the Joint Venture:

E. Resources: Personnel 1:

(i) Number of staff:

Technical: Administrative:

(ii) Please list present executive directors:

Name Present Years of experience

Position

NOTES:

1. Please indicate the personnel who hold authorized power of Attorney.
2. Please indicate whether any of partners(s)/ shareholders(s) of the firm is/are Member of Parliament of India or State Legislature.
3. Please indicate whether any of the key personal of the firm have near relative of any officer of NPCIL.
4. Please indicate whether partners(s)/shareholder(s) is/are dismissed/retired Government/NPCIL servant(s).

F. Resource: Personnel : 2:

GIVE DETAILS OF DEPLOYMENT OF ENGINEERS ,STAFF& WORKERS AT SITE FOR EXECUTING THE CIVIL WORKS

Sl. No.	Position	Nos.	Period From	To
CIVIL:				
1.	Sr.Engineer			
2.	Geotechnical Engineer			
3.	Engineer			
4.	Supervisor			
	Staff			
5.	Surveyor			
6.	Blasting F'Man			
7.	Blasting Supervisor			
MECHANICAL:				
8.	Sr. Engineer			
9.	Engineer			
ELECTRICAL				
10.	Sr. Engineer			
11.	Engineer			
12.	F' Man/Supervisor			

Resource: Personnel : 2: Contd.

Sl.No.	Position	Nos	Period From	To
	Q.C. & INSPECTION			
13.	Sr.Engineer			
14.	Engineer			
15.	F'Man/ Supervisor			
	OPERATION & MAINTENANCE OF CONSTRUCTION EQUIPMENT:			
16.	Sr. Engineer			
17.	Engineer			
18.	F' Man/ Supervisor			
	OPERATION & MAINTENANCE OF SERVICES:			
19.	Sr. Engineer			
20.	Engineer			
21.	F' Man/ Supervisor			
	INDUSTRIAL SAFETY			
21 .	SAFETY OFFICERS			
21	SAFETY SUPERVISORS			
23	The proposed site organization chart shall be enclosed.			

INDUCTION OF WORKERS

Sl.No.	CATEGORY	NOS	PERIOD FROM	PERIOD TO
1.	Mason			
2.	Welder			
3.	Fitter			
4.	Crane Operator			
5.	Concrete Batching Plant Operator			
6.	Vibrator Operator			
7.	Placer Boom operator			
8.	Compressor Operator			
9.	Licensed Wireman			
10.	Licensed blaster			
11.	Dozer operator			
12.	Shovel Operator			
13.	Driller			
14.	Rigger			
15.	Khalasi			
16.	Gas cutter			
17.	Driver			
18.	Pump Operator			
19.	Surveyors			
20.	Helpers			
21.	Other(not Covered above)			
Total of skilled workers				
Total of Unskilled Workers				
Grand total				

G: Resources : Plant and Machinery

On the basis of the information provided in the tender document please indicate the plant and equipment considered by the company to be necessary for undertaking the scope of work of this tender and whether these are already in the company's ownership or will be purchased/hired.

(Basis of arriving at these figures shall be furnished with detailed back-up calculations alongwith tender.)

Note:

1. Tenderer is requested to fill in the details of plant and machinery in Annexure- 6.

2. The bare minimum time they would required for mobilisation of manpower and machineries for starting up of the work.

3. Detailed locations where plant and machinery in the custody of the organisation are presently kept under use or otherwise & will be spared. Alternatively or additionally the arrangements that would be made to hire plant and machinery form outside. Documentary evidence may be furnished on the sparability of the equipment from the sources identified for picking up equipment for NPCIL.

4. Construction schedule/ scheme & sketches with proper break up of activities and construction methodology detailing the equipment deployment layout, crane locations, material feed point, access for construction, requirement & layout for contractor site office, laboratory, batching plant, storage for material etc. proposed by him to perform the job in the most effective and efficient way.

   In case the bidders propose innovative methods that could possibly reduce time, then he shall detail the same with his back up calculations.

These informations are considered very essential in timely start of work and its adequate progress and hence all Bidders are required to give sufficiently detailed plan in this regard.

H.Resources: Other:

If any part of the contract will be sub-contracted, state the type of work to be executed by the sub-contractor(s) and if known, give the name address of the sub-contractor(s) be used.

I.SPECIFIC INFORMATION REGARDING THIS OFFER :

1. Is the offer complete covering the intent of this specification ? : Yes/No

2. The Schedules are attached : Yes/No

3. Bidder fully satisfies the qualifying requirements for Designer & Executing agency for civil works as per Tender :Yes/No

4. Are all the following works and services included as specified for the items under this specification?

   I. Design ,Engineering& appointing an independent Proof consultancy agency for Civil Works. :Yes/No

   II. Supply and construction and testing of materials and built items at site and manufacturer's works :Yes/No

   III. Supervision service for erection, testing, successful completion of works :Yes/No

   IV. All other services as specified to cover the entire scope : Yes/No

J. CIVIL WORKS :

Clause No.	CIVIL WORKS	Bidder to confirm whether included or not
1.00	**WORKS**	
1.01	Civil works for entire Turbine Building structure including foundation for Turbo Generator, Annexure Building & all other equipments, Crane Girder etc as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.02	Civil works for entire Electrical bay structure including foundation for equipments based on the engineering input of NPCIL as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.03	Civil works for entire Transformer Yard structure including foundation for SUT, UT, GT, Oil Separation Pit, Bus Duct, Rail yard for maintenance upto Turbine building including rails in transformer yard to & within the turbine building unloading bay, spare GT area based on the engineering input of NPCIL as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.04	Civil works for entire PCB (Pipe & Cable Bridge) between Turbine & Control Building as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.05	Civil works for entire CCW inlet &out let tunnels from Turbine Building condenser to road edge upto terminal point & All other Tunnels & Trenches within the terminal points as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.06	Access Bridge connecting to turbine building from control building from each floor of Control building as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.07	Fabrication & erection of all structural steel works like trusses , crane girders etc. as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.08	Finishing works for all structures &Area Grading within the terminal point as specified in clause 1.7 to 1.12 per and as per specification considered?	Yes/No
1.09	Installation, Commissioning and maintenance of analysis & design software proposed to be used for civil structures by the bidder alongwith compatible hardware at NPCIL premises at Mumbai to enable checking of the analysis & design during the currency of the contract. on nonreturnable basis prior to start of review of first document and training of 5 purchaser's engineers at NPCIL premises.	Yes/No
1.10	Supply of inhouse softwares with their executable files used in analysis & design of various structures	Yes/No

2.00	**Documents & Drawings**	
2.01	Detailed analysis and design as per load data furnished by the equipment manufacturer and detailed technical specifications	Yes/No
2.01.1	Submission of the following reports for review/approval to Proof Consultant & subsequently to Purchaser for final approval: a) Design Basis Reports b) Static & seismic analysis Reports, Collapse Analysis Report c) Design Reports d) Validation reports for the softwares used for Analysis/design. e) Input files/Data Base information in soft copies for checking, approval &record by Purchaser/Purchaser's consultants	a) Yes / No b) Yes / No c) Yes / No d) Yes / No e) Yes / No
2.02	Preparation of civil design, Equipment GA drawings, Structural GA drawings, Loading Drawings, Concrete Forming drawings, Reinforcement Drawings, Bar Bending Schedules and architectural drawings and getting approval of Proof Consultant &submission of this approved copy same to purchaser for final approval along with detailed analysis and design calculations	Yes/No
2.03	Preparation of detailed (steel fabrication drawings & EP drawings including material list) drawings based on approved design drawing and submission of the same to purchaser/purchaser's consultant.	Yes/No
2.07	To supply scaffolding/shuttering design &drawings to be used for entire structures of this package along with calculation and getting approval form the engineer	Yes/No
2.09	Getting approval of all materials by the engineer prior to start of relevant items of work	Yes/No
2.10	Submission for test report of all materials/items of the work as required by the engineer	Yes/No
2.11	Submission of construction and erection methodology document and obtaining approval from the purchaser/purchaser's consultant	Yes/No
2.12	Submission of complete QA(Quality Assurance) / QC (Quality control) report and obtaining approval from the purchaser.	Yes/No
2.13	Engineering Interface with other contractors working for balance activities of structures not in the scope of TI Package vendor, own sub vendors and supplier as applicable.	Yes/No
2.14	To furnish construction schedule as per specification including amended schedule wherever necessary	Yes/No
2.15	Submission of structural GA drawings, concrete forming drawing showing embedded plates (EP) with EP list , EP fabrication drawing alongwith the List of drawings and their schedule of submission	Yes/No
2.16	To prepare the Construction Completion Certificate on completion of work and obtaining approval from the purchaser/purchaser's consultant	Yes/No

K.**CONSTRUCTION SCHEDULE :-**

Bidder shall provide detailed bar chart / project schedule, required to complete the work in stipulated period as per the tender. Schedule shall cover all the major activities and milestones like Engineering (DBR, GA Drawings, analysis, analysis report, design &preparation of design documents , preparation of drawings etc)., Construction (

consisting details like excavation, piling, raft foundation, backfilling construction upto plinth level, floor wise schedule upto roof, brickwork, finishing & painting etc) shall be provided for each structure separately.

L. GUARANTEE

1.00 The Contractor shall guarantee the installation / work for a period of 12 months from the date of completion of work as certified by the Purchaser and this date will be as indicated in the completion certificate. Any damage or defect that may arise though remained undetected at the time of issue of completion certificate or occurs later during defect liability/guarantee period and which is connected in any way with the equipment or materials supplied by him or in the workmanship shall be rectified or replaced by the Contractor at his own expense as deemed necessary by the Purchaser or in default, the Purchaser may cause

the same to be made good by other agency and deduct expenses (of which the certificate of Purchaser shall be final) from any sums that may be then or at any time thereafter, become due to the Contactor or from his security deposit, or the proceeds of sale thereof, or of a sufficient portion thereof.

1.01 If at any time before the work is taken over, the Purchaser shall:

a) That any work done or materials needed by the contractor or any sub contractor is defective or not in accordance with the contract, or that the works or any portion thereof are defective, or do not fulfill the requirements of contract fall such matters being hereinafter, called "Defects" in this clause 1, and

b) As soon as reasonably practicable, give notice to the contractor in writing of the said decision, specifying particulars of the defects claimed to exist or to have occurred then the contractor shall at his own expenses and with all speed make good the defects so specified.

In case contractor shall fail to do so, the Owner may take, at the cost of the Contractor, such steps as may in all circumstances be reasonable to make good such defects. The expenditure so incurred by the Owner will be recovered from the amount due to the contractor. The decision of the Purchaser with regard to the amount to be recovered from the contractor will be final and binding on the contractor. As soon as the works have been completed in accordance with the contract (except in minor respects that do not effect their use for the purpose for which they are intended and except for maintenance thereof provided in General conditions of Contract and have passed the tests on completion, the Purchaser shall issue a certificate in which he shall certify the date on which the works have been so completed and have passed the said tests and the Owner shall be deemed to have taken over the works on the date so certified. If the works have been divided into various groups in the contract, the Owner shall be entitled to take over any group or groups before the other or others.

1.02 In order that the Contractor could obtain a completion certificate he shall make good with all possible speed, any defect arriving from the defective materials supplied by the contractor or that may have been noticed or developed, after the works or group of the works has been taken over the period allowed, for carrying out such work will be normally one month. If any defect be not rectified within a reasonable time, the Owner may proceed to do the work at Contractor's risk and expenses and deduct from the final bill such amount as may be decided by the Owner.

If by reason of any default on the part of the contractor a completion certificate has not been issued in respect of every portion o f the works within one month after scheduled date fixed by the contract for the completion of the works, the Owner shall be at liberty to use the work or any portion thereof in respect of which a completion certificate has not been issued, provided that the works or the portion thereof so used as aforesaid shall be afforded reasonable opportunity for completion of these works for the issue of completion certificate.

1.03 For works like grouting, water-proofing, Fire Protection, shotcrete etc. or any other specialized works etc., the Contractor shall invariably engage Subcontractors who are specialists in the field and are firms of repute and such a sub-contractor shall furnish guarantee for their workmanship to the Owner, through the Contractor. In case such a sub-contractor firm is not prepared to furnish a guarantee to the Owner, the Contractor shall give the guarantee to the Owner directly.

The Tenderer shall give the guarantee as detailed above.

Signature : …….

SEAL OF COMPANY Name : …….

Designation : …….

ANNEXURE - 6

PROPOSED DEPLOYMENT OF PLANT & MACHINERY
To meet the requirement as per the time schedule

Sl No	Description	Required as per tender Nos. (Tentative)	Available with the company	Proposed Nos. to be deployed	Period of Deployment From To	Remarks
1	Compressor (365 CFM)	2				
2	Fully Automatic Batching plant 60 cum/hr with chilling plant of adequate capacity to take care of biggest concrete pour at lowest pouring temperature.	1				
3	Spare Fully Automatic Batching plant 30 cum/hr with chilling plant of adequate capacity to take care of biggest concrete pour at lowest pouring temperature.	1				1 Plant may be removed after completion of TG Deck
4	Piling rigs	Sufficient Nos				
5	Conc. Pump (E) (30 cum/hr)	3				
6	Concrete bucket (1 Cum)	6				
7	Transit mixer (4 Cum)	8				
8	Dumper (10T)	6				
9	Water truck	1				
10	Diesel Generator 40 Kva	1				
11	Diesel Generator 160 Kva	1				
12	Diesel Generating set – 125 kva	2				
13	Diesel Generating set – 220 kva	2				
14	Portable Generating set – 70 kva	10				
15	DG welding set (400 A)	1				
16	Water supply pump (1500 Lpm)	2				
17	EOT crane – 20T	3				
18	**Crawler crane – 20T cap**	2				
19	Crawler crane – 75T cap	2				
20	20T trailor	1				
21	Grout Pump					
22	Cement silo 500T Cap.	2				Addittional cement storage yard also

						shall be provided.
23	Dewatering pump	As required				
24	Laboratory testing equipment set	1				
25	Concrete mixer 14/10	2				
26	Builder hoist	4				
27	Tata P&H crane	3				
28	Reinf. Bending machine	2				
29	Reinf. Cutting machine	2				
30	Shot blasting unit	1				
31	Tower Crane of 3.5 T capacity at 50 M Radius	4				
32	Mobile Placer Boom of 40 m radius	2				
33	Survey instruments set with GPS, DGPS, Echo-sounder etc. for marine works	As Required				
34	Total station	2				
35	Hydraulic weigh batcher	1				
36	Welding generator	3				
37	Welding transformer	10				
38	Jack hammers for drilling	As Required				
39	Computer accessories / softwares (Hydro pro software or equivalent for marine works)	As Required				

Tenderer may please note that the equipment/ plant and machinery listed above is only indicative and not exhaustive. The Tenderer is advised to formulate the complete plant for executing the work in the specified time frame and provide for any additional equipment/ plant and machinery as deemed necessary at his own cost.

ANNEXURE - 7

TECHNICAL DETAILS TO BE SUPPLIED ALONG WITH BID

1.0 SIZE OF THE STRUCTURES:

		Length	Width	Depth	Height
a)	TurbineBuilding with Annexure Portion				
b)	Electrical bay				
c)	Access Bridge				
d)	Pipe & Cable Bridge				
e)	Transformer Yard including SUT UT, GT, Rail Yard, Bus Duct, Oil Seperation pit				
f)	VentilationBuilding				
g)	Steam Condensate Area				
h)	Fuel oil storage area				
i)	CCW Inlet Tunnel				
j)	CCW Discharge Tunnel				
k)	Culvert for CCW pipes below Rail Track				
l)	Other Structures				

1.1 Whether proposed size of structures are fitting adequately in the available space shown in the tender drawings? If space is found to be inadequate what alternative measures are proposed

1.2 Type of super structure considered for various structures Whether RCC or Steel?

1.3 Type of side cladding / walls & roofing considered for various structure?

1.4 Feasibility of construction of PCB and its foundation, considering the tunnels & roads?

1.5 Whether PCB & Turbine building floor levels are matching with floor elevations of control building?

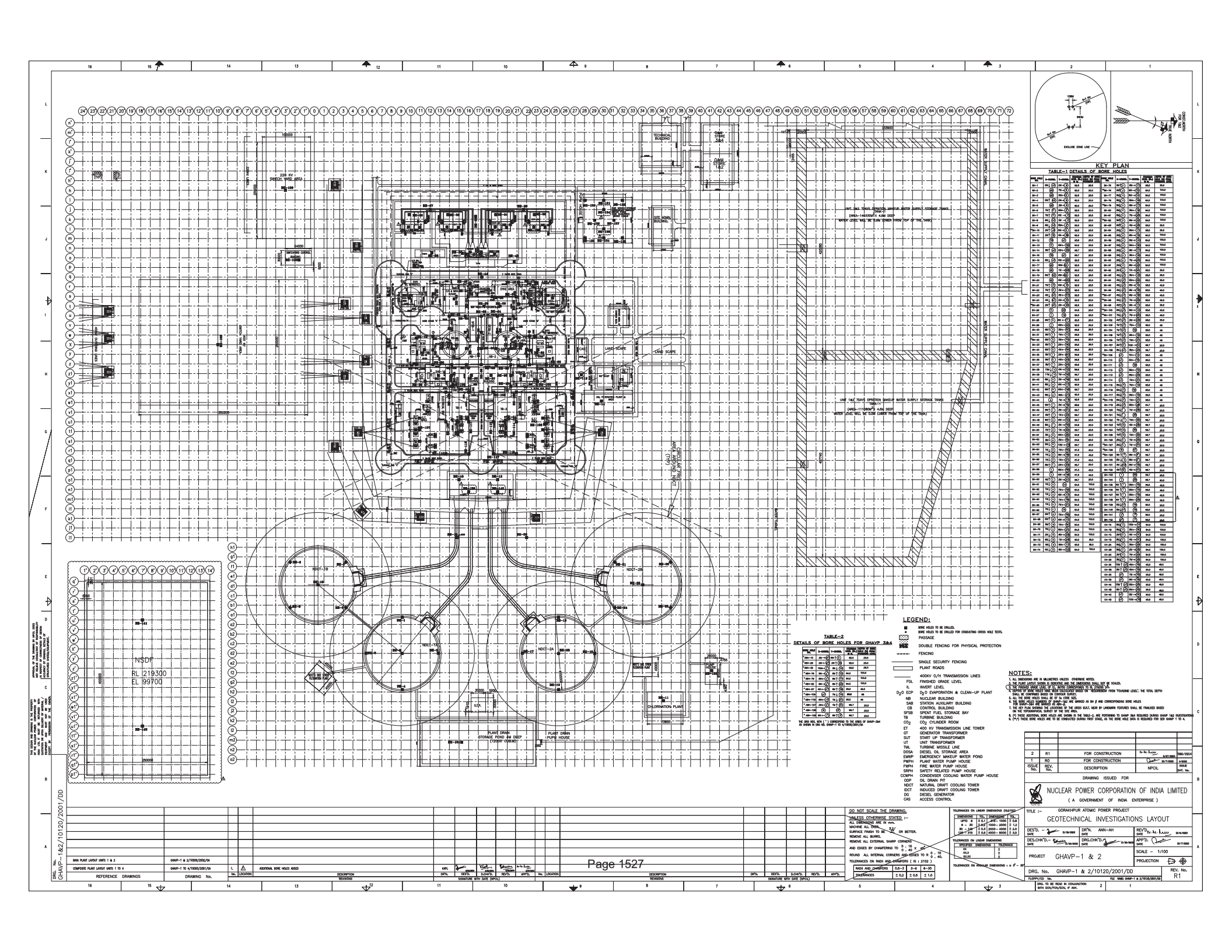
1.6 Detail of access from control building to Turbine building?

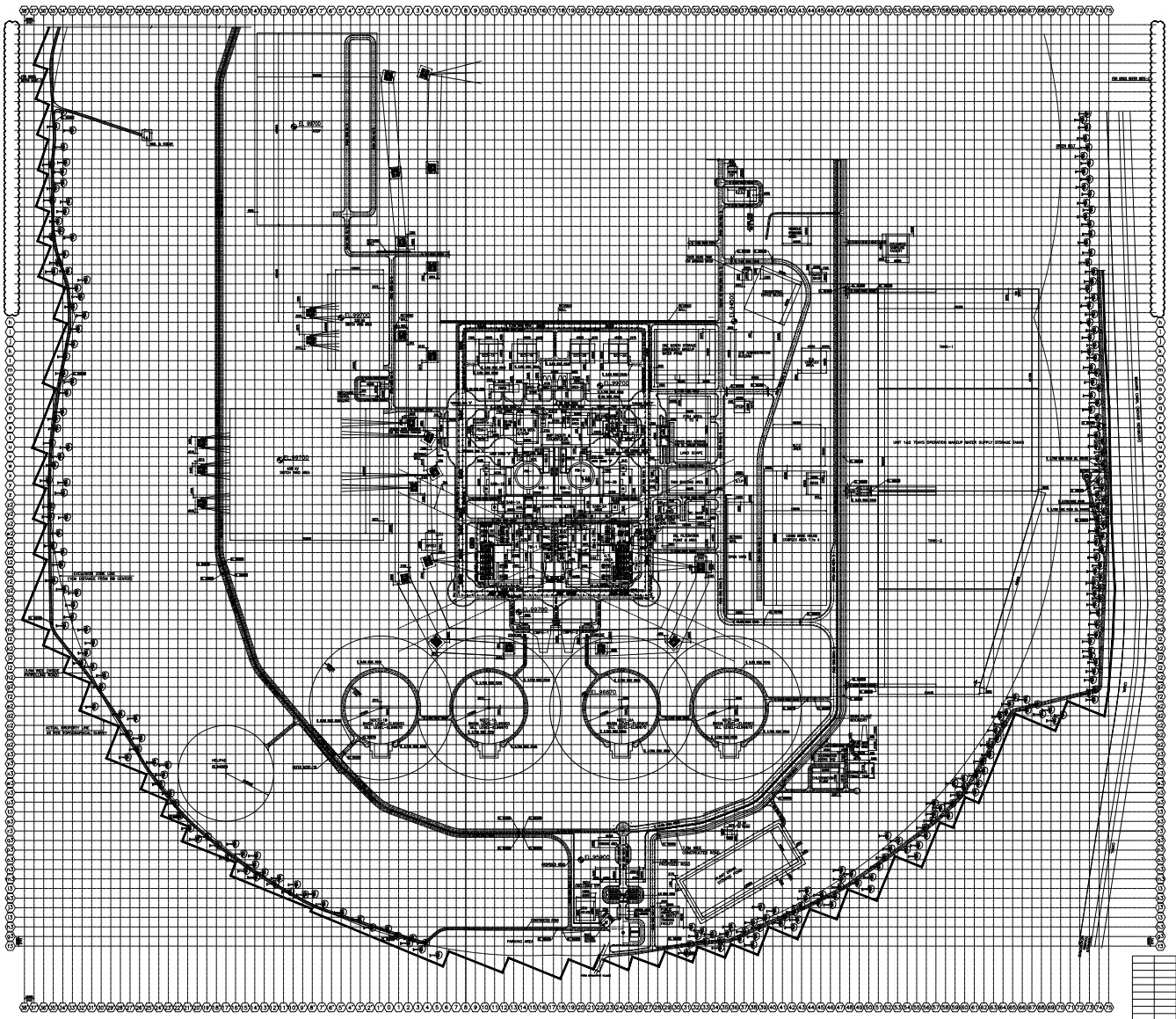
2.0 FOUNDATION (for all the structures within the scope of bidder)

2.1 Type of foundation offered

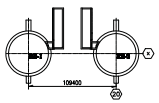
2.2 Foundation level considered

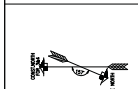
2.3 Safe bearing capacity of soil considered in foundation design (T/m^2)

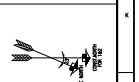

KEY PLAN
TABLE-1 DETAILS OF BORE HOLES
TABLE-2
DETAILS OF BORE HOLES FOR GHAVP 3&4
LEGEND:
NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.
2. THE PLANT LAYOUT SHOWN IS INDICATIVE AND THE DIMENSIONS SHALL NOT BE SCALED.
3. THE FINISHED GRADE LEVEL OF ALL ENTRY CONDITIONSHALL TO BE 210000 MM.
4. THE DEPTH OF BORE HOLES SHALL BE TAKEN FROM FINISHED GRADE LEVEL.
5. ALL THE BORE HOLES SHALL BE OF 54 CORE SIZE.
6. THE BORE HOLES NUMBERS OF GHAVP-3&4 ARE MARKED AS BH # AND CORRESPONDING BORE HOLES FOR GHAVP-1&2 ARE MARKED AS BH-#.
7. THE KEY PLAN SHOWING THE LOCATIONS OF THE CROSS R.M.T. NEAR BY LANDMARK FEATURES SHALL BE FINALISED BASED ON THE TOPOGRAPHICAL SURVEY OF THE SITE AREA.
8. (*) THESE ADDITIONAL BORE HOLES ARE SHOWN IN THE TABLE-2, ARE PERTAINING TO GHAVP 3&4 REQUIRED DURING GHAVP 1&2 INVESTIGATIONS
9. (**) THESE BORE HOLES ARE TO BE CONDUCTED DURING FIRST STAGE, AS THE BORE HOLE DATA IS REQUIRED FOR SER GHAVP 1 TO 4.
DO NOT SCALE THE DRAWING.
UNLESS OTHERWISE STATED :-
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER
SURFACE FINISH TO BE ▽ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS
AND EDGES BY CHAMFERING TO 0.15 X 45°
ROUND ALL INTERNAL CORNERS AND EDGES TO R 3.15
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)
TOLERANCES ON LINEAR DIMENSIONS (ISO 2768)
TOLERANCES ON REGULAR DIMENSIONS ± 0° - 30'
DRAWING ISSUED FOR
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)
GORAKHPUR ATOMIC POWER PROJECT
GEOTECHNICAL INVESTIGATIONS LAYOUT
PROJECT GHAVP-1 & 2
DRG. No. GHAVP-1 & 2/10120/2001/DD
REV. No. R1
SCALE - 1:100
PROJECTION
MAIN PLANT LAYOUT UNITS 1 & 2 GHAVP-1 & 2/10000/2002/GA
COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GHAVP-1 TO 4/10000/2001/GA
REFERENCE DRAWINGS
DRAWING No.
ADDITIONAL BORE HOLES ADDED
Page 1527



KEY PLAN







ANNUAL WIND ROSE DIAGRAM (08:30HRS)

WIND SPEED (M/S)

- >= 6.0
- 5.0–6.0
- 4.0–5.0
- 3.0–4.0
- 2.0–3.0
- 0.4–2.0

LEGENDS:–

FGL	– FINISHED GRADE LEVEL		– ROAD
TB	– TURBINE BUILDING		– MAIN PLANT BOUNDARY
NB	– NUCLEAR BUILDING		– FENCING
RB	– REACTOR BUILDING		– PROPERTY BOUNDARY
RAB	– REACTOR AUXILIARY BUILDING		– RETAINING WALL
CAB	– CONTROL AUXILIARY BUILDING		– EXCLUSION ZONE BOUNDARY
FHB	– FUEL HANDLING BUILDING		– DOUBLE FENCING FOR PHYSICAL PROTECTION
NFHB	– NEW FUEL STORAGE BUILDING	EL	– ELEVATION
TH	– TURBINE BUILDING	TYP	– TYPICAL
ST	– START UP TRANSFORMER	℄	– CENTERLINE
SUT	– STAND BY TRANSFORMER		
UT	– UNIT TRANSFORMER		
TGL	– TURBINE MISSILE LINE		
SWA	– SERVICE WATER PUMP HOUSE		
EMRP	– EMERGENCY MAKEUP WATER POND		
PWPH	– PLANT WATER PUMP HOUSE		
FWPH	– FIRE WATER PUMP HOUSE		
SWH	– SAFETY RELATED PUMP HOUSE		
DMWPH	– DEMINERALISED MAKEUP WATER PUMP HOUSE		
COT	– OIL CRANE PIT		
NDCT	– NATURAL DRAFT COOLING TOWER		
IDCT	– INDUCED DRAFT COOLING TOWER		
DGH	– DIESEL GENERATOR HOUSE		
CES	– CENTRAL ELECTRICAL & ELECTRICAL HOUSE		
CAS	– CENTRAL ALARM STATION/CONTROL ROOM ACCESS SYSTEM		
BOP	– BURNT OIL PIT		
FPS	– FIRE PROTECTION SYSTEM		
FPP	– FIRE PROTECTION PUMP HOUSE		
MPB	– MAIN PLANT BOUNDARY		
CPVS	– CONVENIENT FILTERED VENTILATION SYSTEM		
OCSC	– ON SITE EMERGENCY SUPPORT CENTER		
MBL	– MICROBIOLOGICAL LAB		
SER	– SERVICE BUILDING		
SES	– SERVICE WATER POND		
CPSS	– CONSTRUCTION POWER SUPPLY STATION		
MRSS	– MAIN RECEIVING SUB-STATION		

NOTES:–

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS NOTED OTHERWISE. ALL CO-ORDINATES ARE IN METERS WITH RESPECT TO PLANT GRID SYSTEM. CENTER OF REACTOR BUILDING 2 LOCATED AT INTERSECTION OF GRID 33 & Y 1440.
2. EL 99700 CORRESPONDS TO EL 218000.
3. IN ORDER TO REVISE THE GRID NUMBERING SYSTEM FOR UNITS-3&4 SIMILAR AS UNITS-1&2, A SEPARATE GRID SYSTEM HAS BEEN INTRODUCED FOR UNITS-3&4 WHICH IS INDICATED IN THE NPCIL DRAWING NO. GHAVP-3&4/10000/2002/GA.
4. ACCESS ROADS, IF NOT SHOWN IN THE LAYOUT, SHALL BE CONSTRUCTED TO SUIT THE BUILDING ENTRY/EXIT.
5. REFER TO OUTLINE DIMENSIONS OF BUILDINGS SHOWN IN THIS DRAWING AND ALSO INDIVIDUAL DRAWINGS.
6. ALL DIMENSIONS ARE TO OUTSIDE FACE OF WALLS OR CENTRE LINE OF COLUMNS UNLESS NOTED OTHERWISE.
7. MINIMUM CLEAR GAP OF 1200MM SHALL BE MAINTAINED BETWEEN THESE STRUCTURES UNLESS NOTED OTHERWISE.
8. THE DISTANCE BETWEEN THE CENTRE LINE OF RB AND LAST STAGE OF FIRST LP TURBINE IS MAINTAINED AS 185.000MM WHICH IS MORE THAN THE MINIMUM REQUIRED FROM TURBINE MISSILE CONSIDERATIONS.
9. THE CONSTRUCTION OF APH STORAGE TANKS SUPPORTING STRUCTURE, NEW FUEL STORAGE AREA, FOR4-1 TO FOR4-2 STRUCTURE AND TRACKS OF CWLP AFTER THE COMPLETION OF DRAINAGE ASSEMBLY AND END SHIELD WALL FILLING ACTIVITIES.
10. OUTDOOR SERVICES LINE TUNNELS & TRENCHES, SURFACE DRAINS, SEWERAGE LINES, ROOF DRAINS, PLANT DRAINS, NON CONTACT BURIED PIPE LINES ETC ARE NOT SHOWN IN THIS DRAWING. THESE OUTDOOR SERVICES MAY BE ADJUSTED TO SUIT THE FINAL LAYOUT OF STRUCTURES.
11. MINIMUM CLEARANCE SHALL BE MAINTAINED AS PER INDIAN ELECTRICITY RULES FOR ALL BUILDINGS/STRUCTURES FROM 400 KV & 220 KV LINES.
12. SIZES OF BUILDINGS/STRUCTURES SUCH AS NDCT, ECT, DM/FILTRATION PLANT, TURBINE BUILDING VENTILATION, STORAGE AREA, CWPH, DEMINI WATER PLANT, FWPH, CHLORINATION PLANT & METEOROLOGICAL TOWER HAVE BEEN SHOWN TENTATIVELY AND THESE SHALL BE FINALIZED AFTER GETTING INFORMATION FROM RESPECTIVE VENDORS/ PACKAGES.
13. FOR DETAILS OF PLANT BOUNDARY, LINE CONTOUR, SWITCH YARD LOCATIONS ETC., REFER DRAWING NO. GHAVP-1&2/10000/2001/GA.
14. GREEN BELT LOCATION IS SHOWN TENTATIVELY. IT SHALL BE MODIFIED AS PER THE SITE REQUIREMENT.
15. TO AVOID WET & DRY INTERFACE BETWEEN CONCRETE AND STEEL, THE TOP OF STEEL FRAME TRUSS OF COMPOSITE APH TO BE LIMITED TO A TENTATIVE LEVEL OF EL 246000 (+) 500 MM. THE SAME SHALL BE CONFIRMED BY THE SUPPLY COMMITTEE FOR CLEARANCE/APPROVAL.
16. CONSTRUCTION SEQUENCE SHALL BE UNIT-1, UNIT-2 IN THAT ORDER.
17. ALL INFRASTRUCTURE FACILITIES IN MAIN PLANT AREA ARE PROVIDED AS PER VID 8855/AN.
18. PARKING AREA OUTSIDE APH REQUIRED IS 3.75M HOWEVER FOR CATERING TO CONSTRUCTION REQUIREMENTS OF APH, 2.5M WIDE PATH IS PROVIDED AS SHOWN.
19. AS SHOWN THE MAIN ROAD TO BE RETAINED AS Ⓐ-Ⓑ-Ⓒ-Ⓓ-Ⓔ IN UNITS-1&2 AREA SHALL BE OF CHAIN LINK FENCING TO FACILITATE NDCT DRAFT.
20. STRUCTURES WHICH ARE COMMON FOR GHAVP UNITS-1 TO 4 AND FALLING ON THE GHAVP UNITS-3&4 SIDE (NSDF, DESC & RESERVE SYP) SHALL BE LOCATED WRT CENTER OF RB-3 OF UNITS-1&2.

ISSUE No.	REV. No.	DESCRIPTION	DRN.	TCE	MPCIL
1	R0	FOR INFORMATION	AZM 21/12/17		

DRAWING ISSUED FOR SIGNATURE WITH DATE

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

DES'D.	CHK'D.	REV'D.	APP'D.

ENGINEERING CONSULTANT
TATA CONSULTING ENGINEERS LIMITED
MUMBAI

JOB_REF._No. 1059GA

TITLE :- GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA–1&2

MAIN PLANT LAYOUT UNIT 1&2

DES'D. – DATE –	DRN'L. AZM DATE 21/12/2017	REV'D.JRM DATE 21/12/2017
DES. CHK'D. – DATE	DRG. CHK'D.MK DATE 21/12/2017	APP'D. RVI DATE 21/12/2017

PROJECT:- GHAVP–1&2

SCALE – 1:1

PROJECTION

DRG. No. GHAVP–1&2/10000/5001/GA

REV. NO. R0

DRG TO BE READ IN CONJUNCTION WITH DCN/PCN/ECN, IF ANY.

GROUP	ENGR	SIGN	GROUP	ENGR	SIGN	GROUP	ENGR	SIGN	GROUP	ENGR	SIGN
R3			R2			R1			R0		

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :–
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER. ▽
SURFACE FINISH TO BE ▽ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS AND EDGES BY CHAMFERING TO 0 – 15 X 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R 0 – 15 & 0 – 40.

TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5–3	3–6	6–30
TOLERANCES	± 0.2	± 0.5	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (IS:2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	400 – 1000	± 0.8
6 – 30	± 0.2	1000 – 3000	± 1.2
30 – 120	± 0.3	3000 – 4000	± 2.0
120 – 315	± 0.5	4000 – 8000	± 3.0

TOLERANCES ON UNDIM DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	± 1
XX.X	± 0.5
XX.XX	± 0.2

TOLERANCES ON ANGULAR DIMENSIONS ± 0° – 30'

NOT APPLICABLE

DRG. No.	DESCRIPTION	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.
GHAVP–1&2/10000/5001/GA	MAIN PLANT LAYOUT(UNIT 1&2)	GHAVP–3&4/10000/2002/GA					
	MAIN PLANT LAYOUT(UNIT 3&4)	GHAVP–1&2/10000/2002/GA					

REV. No.	DESCRIPTION	DRN.	DES'D.	DES.CHK'D.	REV'D.	APP'D.	CHK'D. (MPCIL)	REV'D.	APP'D.
R0	FOR INFORMATION	AZM 21/12/17	–	–	JRM 21/12/17	RVI 21/12/17			

SIGNATURE WITH DATE (TCE)

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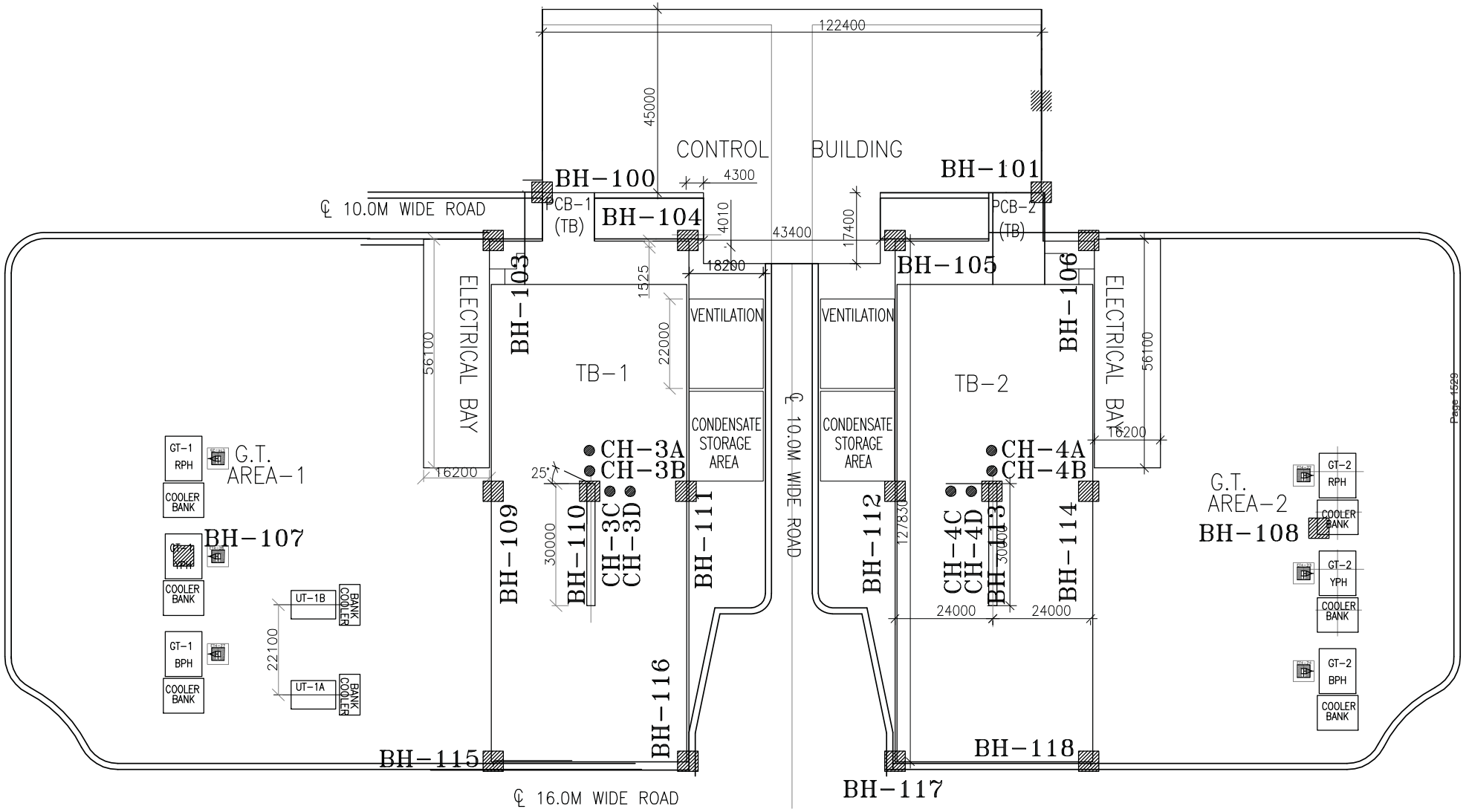
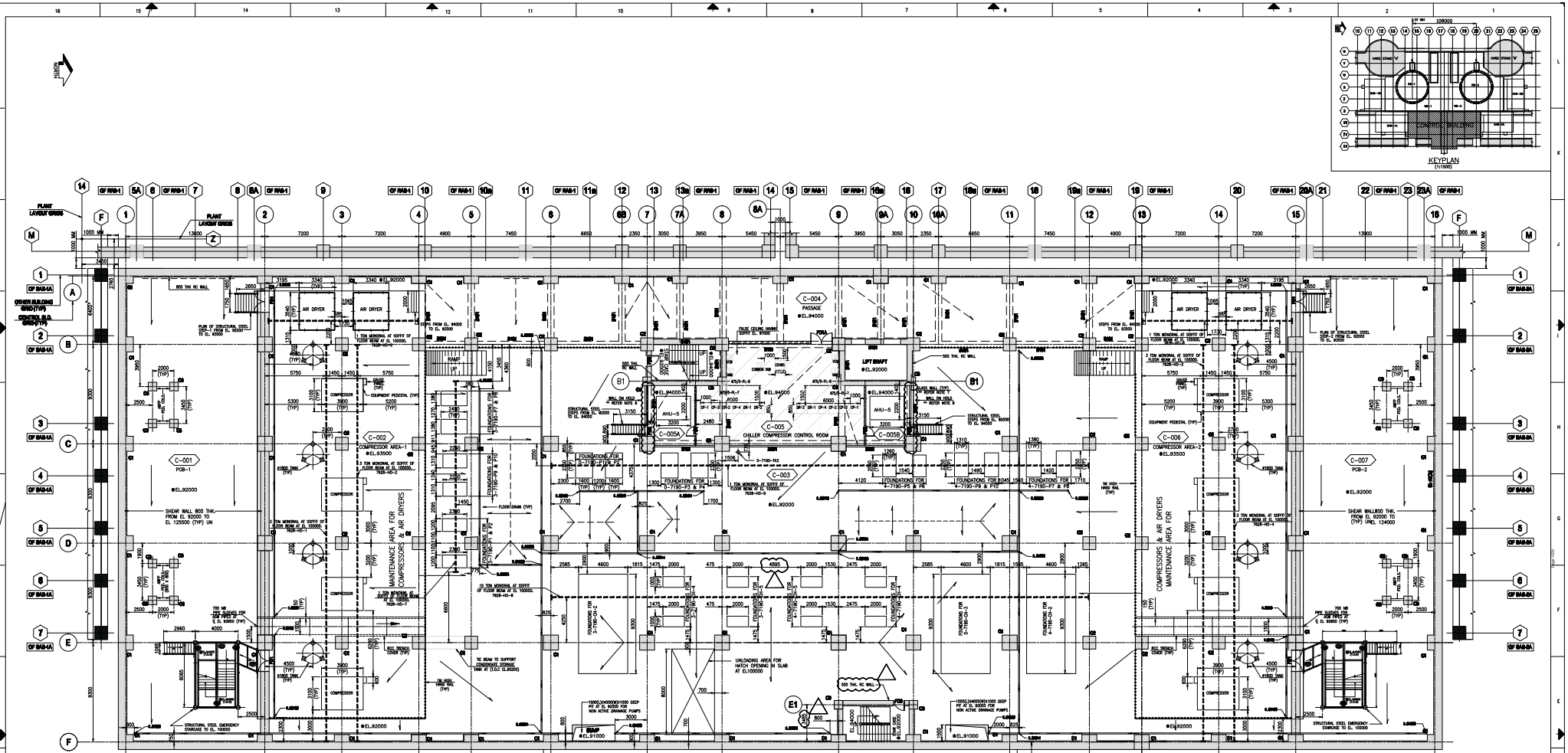
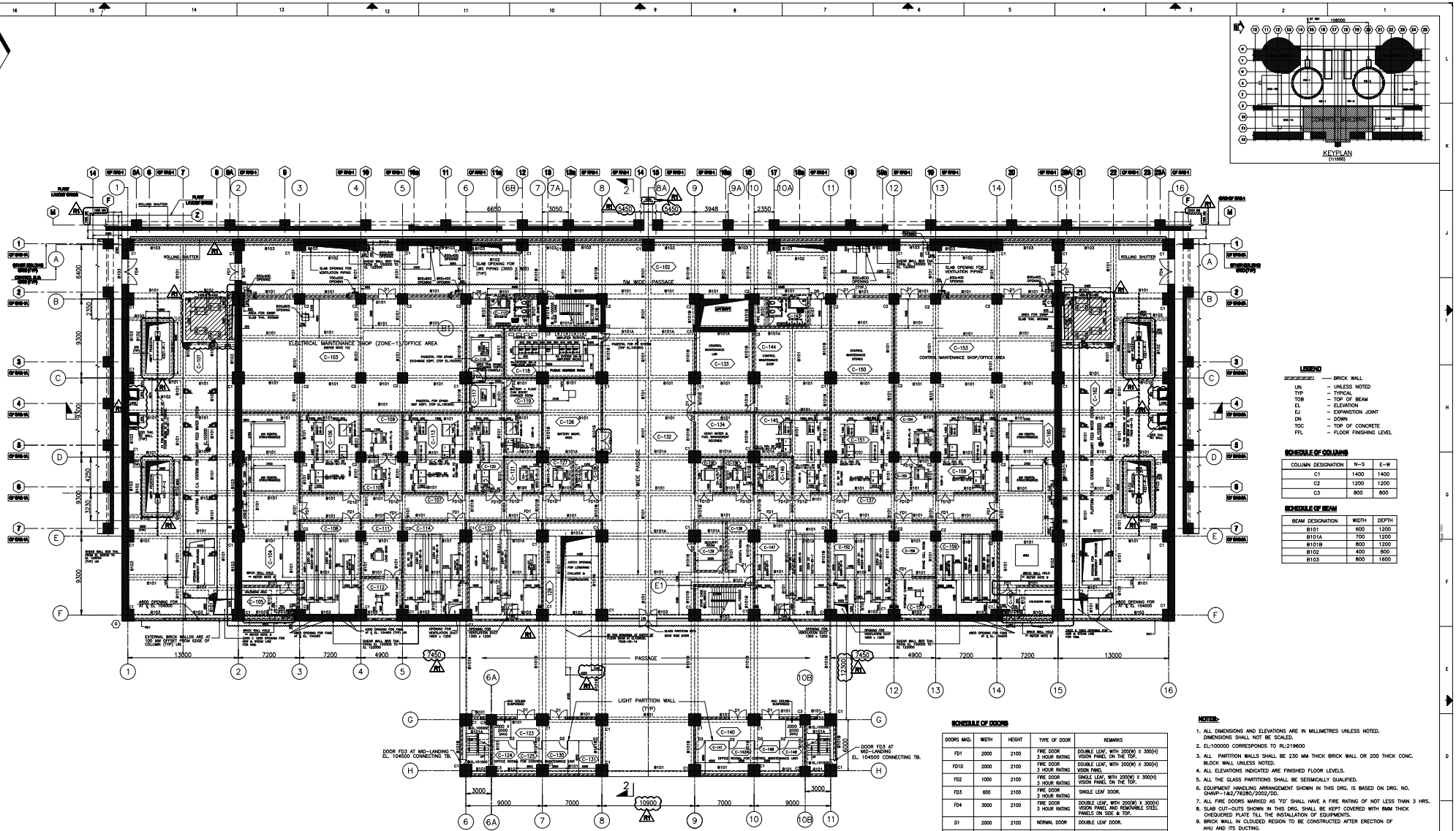

122400
45000
CONTROL BUILDING
BH-100
BH-101
4300
℄ 10.0M WIDE ROAD
PCB-1 (TB)
BH-104
4010
43400
17400
PCB-2 (TB)
18200
BH-105
BH-103
BH-106
1525
ELECTRICAL BAY
56100
VENTILATION
VENTILATION
ELECTRICAL BAY
56100
22000
TB-1
TB-2
CONDENSATE STORAGE AREA
CONDENSATE STORAGE AREA
℄ 10.0M WIDE ROAD
16200
16200
25°
CH-3A
CH-3B
CH-4A
CH-4B
GT-1 RPH
COOLER BANK
G.T. AREA-1
BH-107
GT-1 YPH
COOLER BANK
GT-1 BPH
COOLER BANK
UT-1B
UT-1A
22100
BANK COOLER
BANK COOLER
BH-109
BH-110
30000
CH-3C
CH-3D
BH-111
BH-112
127830
CH-4C
CH-4D
BH-113
30000
BH-114
24000
24000
G.T. AREA-2
BH-108
GT-2 RPH
COOLER BANK
GT-2 YPH
COOLER BANK
GT-2 BPH
COOLER BANK
BH-116
BH-115
BH-118
BH-117
℄ 16.0M WIDE ROAD


PLANT LAYOUT GRIDS
C-001 PCB-1
C-002 COMPRESSOR AREA-1
C-003
C-004 PASSAGE
C-005 CHILLER COMPRESSOR CONTROL ROOM
C-005A
C-005B
C-006 COMPRESSOR AREA-2
C-007 PCB-2
AHU-5
LIFT SHAFT
MAINTENANCE AREA FOR COMPRESSORS & AIR DRYERS
COMPRESSORS & AIR DRYERS MAINTENANCE AREA FOR
AIR DRYER
SHEAR WALL 800 THK. FROM EL 92000 TO EL 125500 (TYP) UN
SHEAR WALL800 THK. FROM EL 92000 TO (TYP) UNEL 124000
STRUCTURAL STEEL EMERGENCY STAIRCASE TO EL. 100000
UNLOADING AREA FOR HATCH OPENING IN SLAB AT EL100000
BOUNDARY LINE OF RAFT (TYP)
FOUNDATIONS FOR 5-7190-P1 & P2
FOUNDATIONS FOR 5-7190-P3 & P4
FOUNDATIONS FOR 4-7190-P5 & P6
FOUNDATIONS FOR 4-7190-P7 & P8
FOUNDATIONS FOR 4-7190-P9 & P10
FOUNDATIONS FOR 3-7190-P11
FOUNDATIONS FOR 2-7190-P12
FOUNDATIONS FOR 2-7190-P13
FOUNDATIONS FOR 3-7190-P14
FOUNDATIONS FOR 4-7190-P15
FOUNDATIONS FOR 4-7190-P16
FOUNDATIONS FOR 5-7190-P17 & P18
FOUNDATIONS FOR 5-7190-P19 & P20
FOUNDATIONS FOR 4-7190-P21
FOUNDATIONS FOR 4-7190-P22
FOUNDATIONS FOR 4-7190-P23
FOUNDATIONS FOR 4-7190-P24
FOUNDATIONS FOR 4-7190-P25
FOUNDATIONS FOR 4-7190-P26
FOUNDATIONS FOR 4-7190-P27
FOUNDATIONS FOR 4-7190-P28
FOUNDATIONS FOR 4-7190-P29
FOUNDATIONS FOR 4-7190-P30
FOUNDATIONS FOR 4-7190-P31
FOUNDATIONS FOR 4-7190-P32
FOUNDATIONS FOR 4-7190-P33
FOUNDATIONS FOR



PLAN AT EL 100000 (FFL UN)

TOC EL.99960 UN

SLAB THICKNESS:
GRADE SLAB BETWEEN GRIDS F–H/6 TO 11 – 500MM.
BALANCE AREA – 400MM.

FOLLOWING ROOMS SHALL HAVE FALSE CEILING WITH BOTTOM ELEVATION AS EL. 102900:
C–102, C–103, C–106, C–107, C–109, C–110, C–113, C–115 TO C–121,
C–123 TO C–128, C–130 TO C–146, C–148 TO C–151, C–153 TO C–155,
C–158.

SCHEDULE OF COLUMNS

COLUMN DESIGNATION	N–S	E–W
C1	1400	1400
C2	1200	1200
C3	800	800

SCHEDULE OF BEAM

BEAM DESIGNATION	WIDTH	DEPTH
B101	600	1200
B101A	700	1200
B101B	800	1200
B102	400	800
B103	800	1600

SCHEDULE OF DOORS

DOORS MKD.	WIDTH	HEIGHT	TYPE OF DOOR	REMARKS
FD1	2000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 200(W) X 300(H) VISION PANEL ON THE TOP.
FD1D	2000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 200(W) X 300(H) VISION PANEL
FD2	1000	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF, WITH 200(W) X 300(H) VISION PANEL ON THE TOP.
FD3	600	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF DOOR.
FD4	3000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 200(W) X 300(H) VISION PANEL AND REMOVABLE STEEL PANELS ON SIDE & TOP.
D1	2000	2100	NORMAL DOOR	DOUBLE LEAF DOOR.
D2	1000	2100	NORMAL DOOR	SINGLE LEAF DOOR.
D3	600	2100	NORMAL DOOR	SINGLE LEAF DOOR.
D5	1500	2100	NORMAL DOOR	DOUBLE LEAF DOOR.
D8	8800	2500	NORMAL DOOR	DOUBLE LEAF ALUMINIUM GLAZED DOOR CUM WINDOW
RS1	3600	3500	NORMAL DOOR	ROLLING SHUTTER
RS2	3100	3000	NORMAL DOOR	ROLLING SHUTTER

SPECIAL NOTE ON SCHEDULE OF DOORS

1. DOOR FD1D SHALL HAVE A REMOVEABLE PANEL OF SIZE 2000 (W) X 500 (H) ABOVE THE REGULAR DOOR FRAME.
2. IN RS1 TYPE ROLLING SHUTTER PROVISON FOR ACCESS DOOR OF SIZE 1000 (W) X 2100 (H) SHALL BE MADE.

NOTES:-

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED. DIMENSIONS SHALL NOT BE SCALED.
2. EL=100000 CORRESPONDS TO RL=219600
3. ALL PARTITION WALLS SHALL BE 230 MM THICK BRICK WALL OR 200 THICK CONC. BLOCK WALL UNLESS NOTED.
4. ALL ELEVATIONS INDICATED ARE FINISHED FLOOR LEVELS.
5. ALL THE GLASS PARTITIONS SHALL BE SEISMICALLY QUALIFIED.
6. EQUIPMENT HANDLING ARRANGEMENT SHOWN IN THIS DRG. IS BASED ON DRG. NO. GHAVP–1&2/76280/2002/DD.
7. ALL FIRE DOORS MARKED AS 'FD' SHALL HAVE A FIRE RATING OF NOT LESS THAN 3 HRS.
8. SLAB CUT–OUTS SHOWN IN THIS DRG. SHALL BE KEPT COVERED WITH 8MM THICK CHEQUERED PLATE TILL THE INSTALLATION OF EQUIPMENTS.
9. BRICK WALL IN CLOUDED REGION TO BE CONSTRUCTED AFTER ERECTION OF AHU AND ITS DUCTING.
10. MAINTENANCE SHOP/CONTROL MAINTENANCE AREA (OR OFFICE AREA) IS SHOWN WITHOUT ANY INTERNAL PARTITION. PARTITION HAS TO BE FINALISED BY SITE O&M GROUP BASED ON THE VENTILATION DESIGN INTENDED FOR CURRENT SINGLE VOLUME ARRANGEMENT. PARTITION SHALL NOT BE OF FULL HEIGHT.
11. CONSTRUCTION AT EL.100000 BETWEEN GRID 11–13/D–F SHALL BE KEPT UNDER HOLD TILL ERECTION/LOWERING OF THE VAM AT EL.92000 IS COMPLETED.
12. THIS DRAWING IS BASED ON KAPP 3&4/24200/2012/R2

REV. No.	DESCRIPTION	DATE	APP'D.
R1	FOR INFORMATION		
R0	FOR INFORMATION	6/17/2014	

DRAWING ISSUED FOR

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :– GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA–1&2
CONTROL BUILDING
GA OF FLOOR AT EL. 100000

DES'D.	6/11/2014	DR'N. KAPL	REV'D. 6/16/2014
DES. CHK'D.	6/12/2014	DRG. CHK'D. 6/11/2014	APP'D. 6/17/2014

PROJECT GHAVP–1&2
SCALE – 1:150
PROJECTION
DRG. No. GHAVP–1&2/24200/2012/GA
REV. No. 1
DRG. TO BE READ IN CONJUNCTION WITH DCN/FCN/ECN, IF ANY.
FILE NAME: GHAVP1&2_24200_2012_GA_R1

DRG. No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.
A0	MAIN PLANT LAYOUT	GHAVP–1&2/10000/2002/GA	CONTROL BUILDING GA OF ROOF AT EL.125000 AND EL.125500	GHAVP–1&2/24200/2017/GA	NUCLEAR BUILDING–2 : GA OF RAB–2 AT EL. 100000	GHAVP–2/21900/2003/GA
	COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA	GHAVP–1T04/10000/2001/GA	CONTROL BUILDING GA OF FLOOR AT EL 122000	GHAVP–1&2/24200/2016/GA	NUCLEAR BUILDING–1 : GA OF RAB–1 AT EL. 100000	GHAVP–1/21900/2003/GA
	CONTROL BUILDING GA OF BASEMENT AT EL. 92000/93500/94000	GHAVP–1&2/24200/2011/GA	CONTROL BUILDING GA OF FLOOR AT EL 116000	GHAVP–1&2/24200/2015/GA	STATION AUXILIARY BUILDING–2A FLOOR PLAN AT EL. 100000	GHAVP–2/24300/2002/GA
	CONTROL BUILDING GA OF FLOOR AT EL 106000	GHAVP–1&2/24200/2013/GA	CONTROL BUILDING GA OF FLOOR AT EL 111000	GHAVP–1&2/24200/2014/GA	STATION AUXILIARY BUILDING–1A FLOOR PLAN AT EL. 100000	GHAVP–1/24300/2002/GA

REV.	DESCRIPTION	DR'N.	DES'D.	DES.CHK'D.	REV'D.	APP'D.
1	DRAWINGS REVISED DUE TO INCREASE IN BUILDING PLAN DIMENSIONS, INCREASE IN ISOLATION GAP BETWEEN THE BUILDINGS, MODIFICATION IN SWRP PIDESTALS, REARRANGEMENT OF EQUIPMENTS/PANEL AND REDESIGNATION OF EQUIPMENT/PANEL/RODMS BASED ON INPUTS PROVIDED BY C&I/ELECT DESIGN AND ASCP GROUP, AND ADDITION OF BRICK WALL ALONG GRID–A.	KAPL 19/04/16				

REVISIONS — DESCRIPTION — SIGNATURE (INITIAL)

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :–
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE $\sqrt{}$ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS AND EDGES BY CHAMFERING TO 0 : 15 X 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R 0 : 15 R 0 : 40.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5–3	3–6	6–30
TOLERANCES	± 0.2	± 0.5	± 1.0

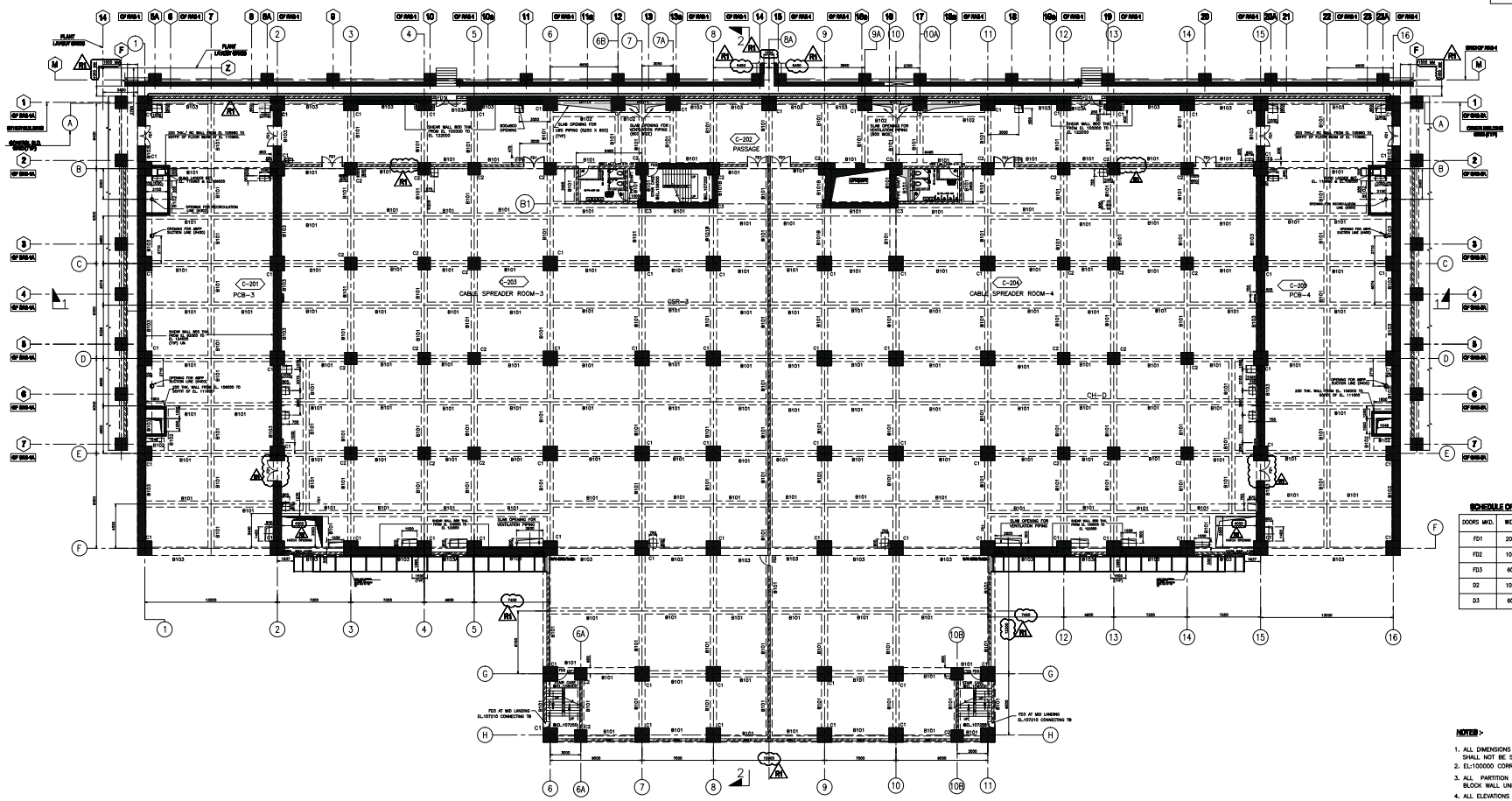
TOLERANCES ON LINEAR DIMENSIONS (ISO2102)

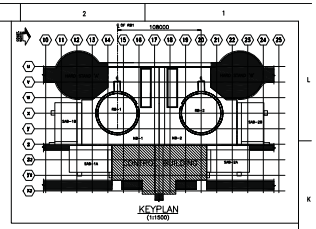
DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 – 1000	± 0.8
6 – 30	± 0.2	1000 – 2000	± 1.2
30 – 120	± 0.3	2000 – 4000	± 2.0
120 – 315	± 0.5	4000 – 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS : ± 0° – 30'





KEYPLAN
(1:1000)

PLAN AT EL 106000 (FFL UN)
(TOC AT EL 105980)
400 THK. SLAB-(UN)

LEGENDS

1) UN – UNLESS NOTED
2) TYP – TYPICAL
3) TOB – TOP OF BEAM
4) EL – ELEVATION
5) EJ – EXPANSION JOINT
6) DN – DOWN
7) TOC – TOP OF CONCRETE
8) FFL – FLOOR FINISHING LEVEL
9) TOO – TOP OF OPENING
10) TB – TURBINE BUILDING

COLUMN SIZES

C1	1400 X 1400
C2	1200 X 1200
C3	800 X 800

BEAM SIZES

B101	600 X 1200
B101A	700 X 1200
B101B	800 X 1200
B102	400 X 800
B103	800 X 1600
B103A	800 X 1800

SCHEDULE OF DOORS

DOORS MKD.	WIDTH	HEIGHT	TYPE OF DOOR	REMARKS
FD1	2000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 200(W) X 300(H) VISION PANEL ON THE TOP.
FD2	1000	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF, WITH 200(W) X 300(H) VISION PANEL ON THE TOP.
FD3	600	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF DOOR.
D2	1000	2100	NORMAL DOOR	SINGLE LEAF DOOR.
D3	600	2100	NORMAL DOOR	SINGLE LEAF DOOR.

NOTES :-

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED. DIMENSIONS SHALL NOT BE SCALED.
2. EL:100000 CORRESPONDS TO RL:219600
3. ALL PARTITION WALLS SHALL BE 230 MM THICK BRICK WALL OR 200 THICK CONC. BLOCK WALL UNLESS NOTED.
4. ALL ELEVATIONS INDICATED ARE FINISHED FLOOR LEVELS.
5. EQUIPMENT HANDLING ARRANGEMENT SHOWN IN THIS DRG. IS BASED ON DRG. NO. GHAVP-1&2/76280/2001/GA.
6. ALL FIRE DOORS MARKED AS 'FD' SHALL HAVE A FIRE RATING OF NOT LESS THAN 3 HRS.
7. THIS DRAWING IS BASED ON KAPP3&4/24200/2013/GA/R2

REF. DRG. No. GHAVP-1&2/24200/2013/GA						
MAIN PLANT LAYOUT	GHAVP-1&2/10000/2002/GA	CONTROL BUILDING GA OF ROOF AT EL.125000 AND EL.125500	GHAVP-1&2/24200/2017/GA	NUCLEAR BUILDING-2 : GA OF RAB-2 AT EL.105000	GHAVP-2/21900/2004/GA	
COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA	GHAVP-1T04/10000/2001/GA	CONTROL BUILDING GA OF FLOOR AT EL 116000	GHAVP-1&2/24200/2016/GA	NUCLEAR BUILDING-1 : GA OF RAB-1 AT EL.105000	GHAVP-1/21900/2004/GA	
CONTROL BUILDING GA OF FLOOR AT EL 100000	GHAVP-1&2/24200/2012/GA	CONTROL BUILDING GA OF FLOOR AT EL 116000	GHAVP-1&2/24200/2015/GA	STATION AUXILIARY BUILDING-2A FLOOR PLAN AT EL 106000	GHAVP-2/24300/2003/GA	
CONTROL BUILDING GA OF BASEMENT AT EL. 92000/93500/94000	GHAVP-1&2/24200/2011/GA	CONTROL BUILDING GA OF FLOOR AT EL 111000	GHAVP-1&2/24200/2014/GA	STATION AUXILIARY BUILDING-1A FLOOR PLAN AT EL 106000	GHAVP-1/24300/2003/GA	
REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	

REV.	DESCRIPTION	DR'N.	DES'D.	DES.CHK'D.	REV'D.	APP'D.
1	DRAWINGS REVISED DUE TO INCREASE IN BUILDING PLAN DIMENSIONS, INCREASE IN ISOLATION GAP BETWEEN THE BUILDINGS, ADDITION OF STRUCTURAL STEEL PLATFORM ALONG GRID F, DELETION OF EXTRA DOORS AND BRICK WALLS AND ADDITION OF BRICK WALL ALONG GRID-A.	KAPL 19/04/16				

REVISIONS — SIGNATURE (NPCIL)

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :-
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE $\sqrt{}$ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS AND EDGES BY CHAMFERING TO $^{0}_{-15}$ X 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R $^{0}_{-15}$.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102) :

RADII AND CHAMFERS	0.5~3	3~6	6~30
TOLERANCES	± 0.2	± 0.5	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (ISO 2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 ~ 1000	± 0.8
6 ~ 30	± 0.2	1000 ~ 2000	± 1.2
30 ~ 120	± 0.3	2000 ~ 4000	± 2.0
120 ~ 315	± 0.5	4000 ~ 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS ± 0° - 30'

R1	FOR INFORMATION		
R0	FOR INFORMATION	6/17/2014	
REV. No.	DESCRIPTION	DATE	APP'D.

DRAWING ISSUED FOR

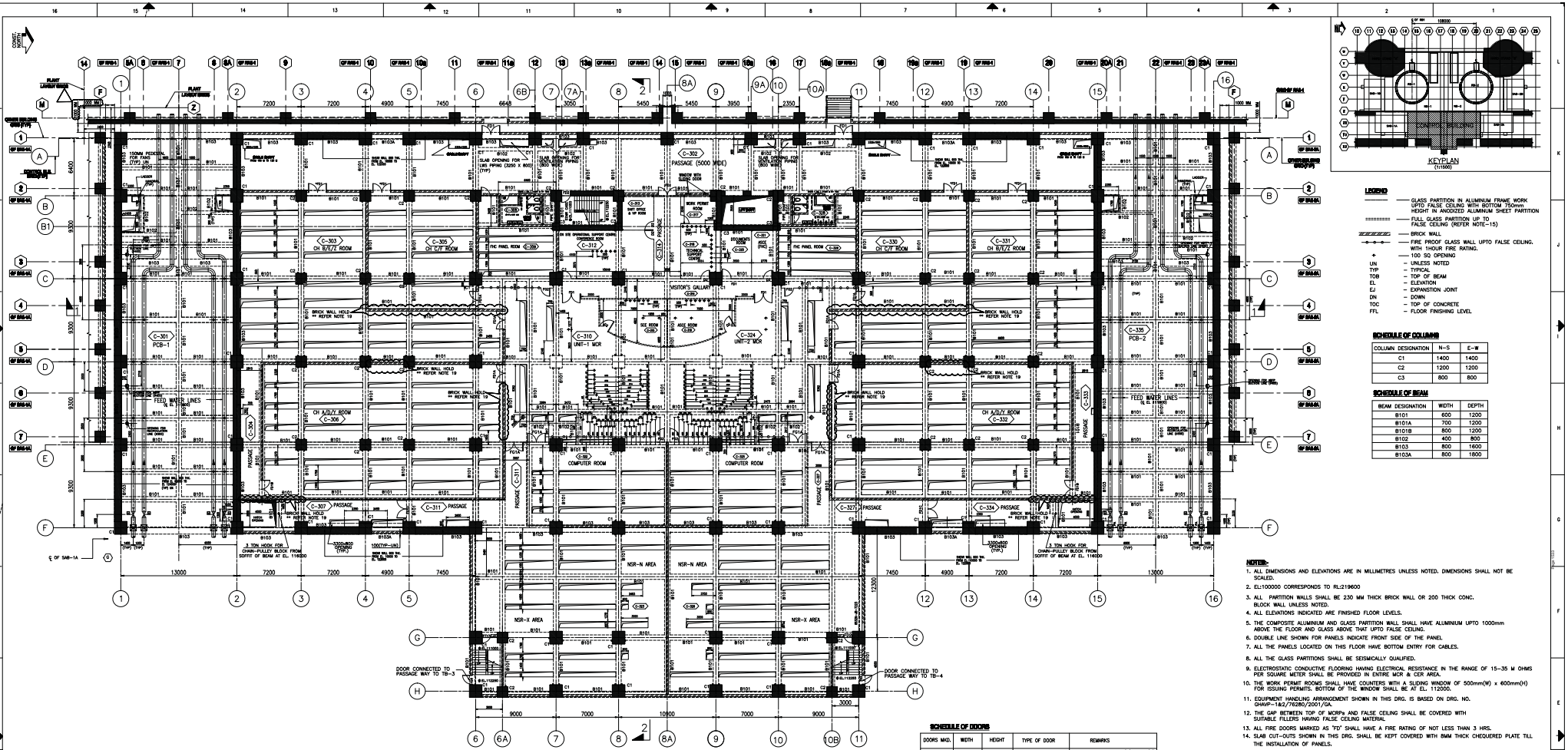
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :- GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA-1&2
CONTROL BUILDING
GA OF FLOOR AT EL. 106000

DES'D.	6/11/2014	DR'N. DATE	KAPL
DES. CHK'D.	6/12/2014	DRG. CHK'D.	6/11/2014
REV'D.	6/16/2014	APP'D.	6/17/2014

PROJECT GHAVP-1&2
SCALE - 1:150
PROJECTION
DRG. No. GHAVP-1&2/24200/2013/GA
REV. No. 1

DRG. TO BE READ IN CONJUNCTION WITH DCN/FCN/ECN, IF ANY.
FILE NAME: GHAVP1_2_24200_2013_GA_R1



PLAN AT EL 111000 (FFL UN)

TOC EL-110960

SLAB THICKNESS: 500 mm.

KEYPLAN (1:1000)

LEGEND

- GLASS PARTITION IN ALUMINIUM FRAME WORK UPTO FALSE CEILING WITH BOTTOM 750mm HEIGHT IN ANODIZED ALUMINIUM SHEET PARTITION
- FULL GLASS PARTITION UP TO FALSE CEILING (REFER NOTE-15)
- BRICK WALL
- FIRE PROOF GLASS WALL UPTO FALSE CEILING. WITH 1HOUR FIRE RATING.
- 100 SQ OPENING

UN	– UNLESS NOTED
TYP	– TYPICAL
TOB	– TOP OF BEAM
EL	– ELEVATION
EJ	– EXPANSION JOINT
DN	– DOWN
TOC	– TOP OF CONCRETE
FFL	– FLOOR FINISHING LEVEL

SCHEDULE OF COLUMNS

COLUMN DESIGNATION	N–S	E–W
C1	1400	1400
C2	1200	1200
C3	800	800

SCHEDULE OF BEAM

BEAM DESIGNATION	WIDTH	DEPTH
B101	600	1200
B101A	700	1200
B101B	800	1200
B102	400	800
B103	800	1600
B103A	800	1800

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED. DIMENSIONS SHALL NOT BE SCALED.
2. EL110000 CORRESPONDS TO RL219600
3. ALL PARTITION WALLS SHALL BE 230 MM THICK BRICK WALL OR 200 THICK CONC. BLOCK WALL UNLESS NOTED.
4. ALL ELEVATIONS INDICATED ARE FINISHED FLOOR LEVELS.
5. THE COMPOSITE ALUMINIUM AND GLASS PARTITION WALL SHALL HAVE ALUMINIUM UPTO 1000mm ABOVE THE FLOOR AND GLASS ABOVE THAT UPTO FALSE CEILING.
6. DOUBLE LINE SHOWN FOR PANELS INDICATE FRONT SIDE OF THE PANEL
7. ALL THE PANELS LOCATED ON THIS FLOOR HAVE BOTTOM ENTRY FOR CABLES.
8. ALL THE GLASS PARTITIONS SHALL BE SEISMICALLY QUALIFIED.
9. ELECTROSTATIC CONDUCTIVE FLOORING HAVING ELECTRICAL RESISTANCE IN THE RANGE OF 15–35 M OHMS PER SQUARE METER SHALL BE PROVIDED IN ENTIRE MCR & CER AREA.
10. THE WORK PERMIT ROOMS SHALL HAVE COUNTERS WITH A SLIDING WINDOW OF 500mm(W) x 600mm(H) FOR ISSUING PERMITS. BOTTOM OF THE WINDOW SHALL BE AT EL. 112000.
11. EQUIPMENT HANDLING ARRANGEMENT SHOWN IN THIS DRG. IS BASED ON DRG. NO. GHAVP–1&2/76280/2001/GA.
12. THE GAP BETWEEN TOP OF MCRPs AND FALSE CEILING SHALL BE COVERED WITH SUITABLE FILLERS HAVING FALSE CEILING MATERIAL
13. ALL FIRE DOORS MARKED AS 'FD' SHALL HAVE A FIRE RATING OF NOT LESS THAN 3 HRS.
14. SLAB CUT–OUTS SHOWN IN THIS DRG. SHALL BE KEPT COVERED WITH 8MM THICK CHEQUERED PLATE TILL THE INSTALLATION OF PANELS.
15. THE GLASS SHALL BE LAMINATED, TOUGHENED, SHATTER PROOF WITH SUITABLE THICKNESS TO GET THE REQUIRED STRENGTH.
16. THE MATERIAL FOR FALSE CEILING AND ITS FIXTURES SHALL BE AS PER CLAUSE NO. 3.2.3 OF AERB FIRE PROTECTION STANDARD (AERB/NF/SS/FPS). SOFFIT OF FALSE CEILING FOR PASSAGE BETWEEN GRID A/B–2/15 IS AT EL.113600. SOFIT OF FALSE CEILING FOR ALL THE ROOMS AT 111M IS AT EL.113900 EXCEPT ROOM NO. C–301 & C–335.
17. '*' THIS DOOR IS FOR EMERGENCY EXIT ONLY AND ACCESSABLE FROM INSIDE ONLY.
18. THIS DRAWING IS BASED ON KAPP 3&4/24200/2014/GA/R2
19. THIS BRICKWALL SHALL BE CONSTRUCTED AFTER INSTALLATION OF PANNELS INSIDE THE ROOM.
20. THIS DOOR SHALL BE INSTALLED AFTER INSTALLATION OF MCR PANELS.
21. ALL THE GLASS WALL SHALL BE CONSTRUCTED ONLY AFTER THE INSTALLATION OF THE PANELS IN THE RESPECTIVE ROOMS.
22. ALL CIRCULAR FLOOR CUT–OUTS SHALL BE OF DIA. 200 UNLESS NOTED OTHERWISE.

SCHEDULE OF DOORS

DOORS MKD.	WIDTH	HEIGHT	TYPE OF DOOR	REMARKS
FD1	2000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 2000(W) X 300(H) VISION PANEL ON THE TOP.
FD1A	2000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 2000(W) X 300(H) VISION PANEL ON THE TOP.
FD1B	2000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 2000(W) X 300(H) VISION PANEL ON THE TOP.
FD1C	2000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 2000(W) X 300(H) VISION PANEL ON THE TOP.
FD2	1000	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF, WITH 2000(W) X 300(H) VISION PANEL ON THE TOP.
FD3	600	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF DOOR
D2	1000	2100	NORMAL DOOR	SINGLE LEAF DOOR.
D3	600	2100	NORMAL DOOR	SINGLE LEAF DOOR.
FG2	1000	2100	GLASS FIRE DOOR 1 HOUR RATING.	SINGLE LEAF DOOR.
FG1A	2000	2100	GLASS FIRE DOOR 1 HOUR RATING	DOUBLE LEAF DOOR.

SPECIAL NOTE ON SCHEDULE OF DOORS

1. DOOR FD1A SHALL HAVE A REMOVEABLE PANEL OF SIZE 2000 (W) X 800 (H) ABOVE THE REGULAR DOOR FRAME.
2. DOOR FD1B SHALL HAVE A REMOVEABLE PANEL OF SIZE 2000 (W) X 1430 (H) ABOVE THE REGULAR DOOR FRAME. THIS REMOVEABLE PANEL SHALL HAVE AN OPENING AS INDICATED IN DRG. NO. KAPP–3&4/24200/2003/00.
3. DOOR FD1C SHALL HAVE A REMOVEABLE PANEL OF SIZE 2000 (W) X 2560 (H) ABOVE THE REGULAR DOOR FRAME. THIS REMOVEABLE PANEL SHALL HAVE AN OPENING AS INDICATED IN DRG. NO. KAPP–3&4/24200/2003/00.

REV. No.	DESCRIPTION	DATE	APP'D.
2	FOR INFORMATION		
1	FOR INFORMATION	15/06/2016	
0	FOR INFORMATION	6/17/2014	

DRAWING ISSUED FOR

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :– GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA–1&2
CONTROL BUILDING
GA OF FLOOR AT EL. 111000

DES'D.	6/11/2014	DR'N. KAPL DATE	REV'D. 6/16/2014
DES. CHK'D.	6/12/2014	DRG. CHK'D. 6/11/2014	APP'D. 6/17/2014
PROJECT	GHAVP–1&2	SCALE – 1:150	
		PROJECTION	
DRG. No.	GHAVP–1&2/24200/2014/GA	REV. No. 2	

DRG. TO BE READ IN CONJUNCTION WITH DCN/FCN/ECN, IF ANY.

FILE NAME: GHAVP1&2_24200_2014_GA_R2

DRG. No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.
GHAVP–1&2/24200/2014/GA	MAIN PLANT LAYOUT	GHAVP–1&2/10000/2002/GA	CONTROL BUILDING GA OF ROOF AT EL.125000 AND EL.125500	GHAVP–1&2/24200/2017/GA	NUCLEAR BUILDING–2 : GA OF RAB–2 AT EL.109000	GHAVP–2/21900/2005/GA
	COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA	GHAVP–1T04/10000/2001/GA	CONTROL BUILDING GA OF FLOOR AT EL 122000	GHAVP–1&2/24200/2016/GA	NUCLEAR BUILDING–1 : GA OF RAB–1 AT EL.109000	GHAVP–1/21900/2005/GA
	CONTROL BUILDING GA OF FLOOR AT EL 100000	GHAVP–1&2/24200/2012/GA	CONTROL BUILDING GA OF FLOOR AT EL 116000	GHAVP–1&2/24200/2015/GA	STATION AUXILIARY BUILDING–2A FLOOR PLAN EL. 108000 & 111000	GHAVP–2/24300/2004/GA
	CONTROL BUILDING GA OF FLOOR AT EL 106000	GHAVP–1&2/24200/2013/GA	CONTROL BUILDING GA OF BASEMENT AT EL. 92000/93500/94000	GHAVP–1&2/24200/2011/GA	STATION AUXILIARY BUILDING–1A FLOOR PLAN EL. 108000 & 111000	GHAVP–1/24300/2004/GA

REV. No.	DESCRIPTION	DRN.	DES'D. SIGNATURE (INITIAL)	DES.CHK'D.	REV'D.	APP'D.
2	2 DRAWING REVISED IN GENERAL DUE TO MODIFICATION IN PANEL LAYOUT OF MCR/CER RESULTING IN CHANGES IN SIZE AND LOCATION OF FLOOR CUT–OUTS. SIZES OF CER IS INCREASED AS PER REQUIREMENT.	KAPL 01/03/17				
1	R1 DRAWINGS REVISED DUE TO INCREASE IN BUILDING PLAN DIMENSIONS, INCREASE IN ISOLATION GAP BETWEEN THE BUILDINGS, AND MODIFICATION IN FLOOR CUT–OUTS BASED ON C&I INPUTS AND ADDITION OF BRICK WALL ALONG GRID–A.	KAPL 19/04/16				

REVISIONS

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :–
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE $\sqrt{}$ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS
AND EDGES BY CHAMFERING TO 0 – 15 X 45°, 0 – 40
ROUND ALL INTERNAL CORNERS AND EDGES TO R 0 – 15, 0 – 40.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5–3	3–6	6–30
TOLERANCES	± 0.2	± 0.5	± 1.0

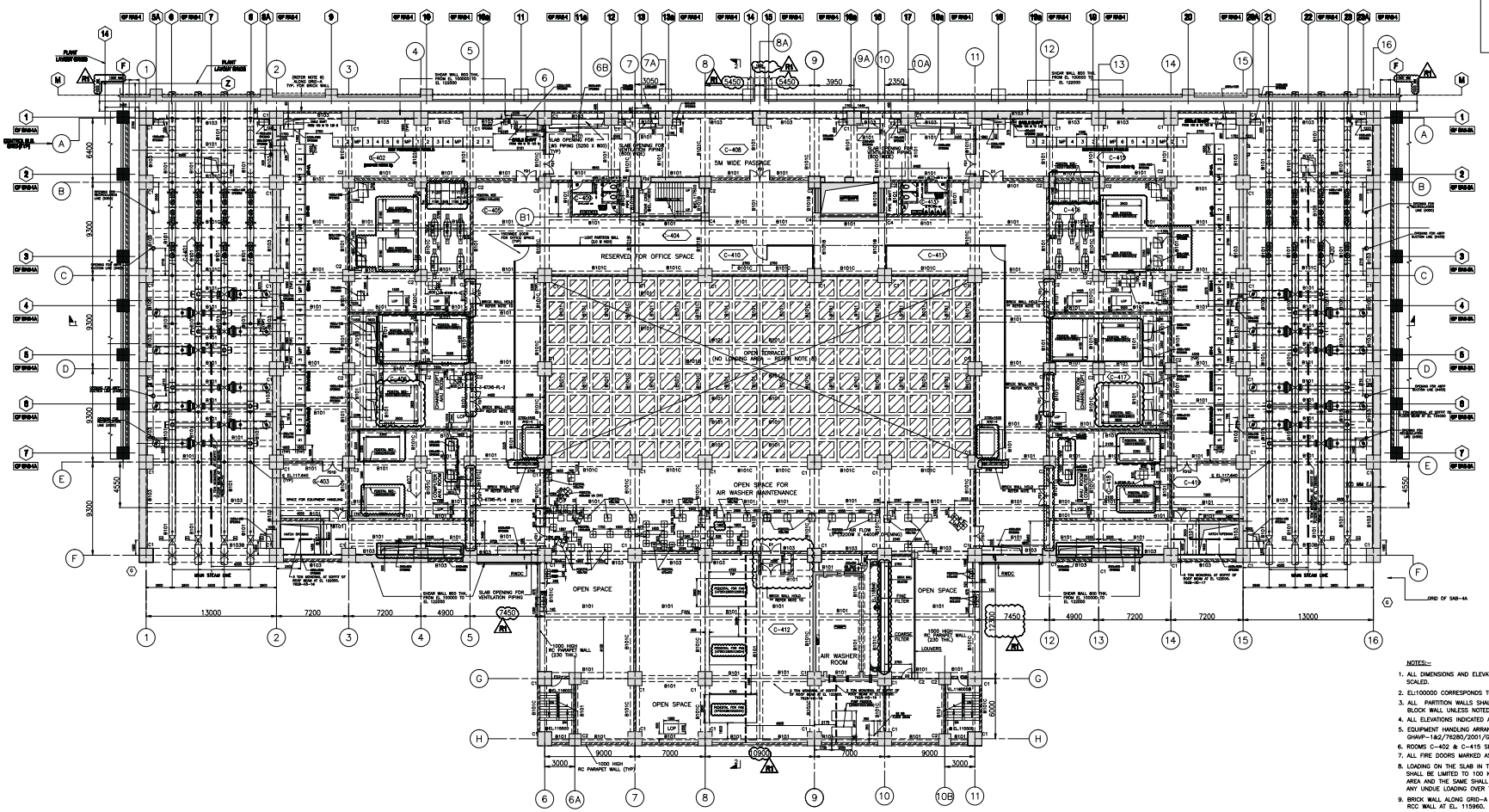
TOLERANCES ON LINEAR DIMENSIONS (ISO2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 – 1000	± 0.8
6 – 30	± 0.2	1000 – 2000	± 1.2
30 – 120	± 0.3	2000 – 4000	± 2.0
120 – 315	± 0.5	4000 – 8000	± 3.0

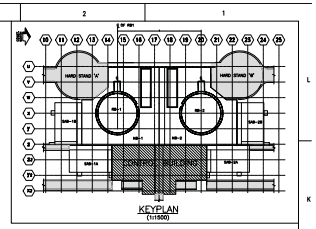
TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS : ± 0° – 30'



PLAN AT EL 116000 (FFL UN)
(TOC AT EL 115960)
400 THK. SLAB–(UN)



KEYPLAN
(1:1500)

LEGEND

	BRICK WALL
UN	– UNLESS NOTED
TYP	– TYPICAL
TOB	– TOP OF BEAM
EL	– ELEVATION
EJ	– EXPANSION JOINT
DN	– DOWN
TOC	– TOP OF CONCRETE
FFL	– FLOOR FINISHING LEVEL
RWDC	– RAIN WATER DOWN COMMER

SCHEDULE OF COLUMNS

COLUMN DESIGNATION	N–S	E–W
C1	1400	1400
C2	1200	1200
C3	800	800

SCHEDULE OF BEAM

BEAM DESIGNATION	WIDTH	DEPTH
B101	600	1200
B101A	700	1200
B101B	800	1200
B101C	900	1200
B102	400	800
B103	800	1600
B103A	800	1800
B103B	1400	1600

SCHEDULE OF DOORS

DOORS MARK	WIDTH	HEIGHT	TYPE OF DOOR	REMARKS
FD1	3000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 300(W) X 300(H) VISION PANEL ON EACH LEAF.
FD1D	3000	2100	FIRE DOOR 3 HOUR RATING	DOUBLE LEAF, WITH 300(W) X 300(H) VISION PANEL ON EACH LEAF.
FD2	1000	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF, WITH 300(W) X 300(H) VISION PANEL ON ONE SIDE.
FD3	800	2100	FIRE DOOR 3 HOUR RATING	SINGLE LEAF DOOR.
D2	1000	2100	NORMAL DOOR	SINGLE LEAF DOOR.
D3	800	2100	NORMAL DOOR	SINGLE LEAF DOOR.

SPECIAL NOTE ON SCHEDULE OF DOORS

1. DOOR FD1D SHALL HAVE A REMOVABLE PANEL OF SIZE 2000 (W) X 900 (H) ABOVE THE REGULAR DOOR FRAME.

NOTES:–

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED. DIMENSIONS SHALL NOT BE SCALED.
2. EL:100000 CORRESPONDS TO RL:219600.
3. ALL PARTITION WALLS SHALL BE 230 MM THICK BRICK WALL OR 200 THICK CONC. BLOCK WALL UNLESS NOTED.
4. ALL ELEVATIONS INDICATED ARE FINISHED FLOOR LEVELS.
5. EQUIPMENT HANDLING ARRANGEMENT SHOWN IN THIS DRG. IS BASED ON DRG. NO. GHAVP–1&2/76280/2001/GA.
6. ROOMS C–402 & C–415 SHALL HAVE FALSE CEILING WITH BOTTOM AT EL 119000.
7. ALL FIRE DOORS MARKED AS 'FD' SHALL HAVE A FIRE RATING OF NOT LESS THAN 3 HRS.
8. LOADING ON THE SLAB IN THE AREA BETWEEN GRIDS C TO E / 6 TO 11 DEMARCATED THUS ☑ SHALL BE LIMITED TO 100 KG/SQ. M. THIS SLAB AREA SHALL BE CLEARLY DEMARCATED AS NO–LOADING AREA AND THE SAME SHALL BE PROMINENTLY PAINTED OVER THE SLAB WITH SUITABLE PAINTS SO THAT ANY UNDUE LOADING OVER THE SLAB IS AVOIDED.
9. BRICK WALL ALONG GRID–A SHALL BE 200 THK. & STARTS FROM THE TOP OF 1690 HIGH RCC WALL AT EL. 115960.
10. BRICK WALL IN CLOUDED REGION TO BE CONSTRUCTED AFTER ERECTION OF AHU AND ITS DUCTING.
11. THIS DRAWING IS BASED ON DRG. NO.: KAPP–3&4/24200/2015/GA/R2.

MAIN PLANT LAYOUT	GHAVP–1&2/10000/2002/GA	CONTROL BUILDING GA OF ROOF AT EL.125000 AND EL.125500	GHAVP–1&2/24200/2017/GA	NUCLEAR BUILDING–2 : GA OF RAB–2 AT EL.116500	GHAVP–2/21900/2006/GA	
COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA	GHAVP–1T04/10000/2001/GA	CONTROL BUILDING GA OF BASEMENT AT EL. 92000/93500/94000	GHAVP–1&2/24200/2011/GA	NUCLEAR BUILDING–1 : GA OF RAB–1 AT EL.116500	GHAVP–1/21900/2006/GA	
CONTROL BUILDING GA OF FLOOR AT EL 100000	GHAVP–1&2/24200/2012/GA	CONTROL BUILDING GA OF FLOOR AT EL 122000	GHAVP–1&2/24200/2016/GA	STATION AUXILIARY BUILDING–2A FLOOR PLAN AT EL. 113000 & 116000	GHAVP–2/24300/2005/GA	
CONTROL BUILDING GA OF FLOOR AT EL 106000	GHAVP–1&2/24200/2013/GA	CONTROL BUILDING GA OF FLOOR AT EL 111000	GHAVP–1&2/24200/2014/GA	STATION AUXILIARY BUILDING–1A FLOOR PLAN AT EL. 113000 & 116000	GHAVP–1/24300/2005/GA	
REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	

REV. No.	DESCRIPTION	DRN.	DES'D.	DES.CHK'D.	REV'D.	APP'D.
1	DRAWINGS REVISED DUE TO INCREASE IN BUILDING PLAN DIMENSIONS, INCREASE IN ISOLATION GAP BETWEEN THE BUILDINGS, MODIFICATION IN FLOOR CUTOUTS, MODIFICATION OF AHU ROOM, PROVISION OF STUB COLUMN, PEDESTAL MODIFICATION AND AND ADDITION OF BRICK WALL ALONG GRID–A.	KAPL 19/04/16				

REVISIONS — SIGNATURE (NPCIL)

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :–
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE $\sqrt{}$ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS AND EDGES BY CHAMFERING TO $^{0}_{-15}$ X 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R $^{0}_{-15}$.

TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5–3	3–6	6–30
TOLERANCES	± 0.2	± 0.5	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (ISO 2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 – 1000	± 0.8
6 – 30	± 0.2	1000 – 2000	± 1.2
30 – 120	± 0.3	2000 – 4000	± 2.0
120 – 315	± 0.8	4000 – 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	± 1
XX.X	± 0.1
XX.XX	± 0.01

TOLERANCES ON ANGULAR DIMENSIONS ± 0° – 30'

R1	FOR INFORMATION		
R0	FOR INFORMATION	6/17/2014	
REV. No.	DESCRIPTION	DATE	APP'D.

DRAWING ISSUED FOR

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :– GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA–1&2
CONTROL BUILDING
GA OF FLOOR AT EL. 116000

DES'D.	6/11/2014	DR'N. DATE	KAPL 6–17–2014
DES. CHK'D.	6/12/2014	DRG. CHK'D.	6/11/2014
		APP'D.	6/17/2014

PROJECT GHAVP–1&2 — SCALE – 1:150 — PROJECTION

DRG. No. GHAVP–1&2/24200/2015/GA — REV. No. 1

FILE NAME: GHAVP1_2400_2015_GA_R1

DRG. TO BE READ IN CONJUNCTION WITH DCN/FCN/ECN, IF ANY.

DRG. No. GHAVP–1&2/24200/2015/GA — AD

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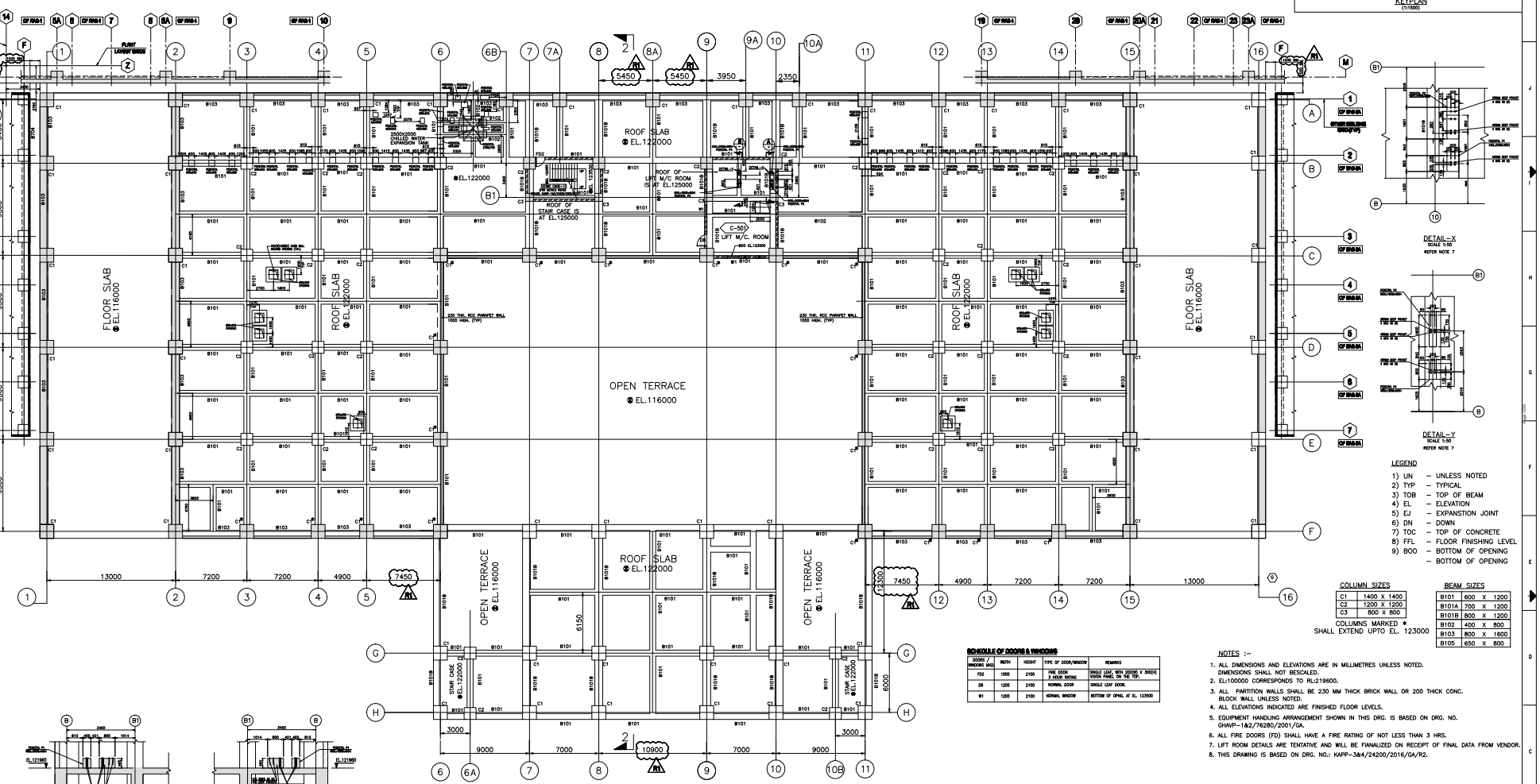
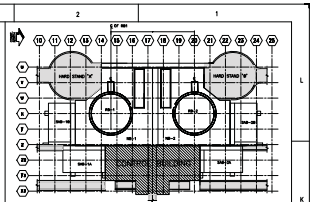
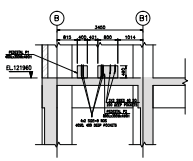
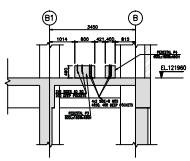


PLAN AT EL 122000 (FFL UN)
(TOC AT EL 121960)
400 THK. SLAB-(UN)







LEGEND

1) UN – UNLESS NOTED
2) TYP – TYPICAL
3) TOB – TOP OF BEAM
4) EL – ELEVATION
5) EJ – EXPANSTION JOINT
6) DN – DOWN
7) TOC – TOP OF CONCRETE
8) FFL – FLOOR FINISHING LEVEL
9) BOO – BOTTOM OF OPENING
– BOTTOM OF OPENING

COLUMN SIZES	
C1	1400 X 1400
C2	1200 X 1200
C3	800 X 800

COLUMNS MARKED * SHALL EXTEND UPTO EL. 123000

BEAM SIZES	
B101	600 X 1200
B101A	700 X 1200
B101B	800 X 1200
B102	400 X 800
B103	800 X 1600
B105	650 X 800

SCHEDULE OF DOORS & WINDOWS

DOORS / WINDOWS MKS	WIDTH	HEIGHT	TYPE OF DOOR/WINDOW	REMARKS
FD2	1000	2100	FIRE DOOR 2 HOUR RATING	SINGLE LEAF WITH 300(W) X 300(H) VISION PANEL ON THE TOP.
D8	1200	2100	NORMAL DOOR	SINGLE LEAF DOOR.
W1	1200	2100	NORMAL WINDOW	BOTTOM OF OPNG. AT EL. 123300

NOTES :-

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED. DIMENSIONS SHALL NOT BESCALED.
2. EL:100000 CORRESPONDS TO RL:219600.
3. ALL PARTITION WALLS SHALL BE 230 MM THICK BRICK WALL OR 200 THICK CONC. BLOCK WALL UNLESS NOTED.
4. ALL ELEVATIONS INDICATED ARE FINISHED FLOOR LEVELS.
5. EQUIPMENT HANDLING ARRANGEMENT SHOWN IN THIS DRG. IS BASED ON DRG. NO. GHAVP-1&2/76280/2001/GA.
6. ALL FIRE DOORS (FD) SHALL HAVE A FIRE RATING OF NOT LESS THAN 3 HRS.
7. LIFT ROOM DETAILS ARE TENTATIVE AND WILL BE FIANALIZED ON RECEIPT OF FINAL DATA FROM VENDOR.
8. THIS DRAWING IS BASED ON DRG. NO.: KAPP-3&4/24200/2016/GA/R2.

BETWEEN GRID 1-2 & 15-16;
(1) COLUMNS SHALL EXTEND UPTO EL. 125500.
(2) TOP OF CONCRETE FOR BEAMS AND SLAB SHALL BE AT EL. 125500.
(3) ALONG GRIDS 2 & 15 BEAMS SHALL BE AT EL. 122000 & EL 125500.

DRG. No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.
GHAVP-1&2/24200/2016/GA	MAIN PLANT LAYOUT	GHAVP-1&2/10000/2002/GA	CONTROL BUILDING GA OF ROOF AT EL.125000 AND EL.125500	GHAVP-1&2/24200/2017/GA	NUCLEAR BUILDING-2 : GA OF RAB-2 AT EL.123000, EL.30200, EL.134600 & EL.139000	GHAVP-2/21900/2007/GA
	COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA	GHAVP-1T04/10000/2001/GA	CONTROL BUILDING GA OF BASEMENT AT EL. 92000/93500/94000	GHAVP-1&2/24200/2011/GA	NUCLEAR BUILDING-1 : GA OF RAB-1 AT EL.123000, EL.30200, EL.134600 & EL.139000	GHAVP-1/21900/2007/GA
	CONTROL BUILDING GA OF FLOOR AT EL 100000	GHAVP-1&2/24200/2012/GA	CONTROL BUILDING GA OF FLOOR AT EL 116000	GHAVP-1&2/24200/2015/GA	STATION AUXILIARY BUILDING-2A ROOF PLAN AT EL. 121000	GHAVP-2/24300/2006/GA
	CONTROL BUILDING GA OF FLOOR AT EL 106000	GHAVP-1&2/24200/2013/GA	CONTROL BUILDING GA OF FLOOR AT EL 111000	GHAVP-1&2/24200/2014/GA	STATION AUXILIARY BUILDING-1A ROOF PLAN AT EL. 121000	GHAVP-1/24300/2006/GA

REV. No.	DESCRIPTION	DRN.	DES'D.	DES.CHK'D.	REV'D.	APP'D.
1	DRAWINGS REVISED DUE TO INCREASE IN BUILDING PLAN DIMENSIONS AND INCREASE IN ISOLATION GAP BETWEEN THE BUILDINGS.	KAPL 19/04/16				

REVISIONS — SIGNATURE (INITIAL)

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :-
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE $\sqrt{}$ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS AND EDGES BY CHAMFERING TO 0 : 15 X 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R 0 : 15 OR 0 : 40.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5-3	3-6	6-30
TOLERANCES	± 0.2	± 0.5	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (ISO2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 - 1000	± 0.8
6 - 30	± 0.2	1000 - 2000	± 1.2
30 - 120	± 0.3	2000 - 4000	± 2.0
120 - 315	± 0.5	4000 - 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS : ± 0° - 30'

REV. No.	DESCRIPTION	DATE	APP'D.
R1	FOR INFORMATION		
R0	FOR INFORMATION	6/17/2014	

DRAWING ISSUED FOR

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :- GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA-1&2
CONTROL BUILDING
GA OF ROOF AT EL. 122000

DES'D.	6/11/2014	DR'N. DATE	KAPL 6-17-2014	REV'D.	6/16/2014
DES. CHK'D.	6/12/2014	DRG. CHK'D.	6/11/2014	APP'D.	6/17/2014

PROJECT GHAVP-1&2

SCALE :- 1:140

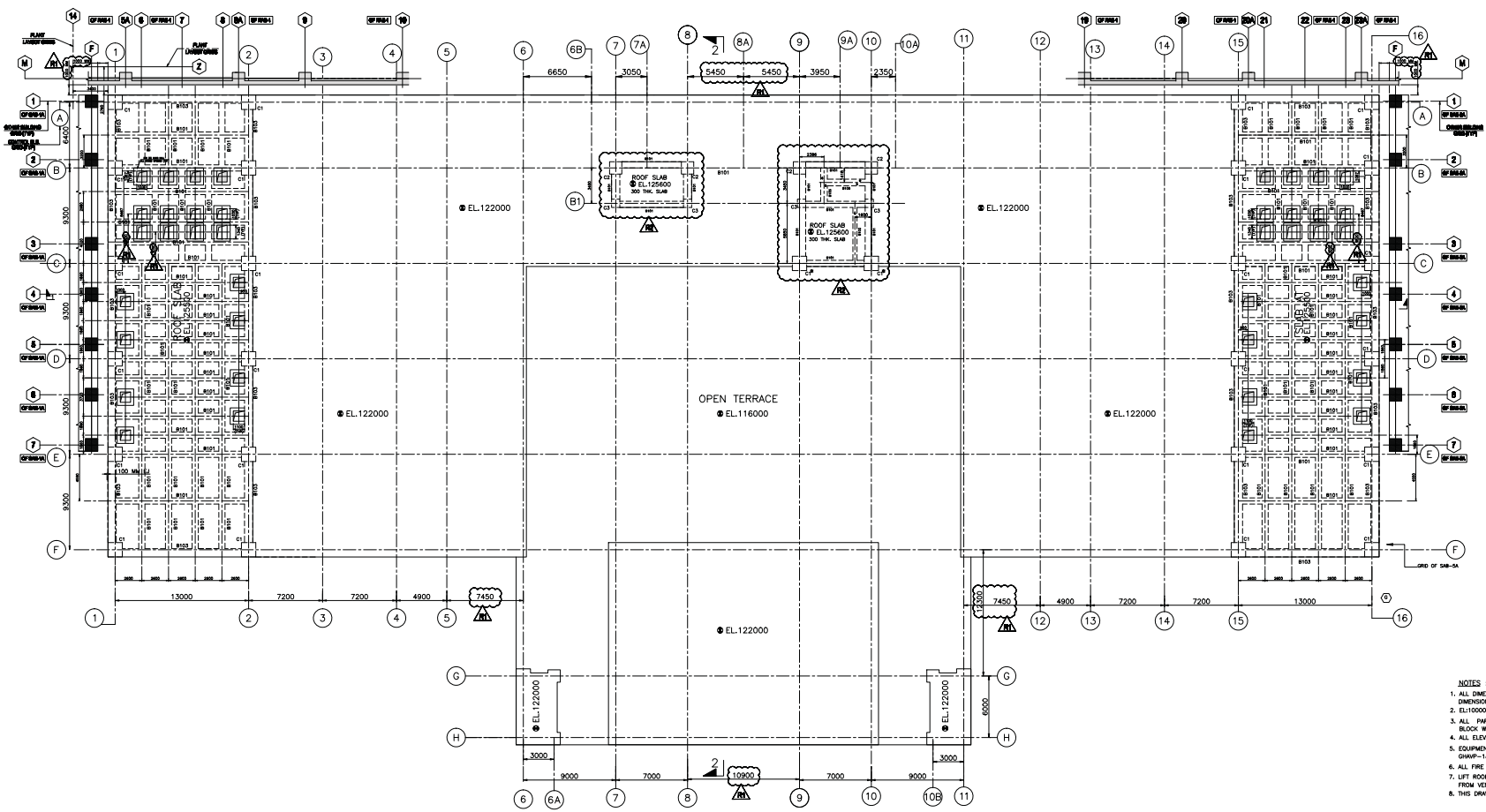
PROJECTION

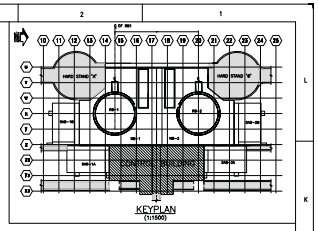
DRG. No. GHAVP-1&2/24200/2016/GA

REV. No. 1

DRG. TO BE READ IN CONJUNCTION WITH DCN/FCN/ECN, IF ANY.

FILE NAME: GHAVP12_24200_2016_GA_R1





LEGEND

1) UN – UNLESS NOTED
2) TYP – TYPICAL
3) TOB – TOP OF BEAM
4) EL – ELEVATION
5) EJ – EXPANSTION JOINT
6) DN – DOWN
7) TOC – TOP OF CONCRETE
8) FFL – FLOOR FINISHING LEVEL
9) BOO – BOTTOM OF OPENING
– BOTTOM OF OPENING

COLUMN SIZES

C1	1400 X 1400
C2	1200 X 1200
C3	800 X 800

BEAM SIZES

B101	600 X 1200
B101A	700 X 1200
B101B	800 X 1200
B102	400 X 800
B103	800 X 1600
B105	650 X 800

NOTES :–

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED. DIMENSIONS SHALL NOT BESCALED.
2. EL:100000 CORRESPONDS TO RL:219600.
3. ALL PARTITION WALLS SHALL BE 230 MM THICK BRICK WALL OR 200 THICK CONC. BLOCK WALL UNLESS NOTED.
4. ALL ELEVATIONS INDICATED ARE FINISHED FLOOR LEVELS.
5. EQUIPMENT HANDLING ARRANGEMENT SHOWN IN THIS DRG. IS BASED ON DRG. NO. GHAVP–1&2/76280/2001/GA.
6. ALL FIRE DOORS (FD) SHALL HAVE A FIRE RATING OF NOT LESS THAN 3 HRS.
7. LIFT ROOM DETAILS ARE TENTATIVE AND WILL BE FIANALIZED ON RECEIPT OF FINAL DATA FROM VENDOR.
8. THIS DRAWING IS BASED ON DRG. NO.: KAPP–3&4/24200/2016/GA/R2.

PLAN AT EL 125000/125500 (FFL UN)

(TOC AT EL 124960/125460)

400 THK. SLAB–(UN)

BETWEEN GRID 1–2 & 15–16:
(1) COLUMNS/SHEAR WALLS SHALL EXTEND UPTO EL. 125500.
(2) TOP OF CONCRETE FOR BEAMS AND SLAB SHALL BE AT EL. 125500.
(3) ALONG GRIDS 2 & 15 BEAMS SHALL BE AT EL. 122000 & EL 125500.

REV. No.	DESCRIPTION	DATE	APP'D.
2	FOR INFORMATION		
1	FOR INFORMATION	28-10-2016	
0	FOR INFORMATION		

DRAWING ISSUED FOR

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :– GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA–1&2
CONTROL BUILDING
GA OF ROOF AT EL. 125000 / 125500

DES'D.	DR'N. KAPL 19-04-2016	REV'D.
DES. CHK'D.	DRG. CHK'D.	APP'D.

PROJECT GHAVP–1&2 | SCALE – 1:150 | PROJECTION

DRG. No. GHAVP–1&2/24200/2017/GA | REV. No. 2

DRG. TO BE READ IN CONJUNCTION WITH DCN/FCN/ECN, IF ANY.

FILE NAME: GHAVP1&2_24200_2017_GA_R2

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :–
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE ▽ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS
AND EDGES BY CHAMFERING TO 0 : 15 X 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R 0 : 15 OR 0 : 40.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5–3	3–6	6–30
TOLERANCES	± 0.2	± 0.5	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (ISO2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 – 1000	± 0.8
6 – 30	± 0.2	1000 – 2000	± 1.2
30 – 120	± 0.3	2000 – 4000	± 2.0
120 – 315	± 0.5	4000 – 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS : ± 0° – 30'

DRG. No.	DESCRIPTION	
GHAVP–1&2/24200/2017/GA	MAIN PLANT LAYOUT	GHAVP–1&2/10000/2002/GA
	COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA	GHAVP–1T04/10000/2001/GA
	CONTROL BUILDING GA OF FLOOR AT EL 100000	GHAVP–1&2/24200/2012/GA
	CONTROL BUILDING GA OF FLOOR AT EL 106000	GHAVP–1&2/24200/2013/GA
	REFERENCE DRAWINGS	DRAWING No.

	DESCRIPTION	REFERENCE DRAWINGS	DRAWING No.
	CONTROL BUILDING GA OF BASEMENT AT EL 92000/93500/94000	GHAVP–1&2/24200/2011/GA	
	CONTROL BUILDING GA OF FLOOR AT EL 122000	GHAVP–1&2/24200/2016/GA	
	CONTROL BUILDING GA OF FLOOR AT EL 116000	GHAVP–1&2/24200/2015/GA	
	CONTROL BUILDING GA OF FLOOR AT EL 111000	GHAVP–1&2/24200/2014/GA	
	REFERENCE DRAWINGS	DRAWING No.	

		NUCLEAR BUILDING–2 ; GA OF RAB–2 AT EL.123000, EL.30200, EL.134600 & EL.139000	GHAVP–2/21900/2007/GA	2	DRAWING REVISED AS MARKED.	KAPL 23/03/17
		NUCLEAR BUILDING–1 ; GA OF RAB–1 AT EL.123000, EL.30200, EL.134600 & EL.139000	GHAVP–1/21900/2007/GA	1	DRAWINGS REVISED DUE TO INCREASE IN BUILDING PLAN DIMENSIONS AND INCREASE IN ISOLATION GAP BETWEEN THE BUILDINGS AND ADDITION OF ROOF SLAB BETWEEN GRID 1–2/A–F AND 15–16/A–F.	KAPL 19/04/16
		REFERENCE DRAWINGS	DRAWING No.	REV. No.	DESCRIPTION	DR'N.

REVISIONS

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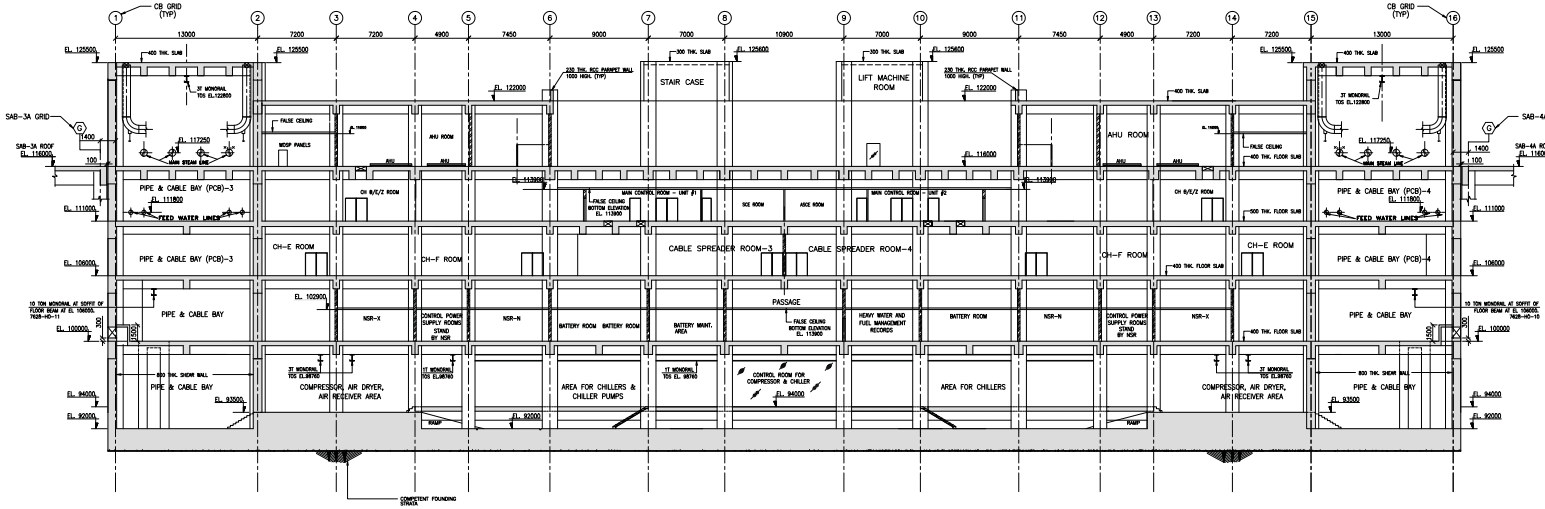
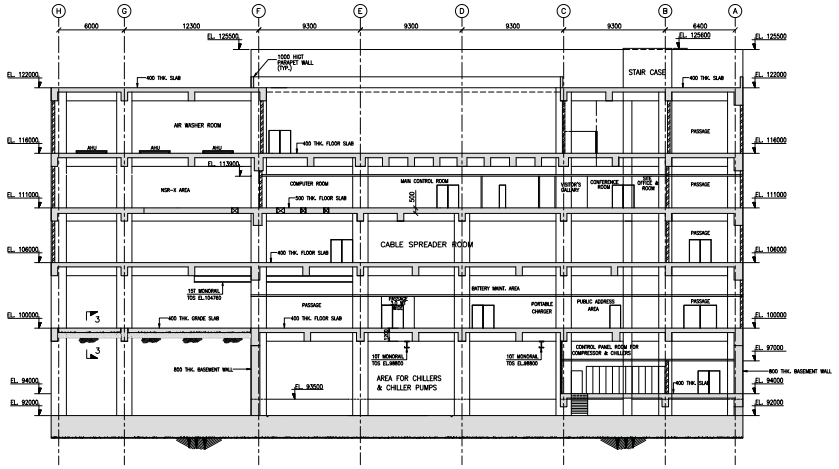
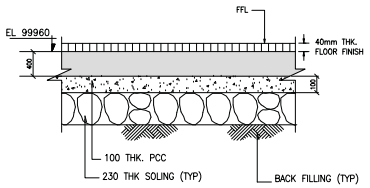
AO



SECTION 1–1

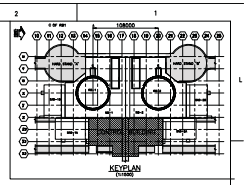


SECTION 2–2



SECTION 3–3

TYP SECT THROUGH GRADE SLAB



LEGEND

FOR LEGEND REFER DRG. NO. GHAVP-1&2/24200/2012/GA

NOTES

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES UNLESS NOTED. DIMENSIONS SHALL NOT BE SCALED.
2. FOR OTHER NOTES REFER DRG. NO. GHAVP-1&2/24200/2012/GA
3. THIS DRAWING IS BASED ON DRG. NO.: KAPP-3&4/24200/2017/GA/R2

MAIN PLANT LAYOUT	GHAVP-1&2/10000/2002/GA	CONTROL BUILDING GA OF ROOF AT EL.125000 AND EL.125500	GHAVP-1&2/24200/2017/GA	NUCLEAR BUILDING-2: GA OF RAB-2 AT EL. 90000	GHAVP-2/21900/2001/GA
COMPOSITE PLANT LAYOUT UNITS 1 TO 4 GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA	GHAVP-1T04/10000/2001/GA	CONTROL BUILDING GA OF FLOOR AT EL 122000	GHAVP-1&2/24200/2016/GA	NUCLEAR BUILDING-1: GA OF RAB-1 AT EL. 90000	GHAVP-1/21900/2001/GA
CONTROL BUILDING GA OF FLOOR AT EL 100000	GHAVP-1&2/24200/2012/GA	CONTROL BUILDING GA OF FLOOR AT EL 116000	GHAVP-1&2/24200/2015/GA	STATION AUXILIARY BUILDING-2A FOUNDATION PLAN AT EL. 92000	GHAVP-2/24300/2001/GA
CONTROL BUILDING GA OF FLOOR AT EL 106000	GHAVP-1&2/24200/2013/GA	CONTROL BUILDING GA OF FLOOR AT EL 111000	GHAVP-1&2/24200/2014/GA	STATION AUXILIARY BUILDING-1A FOUNDATION PLAN AT EL. 92000	GHAVP-1/24300/2001/GA
REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.

DRG. No. GHAVP-1&2/24200/2018/GA

AD

REV. No.	DESCRIPTION	DR'N.	DES'D.	DES.CHK'D.	REV'D.	APP'D.
R0	FOR INFORMATION					

REVISIONS

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :-
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE $\sqrt{}$ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS AND EDGES BY CHAMFERING TO $^{0}_{0.15}$ X 45°, $^{0}_{0.40}$.
ROUND ALL INTERNAL CORNERS AND EDGES TO R $^{0}_{0.15}$, $^{0}_{0.40}$.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5–3	3–6	6–30
TOLERANCES	± 0.2	± 0.5	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (ISO 2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 – 1000	± 0.8
6 – 30	± 0.2	1000 – 2000	± 1.2
30 – 120	± 0.3	2000 – 4000	± 2.0
120 – 315	± 0.5	4000 – 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS ± 0° - 30'

R0	FOR INFORMATION		
REV. No.	DESCRIPTION	DATE	APP'D.

DRAWING ISSUED FOR

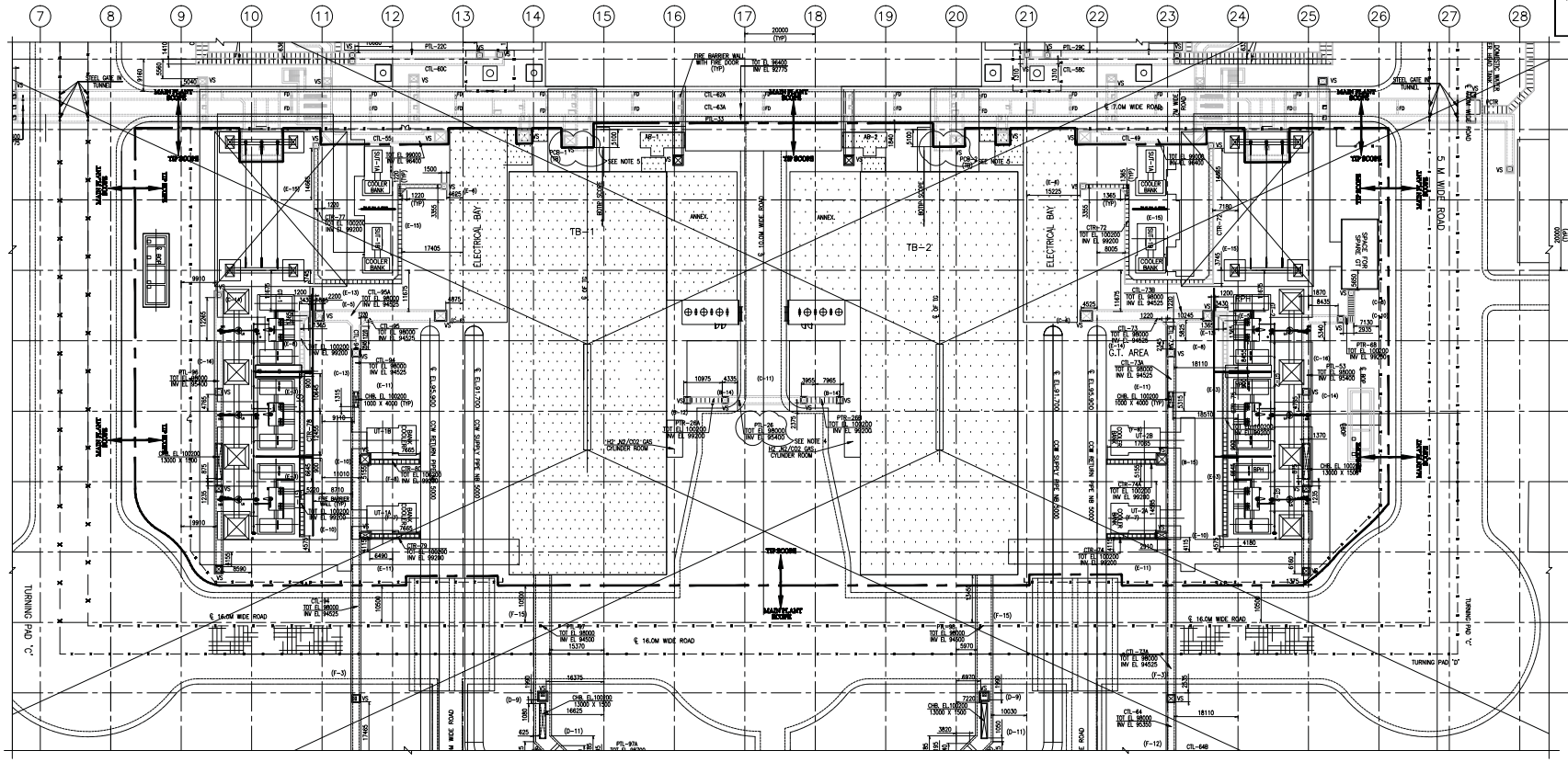
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :- GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA-1&2
CONTROL BUILDING
SECTIONS

DES'D.	DR'N. KAPL	REV'D.	
DES. CHK'D.	DRG. CHK'D.	APP'D.	
PROJECT GHAVP–1&2		SCALE – 1:160	
		PROJECTION	
DRG. No. GHAVP–1&2/24200/2018/GA		REV. No. 0	

DRG. TO BE READ IN CONJUNCTION WITH DCN/FCN/ECN, IF ANY.

FILE NAME: GHAVP1_2A200_2018_00_R0



NOTES:-

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETRES, UNLESS NOTED OTHERWISE.
2. ELEVATIONS EL 99700 CORRESPONDS TO RL 219300.
3. THIS DRAWING SHALL BE REFEREED ONLY FOR SCOPE OF TUNNELS & TRENCHES UNDER TIP.
4. TOT OF PTL-26 SHALL BE FIXED AT EL 98000.
5. INNER DIMENSION TUNNELS EXTENDING BEYOND TIP AREA WIZ. ASW TUNNEL, PTL 97,98 AND CTL 73A, 94 SHALL BE SAME AS THAT OF OUTSIDE AREA TO MAINTAIN UNIFORMITY.

REV. No.	DESCRIPTION	DATE	APP'D.

DRAWING ISSUED FOR

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :- GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA-1&2
TUNNELS & TRENCHES UNDER TIP SCOPE

DES'D.	DR'N. KAPL	REV'D.
DES. CHK'D.	DRG. CHK'D.	APP'D.
PROJECT GHAVP-1 & 2		SCALE - 1:1
		PROJECTION
DRG. No. GHAVP-1&2/29700/2001/SK		REV. No.

GROUP	ENGR	SIGN	GROUP	ENGR	SIGN	GROUP	ENGR	SIGN	GROUP	ENGR	SIGN
R3			R2			R1			R0		

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :-
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE $\sqrt{}$ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS
AND EDGES BY CHAMFERING TO $^{0.15}_{0.40}$ x 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R $^{0.15}_{0.40}$.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5-3	3-6	6-30
TOLERANCES	± 0.2	± 0.3	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (IS:2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 - 1000	± 0.8
6 - 30	± 0.2	1000 - 2000	± 1.2
30 - 120	± 0.3	2000 - 4000	± 2.0
120 - 315	± 0.5	4000 - 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS : ± 0° - 30'

DRG. TO BE READ IN CONJUNCTION

REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.

REV. No.	DESCRIPTION	DR'N.	DES'D.	DES./CHK'D. SIGNATURE (NPCIL)	REV'D.	APP'D.
	REVISIONS					

DRG. No. GHAVP-1&2/29700/2001/SK

A0

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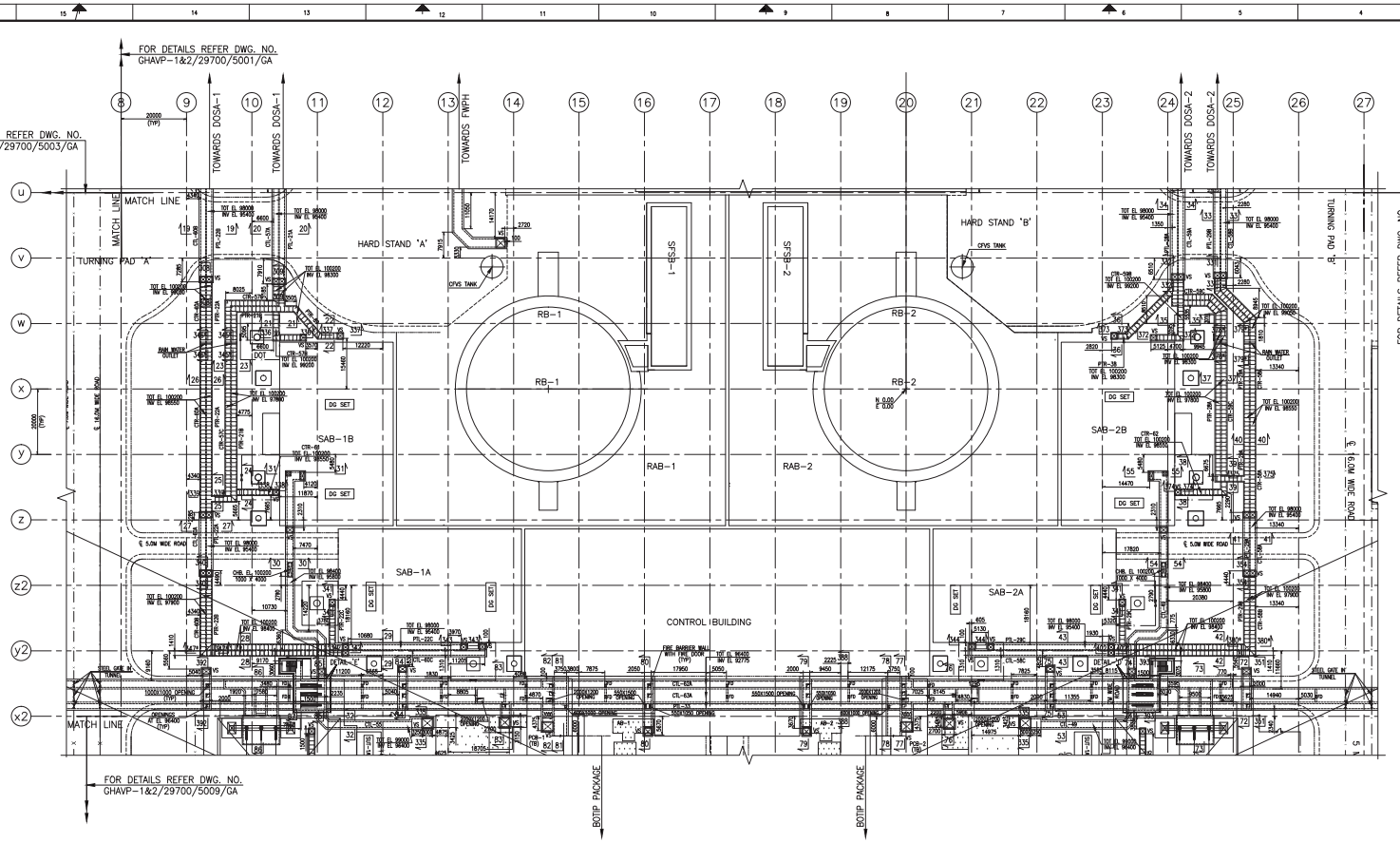
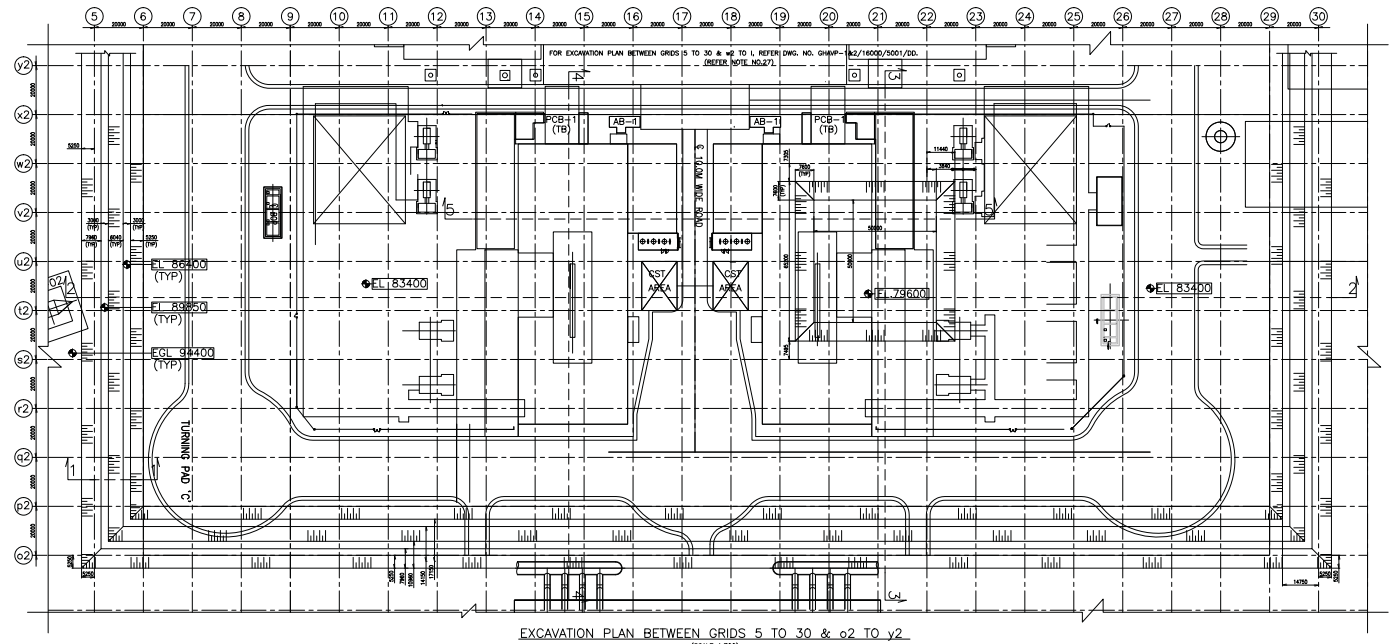
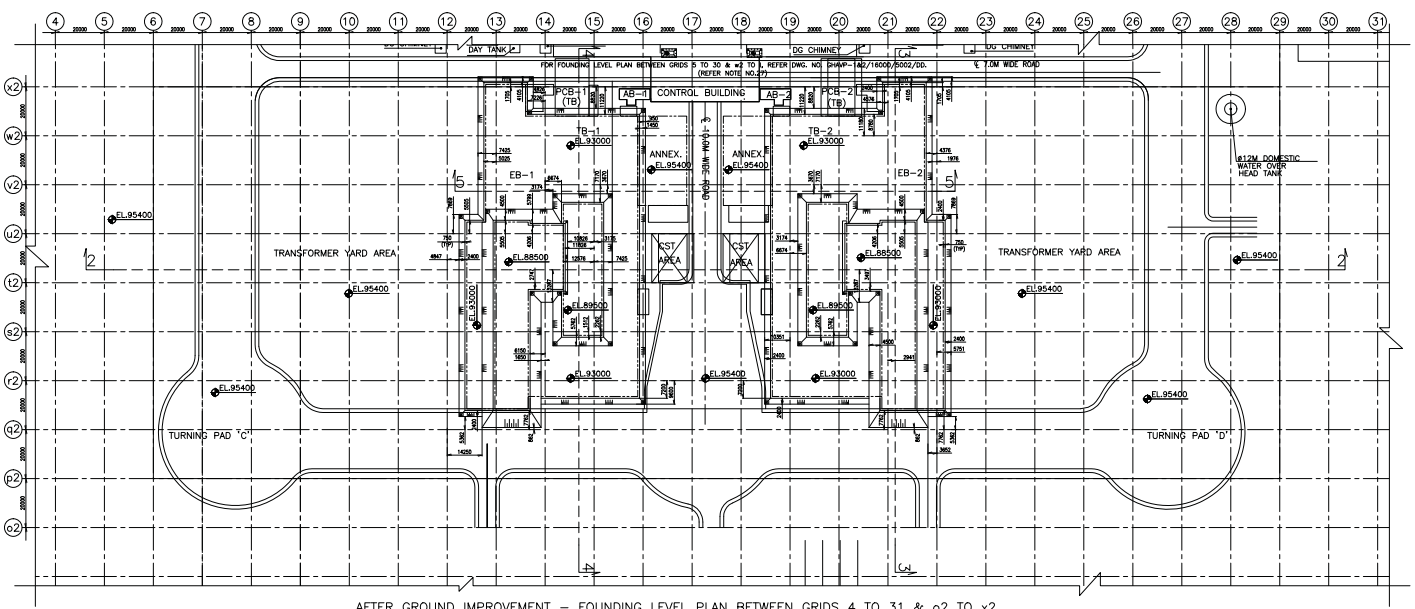

FOR DETAILS REFER DWG. NO. GHAVP-1&2/29700/5001/GA
FOR DETAILS REFER DWG. NO. GHAVP-1&2/29700/5003/GA
TOWARDS DOSA-1
TOWARDS DOSA-1
TOWARDS TAPS
TOWARDS DOSA-2
TOWARDS DOSA-2
MATCH LINE
TURNING PAD 'A'
HARD STAND 'A'
HARD STAND 'B'
TURNING PAD 'B'
CFVS TANK
CFVS TANK
SISS-1
SISS-2
RB-1
RB-2
RAB-1
RAB-2
SAB-1A
SAB-2A
SAB-2B
ISAB-1B
CONTROL BUILDING
FIRE BARRIER WALL WITH FIRE DOOR (TYP)
DG SET
DG SET
DG SET



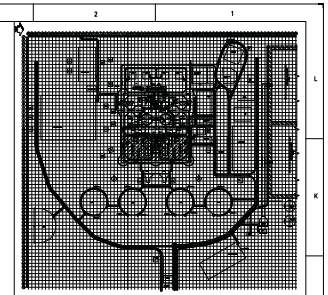
EXCAVATION PLAN BETWEEN GRIDS 5 TO 30 & o2 TO y2

(SCALE 1:700)



AFTER GROUND IMPROVEMENT – FOUNDING LEVEL PLAN BETWEEN GRIDS 4 TO 31 & o2 TO x2

(SCALE 1:700)



KEY PLAN

(SCALE 1:10000)

LEGEND :–

APPROX – APPROXIMATE
DWG – DRAWING
DN – DOWN
E.G.L. – EXISTING GROUND LEVEL.
E.L. – ELEVATION LEVEL.
F.G.L. – FINISHED GRADE LEVEL.
R.L. – REDUCED LEVEL.

EXCAVATION LEVEL.

SLOPING PORTION

(X):(Y) SLOPE
Y HORIZONTAL
X VERTICAL

NOTES :–

1. ALL DIMENSIONS AND ELEVATIONS ARE IN MILLIMETERS.
2. EL.100000 CORRESPONDS TO RL. 219.800M.
3. FINISHED GRADE LEVEL WITHIN MAIN PLANT AREA IS EL.99700 CORRESPONDS TO RL. 219.500M.
4. FOR DETAILS OF SECTIONS 1–1 TO 5–5 REFER DWG. NO. GHAVP–1&2/16000/2004/DD.
5. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE CONTRACT TERMS, CONDITIONS AND SPECIFICATIONS.
6. THIS DRAWING IS BASED ON PLANT LAYOUT DWG. NO. GHAVP–1&2/10000/5001/GA.
7. EXTENT OF EXCAVATION INDICATED IS BASED ON THE DIMENSIONS OF FOUNDATIONS AS DESIGNED INCLUDING 750 mm WORKING SPACE FROM THE FACE OF FOUNDATION. WORKING SPACE REQUIRED MORE THAN 750mm FOR DEWATERING, PLACEMENT AND REMOVAL OF SHUTTERING,WATERPROOFING TREATMENT, ETC. MAY BE PROVIDED WHEREVER REQUIRED WITH PRIOR APPROVAL OF ENGINEER IN CHARGE.
8. THE SPACE FOR STORAGE OF ALL USABLE EXCAVATED MATERIAL SHALL BE IDENTIFIED INSIDE THE SITE AREA, WITH THE APPROVAL OF THE ENGINEER IN CHARGE.
9. HEAVY EQUIPMENT AND VEHICULAR TRAFFIC SHALL BE KEPT AWAY FROM THE EXCAVATED EDGES AT A DISTANCE NOT LESS THAN THE DEPTH OF EXCAVATED PIT OR AT LEAST 6M FOR AN EXCAVATED PIT DEEPER THAN 6M. (REFER IS 3764).
10. EXCAVATION PROCEDURE & DEWATERING SCHEME SHALL BE PREPARED BY CONTRACTOR & DULY APPROVED BY ENGINEER IN CHARGE BEFORE START OF THE WORK.
11. FOR EXCAVATION PLAN IN BETWEEN GRIDS 4 TO 30 & w2 TO 1, REFER DRG. NO. GHAVP–1&2/16000/5001/DD.
12. EXCAVATION AND CONSTRUCTION SEQUENCE SHALL BE PLANNED CAREFULLY TO AVOID EFFECT OF WATER LOWERING IN TERMS OF SETTLEMENT OF NEARBY STRUCTURES.
13. ANY CHANGE IN SERATA AT EXCAVATION LEVEL SHALL BE REFERRED TO ENGINEER IN CHARGE BEFORE COMMENCEMENT OF FURTHER WORK.
14. APPROVAL OF THE ENGINEER IN CHARGE SHALL BE TAKEN AFTER REACHING THE EXCAVATION LEVEL INDICATED IN THE DRAWING BEFORE STARTING FURTHER ACTIVITY.
15. ALL THE MEASURES TO BE TAKEN TO PREVENT ENTRY OF RAIN WATER INTO EXCAVATED PIT VIZ MAKING OF BUNDS, TEMPORARY TRENCHES, SUMPS ETC. AND SLOPE PROTECTION ASPECTS INCLUDING PREVENTION OF SOIL EROSION.
16. THE METHODOLOGY FOR EXCAVATION ACTIVITY ADDRESSING ALL THE PERTINENT ISSUES INCLUDING SLOPE STABILITY, SOIL EROSION DUE TO RAIN AND CONFORMANCE TO CONSTRUCTION SCHEDULE SHALL BE FORMULATED AND SUBMITTED BY CONTRACTOR FOR APPROVAL BY ENGINEER IN CHARGE.
17. SUITABLE VERTICAL SHORING/SHEET PILE/SLOPE PROTECTION MEASURES ETC. SHALL BE PROVIDED TO FACILITATE PARALLEL CONSTRUCTION/GROUND IMPROVEMENT ACTIVITY WHEREVER REQUIRED WITH THE APPROVAL OF ENGINEER IN CHARGE.
18. SLOPE OF EXCAVATED AREA SHALL BE SUITABLY PROTECTED FROM RAINWATER BY ANY OF THE FOLLOWING SUITABLE METHOD FOR CARRYING OUT SAFE EXECUTION OF WORK WITH THE APPROVAL OF ENGINEER IN CHARGE.
«STONE PITCHING «TARPAULIN SHEET
«BRICK PITCHING
19. CONTRACTOR SHALL FINALISE THE FOLLOWING WITH ENGINEER IN CHARGE PRIOR TO COMMENCEMENT OF WORK
   a) SEQUENCE AND DETAILED METHOD OF EXCAVATION.
   b) PROGRESSIVE LIFTING AND CARTAGE OF EXCAVATED MATERIAL AS EXCAVATION PROGRESSES IN DEPTH INCLUDING TRANSPORTATION AND STACKING OF USEFUL MATERIAL IN STOCK PILES.
   c) METHOD OF DEWATERING BY WELL–POINT SYSTEM, DULY CONSIDERING PERMEABILITY MEASURES TO AVOID LOSS OF FINES, AND DISPOSAL TO KEEP THE EXCAVATED PITS DRY ALL THE TIME.
   d) UTILIZATION OF APPROVED EXCAVATED MATERIAL FOR PURPOSES OF SITE GRADING, BACKFILLING, FORMATION OF ROADS ETC.
   e) GROUND IMPROVEMENT SHALL BE CARRIED OUT UPTO BOTTOM OF RAFT/FOUNDATION BY SOIL/SOIL CEMENT COMPACTION BY APPROVED PROCEDURE/SPECIFICATION.
20. ALL STIPULATIONS OF IS: 3764–1992 SHALL BE STRICTLY FOLLOWED FOR CARRYING OUT SAFE EXCAVATION.
21. DEWATERING SCHEME SHALL BE DEVELOPED BY CONTRACTOR & APPROVAL OF ENGINEER IN CHARGE SHALL BE OBTAINED BEFORE COMMENCEMENT OF WORK.
22. DEWATERING SHALL BE CONTINUED AND GROUND WATER MAINTAINED AT THE LEVEL AS SPECIFIED DURING THE STAGES OF CONSTRUCTION SUCH THAT WATER TABLE REMAINS AT LEAST 1M BELOW THE EXCAVATION LEVEL. THE CUT–OFF DRAIN SHALL BE SLOPED FOR WATER TO FLOW INTO SUITABLE LOCATED TANKS FROM WHERE THE WATER WILL BE PUMPED TO A NEAREST TANK/ POND OR CANAL.
23. ALL PUMPS SHOULD BE CAPABLE OF HANDLING THE REQUIRED QUANTITY OF WATER AND SHOULD NOT BE DAMAGED BY DRY OPERATIONS. THE SYSTEM CAN BE FITTED WITH AN EXTERNAL CONTROL TO AUTOMATICALLY START AND STOP PUMPING AT PREDETERMINED LEVELS.
24. THE SCHEME OF THE PUMPED OUT WATER SHALL BE SUCH THAT, WATER SHALL BE DISCHARGED TO SUITABLE DISCHARGE/ STORAGE POINT AS DIRECTED BY ENGINEER IN CHARGE.
25. DRAINAGE SYSTEM FOR UNSUITABLE PUMPED OUT WATER SHOULD BE PLANNED IN SUCH A WAY AS TO CARRY THE WATER AWAY FROM THE SITE TO NEAREST NALLAH/ CANAL.
26. FOR MULTISTAGE WELL POINT SYSTEM, 30% STANDBY PUMPS SHOULD BE ON LINE IN CASE OF BREAKDOWNS.
27. THE DEWATRING SCHEME (AS PER APPROVED PROCEDURE) SHOWN IN THE DRAWING NO. GHAVP–1&2/16000/5001/DD TO 5005/DD SHALL BE CHANGED BASED ON SITE CONDITION BY THE CONTRACTOR.

READ THIS DWG. IN CONJUNCTION WITH DWG. NO. GHAVP–1&2/16000/2004/DD

THE DESIGNS AND DRAWINGS ARE THE PROPERTY OF THE OWNER & SHALL NOT BE COPIED, DISCLOSED OR USED EITHER BY RECEIVING PARTY OR ANY OTHER PERSON WITHOUT THE EXPRESS PERMISSION OF THE OWNER.

REV. NO.	DESCRIPTION	DATE	APP'D.
R0	CONSTRUCTION		

DRAWING ISSUED FOR

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)

TITLE :– GORAKHPUR HARYANA ANU VIDYUT PARIYOJANA–1&2
EXCAVATION PLAN AND FOUNDING LEVEL PLAN IN BETWEEN GRIDS 4 TO 31 & o2 TO y2

DES'D.	DR'N. KAPL	REV'D.	
DES. CHK'D.	DRG. CHK'D.	APP'D.	
PROJECT GHAVP–1&2		SCALE – 1:1	
		PROJECTION	
DRG. No. GHAVP–1&2/16000/2003/DD		REV. No.	R0

DRG. No. GHAVP–1&2/16000/2003/DD

REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.	REFERENCE DRAWINGS	DRAWING No.

REVISIONS

REV. NO.	DESCRIPTION	DR'N.	DES'D.	DES.CHK'D.	REV'D.	APP'D.

SIGNATURE (WRT DATE)

DO NOT SCALE THE DRAWING.

UNLESS OTHERWISE STATED :–
ALL DIMENSIONS ARE IN mm.
MACHINE ALL OVER.
SURFACE FINISH TO BE ▽ OR BETTER.
REMOVE ALL BURRS.
REMOVE ALL EXTERNAL SHARP CORNERS AND EDGES BY CHAMFERING TO 0 – 15 x 45°.
ROUND ALL INTERNAL CORNERS AND EDGES TO R 0 – 15.
TOLERANCES ON RADII AND CHAMFERS (IS : 2102)

RADII AND CHAMFERS	0.5–3	3–6	6–30
TOLERANCES	± 0.2	± 0.5	± 1.0

TOLERANCES ON LINEAR DIMENSIONS (IS:2102)

DIMENSIONS	TOL.	DIMENSIONS	TOL.
UPTO 6	± 0.1	315 – 1000	± 0.6
6 – 30	± 0.2	1000 – 2000	± 1.2
30 – 120	± 0.3	2000 – 4000	± 2.0
120 – 315	± 0.5	4000 – 8000	± 3.0

TOLERANCES ON LINEAR DIMENSIONS

SPECIFIED DIMENSIONS	TOLERANCE
XX	±
XX.X	±
XX.XX	±

TOLERANCES ON ANGULAR DIMENSIONS : ± 0° – 30'

FILE NAME: GHAVP1_1&2/16000/2003/DD_R0	
DRG. TO BE READ IN CONJUNCTION WITH DCR/TCH/ECN, IF ANY.	

VOLUME – II B
CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

SPECIFICATION NO. PE-TS-999-600-C002

SECTION – D

SUB SECTION – D2

GENERAL TECHNICAL SPECIFICATION

CEMENT CONCRETE (PLAIN & REINFORCED)

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

C 0 N T E N T

CLAUSE NO.	DESCRIPTION	SHEET NO.
1.00.00	SCOPE	3
2.00.00	GENERAL	3
3.00.00	INSTALLATION	12
4.00.00	SAMPLING AND TESTING	41
5.00.00	ACCEPTANCE CRITERIA	43
6.00.00	RATES AND MEASUREMENTS	43
7.00.00	LIST OF I.S.: CODES AND STANDARDS FOR REFERENCE	51

SUB-SECTION – D2

CEMENT CONCRETE (PLAIN & REINFORCED)

1.00.00 SCOPE

1.01.00 General

This specification covers all the requirements, described hereinafter for general use of Plain and Reinforced Cement Concrete work in Structures and locations, cast-in-situ or precast, and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work. Special requirements for structures such as reinforced concrete chimney, cooling towers, etc. have been covered under the respective specifications. Those specifications shall be used in conjunction with this specification.

1.02.00 IS: 456 shall form a part of this specification and shall be complied with unless permitted otherwise. For any particular aspect not covered by this Code, appropriate Code, specifications and/or replacement by any International code of practice as may be specified by the Engineer shall be followed. All codes and Standards shall conform to its latest revisions. A list of IS codes and Standards is enclosed hereinafter for reference. However, should the list be not exhaustive and does not cover any aspect of the work, then relevant Indian and, in its absence, relevant International code shall apply.

2.00.00 General

2.01.00 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless otherwise specified shall include but not be limited to the following

a) Furnish all labour, supervision, services including facilities as may be required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, aids, construction equipment, tools and plants, transportations, etc. required for the work.

b) Prepare Bar bending Schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.

c) Prepare working drawings of formworks, scaffolds, supports, etc.

d) Prepare shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedments, hangers, openings, frames etc.

e) Prepare detailed drawings of supports, templates, hangers, etc. required for

installation of various embedments like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

As decided by the Engineer some or all of the drawings & schedules prepared under item (b) to (e) above will have to be submitted for approval.

f) Submit for approval detailed schemes of all operations required for executing the work, e.g. material handling, Concrete mixing, Placement of concrete, Compaction, curing, services, Approaches, etc.

g) Design and submit for approval concrete mix designs required to be adopted on the job.

Furnish samples and submit for approval results of tests of various properties of the following:

i) The various ingredients of concrete

ii) Concrete

iii) Embedments

iv) Joint seals

i) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings and specifications.

j) For supply of certain materials normally manufactured by specialist firms, the Contractor may have to produce, if directed by the Engineer, a guarantee in approved Performa for satisfactory performance for a reasonable period as may be specified, binding both the manufacturers and the Contractor, jointly and severally.

2.02.00 Work by others

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

2.03.00 Information to be submitted by the Tenderer

2.03.01 With Tender

The following technical information's are required with the tender:

a) Source and arrangement of processing of aggregates proposed to be adopted.

b) Type of plant and equipment proposed to be used.

c) Names of firms with which association is sought for to execute the special items of work in the contract.

d) Types of formwork proposed to be used.

2.03.02 After Award

The Contractor shall submit the following information and data including samples where necessary, progressively during the execution of the contract.

a) Programme of Execution

Within 30 days of the award of contract, the Contractor will submit a Master Programme for completion of the work.

This Master Programme may have to be reviewed and updated by the Contractor, quarterly or at more frequent intervals as may be directed by the Engineer depending on the exigencies of the work.

Detailed day-to-day Programme of every month is to be submitted by the Contractor before the end of the previous month.

b) Samples

Samples of the following materials and any other materials proposed to be used shall be submitted as directed by the Engineer, in sufficient quantities free of cost, for approval. The Engineer for future reference will preserve approved samples. The approval of the Engineer shall not, in any way, relieve the Contractor of his responsibility of supplying materials of specified qualities:

i) Coarse and fine aggregates.

ii) Admixtures.

iii) Plywood for Formwork.

iv) Embedded and anchorage materials as may be desired by the Engineer.

v) Joint sealing strips and other*waterproofing materials.

vi) Joint filling compounds.

vii) Foundation quality Rubber Pads.

c) Design Mix

Design mix as per specification giving proportions of the ingredients, sources of aggregates and cement, along with test results of trial mixes as per relevant I.S., is to be submitted to the Engineer for his approval before it can be used on the works.

d) Bar Bending Schedules

Bar Sending Schedules in accordance with Clause 2.01.00 (b) and 3.16.01 of this specification.

e) Detailed Drawings and Designs of Formworks to be used

Detailed design data and drawings of standard formworks to be used as per clause 2.01.00 (c).

f) Detailed Drawings for Templates & Temporary Supports for embedment As per Clause 2.01.00 (e).

g) Mill Test Reports for Cement & Reinforcing Steel.

h) Inspection Reports

The Engineer in accordance with Clause 2.04.00 of this specification may desire inspection Reports in respect of Formwork and Reinforcement and any other item of work as.

i) Test Reports

Reports of tests of various materials and concrete as required under Clause 4.0: SAMPLING & TESTING of this specification or as directed by the Engineer.

j) Any other data, which may be required as per this specification or as directed by the Engineer.

2.04.00 Conformity with Design

The Contractor will prepare checklists in approved Performa, which will be called "Pour Cards". These Pour Cards will list out all items of work involved. The Contractor will inform the Engineer, sufficiently in advance, whenever any particular pour is ready for concreting. He shall accord all necessary help and assistance to the Engineer for all checking required in the pour. On satisfying himself that all details are in accordance to the drawings and specifications, the engineer will give written permission on the same Pour

Cards allowing the contractor to commence placement of concrete. Details of all instructions issued by the Engineer and the records of compliance by the Contractor, deviations allowed by the Engineer and any other relevant information will be written on accompanying sheets attached to the Pour Cards. The Pour Cards along with accompaniments will be handed over to the Engineer before starting placement of concrete. One of the mix designs developed by the Contractor as per the I.S. Specifications and established to the satisfaction of the Engineer by trial mixes shall be permitted to be used by the Engineer, the choice being dictated by the requirements of designs and workability. The methods of mixing, conveyance, placement, vibration, finishing, curing, protection and testing of concrete will be as approved or directed by the Engineer.

2.05.00 Materials to be used

2.05.01 General Requirement

All materials whether to be incorporated in the work or used temporarily for the construction shall conform to the relevant IS Specifications unless-stated otherwise and be of best approved quality.

2.05.02 Cement

Ordinary Portland cement of grade-43 as per IS:8112/fly ash based Portland puzzolona cement conforming to IS:1489 (Part-1) shall preferably be used in reinforced/plain cement concrete works for all areas other than for the critical structures identified below. However, other types of cement such as ordinary Portland cement conforming to IS:269, Portland slag cement conforming to IS:455 respectively can be used under special circumstances. Cement used in all concrete mixes shall be in general of grade 33/43 unless design requires a higher grade. Ordinary Portland cement shall be used for following structure.

a) TG foundation top deck and sub structures including raft.

b) Spring Supporting decks of all machine foundations.

c) Structures requiring grade of concrete of M30 and above.

In special cases, Rapid Hardening Portland Cement, Low Heat Cement, Sulphate resistant cement, high strength Ordinary Portland Cement etc. may be permitted or directed to be used by the Engineer.
For Brickwork, plaster, flooring and other finishing works, ordinary Portland cement of 33/43 grade shall be used.

2.05.03 Coarse Aggregate

Aggregate of sizes ranging between 4.75 mm and 150 mm will be termed as

Coarse Aggregate. Coarse aggregate for concrete shall be chemically inert, hard, strong durable against weathering, of limited porosity, and free from deleterious materials. It shall be properly graded. Coarse aggregates shall be either crushed gravel or stone. All aggregates shall meet the requirement of IS:383:1970. Only Coarse Aggregate from, approved quarries and conforming to IS-383 will be allowed to be used on the works. Petrographic test shall be carried out by the contractor free of cost for checking the quality of rock from quarry. This test shall be repeated by the Contractor free of cost for change in quarry or as directed by the Engineer. The results shall be checked for reactivity of silica in aggregate with alkalis of cement.

2.05.04 Fine Aggregate

Aggregate smaller than 4.75 mm and within the grading limits and other requirements set in IS: 383 are termed as Fine Aggregate or Sand. Only Fine Aggregate from approved sources and conforming to the above IS Specification will be allowed to be used in works. Sand shall be hard, durable, clean and free from adherent coatings or organic matter and clay balls or pellets. Sand when used as fine aggregate in concrete shall conform to IS:383. For plaster, it shall conform to IS:1542 and for masonry work to IS:2116.

2.05.05 Water

Water for use in Concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts, or other impurities. Generally, IS: 3550 will be followed for routine tests. Acceptance of water shall be as per IS: 456.

2.05.06 Admixture

Only admixtures of approved quality will be used when directed or permitted by the Engineer. The different types of admixtures, which may be necessary to satisfy the concrete mix and the design requirement, shall be as per IS-9103 and may be one of the followings:

a) Accelerating admixture

b) Retarding admixture

c) Water reducing admixture

d) Air entraining admixture

e) Water proofing admixture

The contractor shall inform the Engineer about the type of admixture which he is planning to use in different areas within the scope of work for the approval

of the Engineer. The admixture shall be of proven make and from a reputed manufacturer. It should not have any adverse effect on strength, durability of concrete and reinforcement. Super plasticizers conforming to IS: 9103 or ASTMC-494 shall only be used as admixture having the above properties either individually or in a combination as per the direction of the Engineer.

2.05.07 Reinforcement

Reinforcement shall be as per relevant IS Specification as mentioned in the Contract/Drawing/Instructions. All bars shall be of tested quality.

2.06.00 Storage of Materials

2.06.01 General

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for concrete and shall be removed from site immediately, failing which, the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The Contractor shall maintain upto-date accounts of receipt, issue and balance (stack wise) of all materials. Storage of materials shall conform to IS: 4082.

2.06.02 Cement

Sufficient space for storage, with open passages between stacks, shall be arranged by the Contractor to the satisfaction of the Engineer.

Cement shall be stored off the ground in dry, leak proof, well-ventilated warehouses at the works in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter.

Cement shall be stored in easily countable stacks with consignment identification marks. Consignments shall be used in the order of their receipts at site. Sub-standard or partly set cement shall not be used and shall be removed from the site, with the knowledge of the Engineer, as soon as it is detected.

2.06.03 Aggregates

Aggregates shall be stored on raised surface constructed by providing planks or steel plates or on concrete or brick masonry pavement. Each size shall be kept separated with wooden or steel or concrete or masonry bulkheads or in separate stacks and sufficient care shall be taken to prevent the material at the

edges of the stock piles from getting intermixed. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths as may be directed by the Engineer.

2.06.04 Reinforcement

Reinforcing steel shall be stored consignment-wise and size-wise off the ground and under cover, if desired by the Engineer. It shall be protected from rusting, oil, grease, and distortions.

If necessary, the reinforcing steel may be coated with cement wash before stacking to prevent scale and rust at no extra cost to the Owner. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage.

2.07.00 Quality Control

Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The quality control operation shall include but not be limited to the following items of work:

a) Admixture:	Type, quantity, physical, and chemical properties that affects strength, workability, and durability of concrete. For air entraining admixtures, dosage to be adjusted to maintain air contents within desirable limits.
b) Aggregate:	Physical, chemical and mineralogical qualities. Grading, moisture content and impurities.
c) Water:	Impurities tests.
d) Cement:	Tests to satisfy relevant IS Specifications.
e) Formwork:	Material, shapes, dimensions, lines, elevations, surface finish, adequacy of form, ties, bracing and shoring and coating.
f) Reinforcement:	Shapes, dimensions, length of splices, clearances, ties and supports. Quality and requirement of welded splices.

		Material tests or Certificates to satisfy relevant IS Specification.
	g) Grades of Concrete:	Usage and mix design, testing of all properties.
	h) Batching & Mixing:	Types and capacity of plant, concrete mixers and transportation equipment.
	i) Joints:	Locations of joints, water stops and filler materials. Dimension of joints, quality, and shape of joint material and splices.
	j) Embedded and Anchorage Items:	Material, shape, location, setting.
	k) Placing:	Preparation, rate of pouring, weather limitations, time intervals between mixing and placing and between two successive lifts, covering over dry or wet surfaces, cleaning and preparation of surfaces on which concrete is to be placed, application of mortar/slurry for proper bond, prevention of cold joint, types of chutes or conveyors.
	l) Compaction:	Number of vibrators, their prime mover, frequency and amplitude of vibration, diameter and weight of vibrators, duration of vibration, hand-spreading, rodding and tamping.
	m) Setting of base & Bearing plates:	Lines, elevations, and bedding mortar.
	n) Concrete Finishes:	Repairs of surface defects, screening, floating, steel trowelling and brooming, special finishes.
	o) Curing:	Methods and length of time.

Copies of records and tests for the items noted above, as well as, records of corrective action taken shall be submitted to the Engineer for approval as may be desired.

3.00.00 INSTALLATION

All installation requirements shall be in accordance with IS: 456 and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification do not

cover all the aspects to the full satisfaction of the Engineer.

3.01.00 Washing and Screening of Aggregates

Washing and screening of coarse and fine aggregates to remove fines, dirt, or other deleterious materials shall be carried out by approved means as desired by the Engineer.

3.02.00 Admixture

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete. Admixtures including plasticisers of approved make may be used with the Engineer's approval in accordance with IS-456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Engineer reserves the right to require laboratory test or use test data, or owner satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacturer's directions and/or as directed by the Engineer.

3.03.00 Grades of Concrete

Concrete shall be in one of the grades designated in IS: 456. Grade of concrete to be used in different parts of work shall be as shown on the drawing. In case of liquid retaining structures, IS: 3370 will be followed. Minimum cement content shall be as per IS: 456.

3.04.00 Proportioning and Works Control

3.04.01 General

"Design Mix Concrete" and "Nominal Mix Design" is defined as follows for use in this specification:

a) Proportioning of ingredients of concrete made with preliminary tests by designing the concrete mix. Such concrete shall be called "Design Mix Concrete".

b) Proportioning of ingredients of concrete made without preliminary tests adopting nominal concrete mix. Such concrete shall be called "Nominal Mix Concrete".

As far as possible, design mix concrete shall be used on all concrete works. Nominal mix concrete, in grades M-15 or lower only may be used if shown on drawings or approved by the Engineer. In all cases the Proportioning of ingredients and works control shall be in accordance with IS: 456 and shall be

adopted for use after the Engineer is satisfied regarding its adequacy and after obtaining his approval in writing.

3.04.02 Mix Design Criteria

Concrete mixes will be designed by the Contractor to achieve the strength, durability, and workability necessary for the job, by the most economical use of the various ingredients. In general, the design will keep in view the following considerations

a) Consistent with the various other requirements of the mix, the quantity of water should be kept at the lowest possible level.

b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.

c) The various fractions of coarse and fine aggregates should be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.

d) The finished concrete should have adequate durability in all condition, to withstand satisfactorily the weather and other destruction agencies, which it is expected to be subjected to in actual service.

e) The mix design shall have required workability and characteristic strength as per IS: 456. The quantity of cement, aggregates, and admixtures shall be determined by mass.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete in structural design. The Contractor will strictly abide by the same in his design of concrete mix installation. Various trials shall be given by the contractor with specific cement content on each trial. In some cases, plasticizers and other admixtures may be necessary to achieve the desired results.

3.05.00 Strength Requirements

The strength requirements of both design mix and nominal mix concrete where ordinary Portland Cement or Portland Blast furnace slag cement is used, shall be as per IS:456. All other relevant clauses of IS:456 shall also apply.

3.06.00 Minimum Cement Content

The minimum cement content for each grade of concrete shall be as per IS: 456. Contractor has to consider actual environmental exposure condition at

site. Based on various tests results and as per Engineer, the environment condition shall be adopted for which minimum cement content shall be considered. No extra payment shall be made on account of any variation in environment condition.

a) Sufficient number of trial mixes (to be decided by the Engineer) will be taken at the laboratory for the various designs and graphs of w/c ratio Vs crushing strengths at various ages will be plotted.

b) All tests will be done in presence of the Engineer who shall be the final authority to decide upon the adoption of any revised minimum cement content. The Contractor will always be responsible to produce quality concrete of the required grade as per the acceptance criteria of IS: 456.

c) The Engineer will always have the unquestionable right to revise the minimum cement content as decided above, if, in his opinion, there is any chance of deterioration of quality on account of use of lower cement content or any other reason.

3.07.00 Water-Cement Ratio

The choice of water-cement ratio in designing a concrete mix will depend on:-

a) The requirement of strength.

b) The requirement of durability.

3.07.01 Strength Requirement

In case of "Design Mix Concrete" the water-cement ratio of such value as to give acceptable test results as per IS: 456, will be selected by trial and error. The values of water-cement ratios for different grade and mix designs will have to be established after conducting sufficiently large number of preliminary tests in the laboratory to the satisfaction of the Engineer. Frequent checks on test will have to be carried out and the water-cement ratios will be revised if the tests produce unsatisfactory results. Notwithstanding anything stated above the Contractor's responsibility to produce satisfactory test results and to bear all the consequences in case of default remains unaltered.

In case of nominal mix concrete, the maximum water-cement ratio for different grades of concrete is specified in Table-5 of IS: 456 and no tests are necessary. The acceptance test criterion for nominal mix concrete shall be as per IS: 456.

3.07.02 Durability Requirement

Tables 4 & 5 of IS: 456 give the maximum water-cement ratio permissible from the point of view of durability of concrete subjected to adverse exposure to weather, sulphate attacks, and contact with harmful chemicals. Impermeability may also be an important consideration.

Whenever the water-cement ratio dictated by Durability consideration is lower than that required from strength criteria, the former should be adopted.

In general the water cement ratio between 0.4 and 0.45 will be desirable to satisfy the durability requirement and from the consideration of impermeability of concrete. The contractor may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer/super-plasticizer. Trial mix shall be carried out accordingly. However, the contractor has to propose specifically along with field trials in the event of lower cement content if found suitable along with a plasticizer.

3.08.00 Workability

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments and to give the required surface finish shall depend*on the type and nature of structure and shall be based on experience and tests. The usual limits of consistency for various types of structures are given below:

TABLE-V

LIMITS OF CONSISTENCY

Degree of	Slump in mm with Standard Cone as	Use for which concrete is suitable

workability	per IS: 1199		
	Min.	Max.	
Very low	0	25	Large Mass concrete structure with heavy compaction equipments, roads
Low	25	50	Uncongested wide and shallow R.C.C. structures
Medium	50	100	Deep but wide R.C.C. structures with congestion of reinforcement and inserts
High	100	150	Very narrow and deep R.C.C. structures with congestion due to reinforcement and inserts.

Note: Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer.

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. No extra payment will be made for this additional cement.

The workability of concrete shall be checked at frequent intervals by slump tests.

3.09.00 Size of coarse Aggregates

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer

Very narrow space	- 12 mm
Reinforced concrete Except foundation	- 20 mm
Ordinary Plain concrete and Reinforced concrete foundations	- 40 mm
Mass concrete	- 80 mm

Lean concrete - 40 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the specified proportions, strength and consistency that will work readily into position without segregation.

Coarse aggregate will normally be separated into the following sizes and stacked separately in properly designed stockpiles

80 mm to 40 mm, 40 mm to 20 mm and 20 mm to 5 mm. In certain cases it may be necessary to further split the 20 mm to 5 mm fraction into 20 mm to 10 mm and 10 mm to 5 mm fractions.

This separation of aggregates in different size fractions is necessary so that they may be remixed in the desired proportion to arrive at a correct internal grading to produce the best mix.

3.09.01 Temperature control of concrete in top decks of machine foundations (i.e. of TGs, BFPs, Fans and Mills) as extra payable over RCC item of BOQ:

The temperature of fresh concrete shall not exceed 23°C when placed. A suitable measuring device for measuring the temperature of concrete as approved by the Engineer shall be used. For maintaining the limiting temperature of the 23°C, crushed ice shall be used as mixing water. The ice shall be formed of water conforming IS: 456. The Contractor shall establish the quantity of crushed ice to be mixed in order to achieve the limiting temperature of 23°C.

3.09.02 Base raft of Turbo Generator foundations and top decks of all machine foundations shall be cast in a continuous operation without any construction joint.

3.10.00 Mixing of Concrete

Ingredients of the concrete mix shall be measured by weight. Concrete shall always be mixed in mechanical mixer. Water shall not normally be charged into the drum of the mixer until all the cement and aggregates constituting the batch are already in the drum and mixed for at least one minute. Mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall mixing be done for less than 2 (two) minutes and at least 40 (forty) revolutions after all the materials and water are in the drum. When absorbent Aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Engineer. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing.

The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned & when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner to allow for loss in the drum.

Regular checks on mixer efficiency shall be carried out as directed by the Engineer as per IS: 4634 on all mixers employed at site only those mixers whose efficiencies are within the tolerances specified in IS: 1791 will be allowed to be employed.

Batching Plant shall conform to IS: 4925. The measuring gauges of batching plant shall be periodically calibrated for which the contractor shall provide standard weights. The accuracy of all gauges shall be within limits prescribed by the Engineer.

When hand mixing is permitted by the Engineer, for unimportant out of the way locations in small quantities, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand-mixing, 10% extra cement shall be added to each batch at no extra cost to the owner.

3.11.00 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and compacted in the final position before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation or loss of any of the ingredients. For long distance haulage, agitator cars of approved design will be used. If, in-spite of all precautions, segregations does occur during transport, the concrete shall be properly re-mixed before placement. During very hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers, which will reduce the rate of loss of water, by evaporation or loss of heat. If necessary, the container may have to be covered and insulated. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before, commencement of concrete mixing. Such equipments shall be kept free from set concrete.

3.12.00 Placing and Compacting Concrete

Where specifically covered, the relevant I.S. Code will be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in relevant I.S. code for any particular aspect of work, any other standard code of practice, as may be specified by the Engineer, will be

adopted. Concrete may have to be placed against the following types of surfaces:

a) Earth foundation

b) Rock foundation

c) Formwork

d) Construction joint in concrete or masonry

The surface on or against which concrete is to be placed has to be cleaned thoroughly. Rock or old construction joint has to be roughened by wire brushing, chipping, sand blasting or any other approved means for proper bond. All cuttings, dirt, oil, foreign and deleterious material, laitance, etc. are to be removed by air water jetting or water at high pressure. Earth foundation on which direct placement of concrete is allowed, will be consolidated as directed by the Engineer such that it does not crumble and get mixed up with the concrete during or after placement, before it has sufficiently set and hardened.

Formwork, reinforcement, preparation of surface, embedments, joint seals etc., shall be approved in writing by the Engineer before concrete is placed. As far as possible, concrete shall be placed in the formwork by means approved by the Engineer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1500 mm shall have to be approved by the Engineer.

Rock foundation or construction joint will be kept moist for at least 72 hours prior to placement. Concrete will be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution, as directed by the Engineer will have to be adopted.

Formwork will be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.

A layer of mortar of thickness 12 mm of the same or less w/c ratio and the same proportion as that of the concrete being placed or cement slurry will be spread thoroughly on the rock Foundation or construction joint just prior to placement of concrete.

After concrete has been placed, it shall be spread, if necessary & thoroughly compacted by approved mechanical vibration to maximum, subsidence without segregation and thoroughly worked around shape. Vibrators shall not be used for pushing concrete into adjoining areas. Vibrators must be operated by experienced workmen and the work carried out as per relevant IS Code of

Practice: In thin members with heavy congestion of reinforcement or other embedments, where effective use of internal vibrator is, in the opinion of the Engineer, doubtful, in addition to immersion vibrators the contractor may have to employ form vibrators conforming to IS: 4656. For slabs and other similar structures, the contractor will additionally employ screed vibrator as per IS: 2506. Hand tamping may be allowed in rare cases, subject to the approval of the Engineer. Care must be taken to ensure that the inserts, fixtures, reinforcement, and formwork are not displaced or distorted during placing & consolidation of concrete.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green Concrete, which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete.

Slabs, beams, and similar members shall be poured in one operation, unless otherwise instructed by the Engineer. Mouldings, throating, drip course, etc., shall be poured as shown on the drawings or as directed by the Engineer. Holes shall be provided and bolts, sleeves, anchors, fastenings, or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Engineer. Any deviation there from shall be set right by the Contractor at his own expense as instructed by the Engineer.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same -at the Contractor's expense.

The Engineer shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position, it shall not be distributed.

3.13.00 Construction Joints and Cold Joints

3.13.01 Construction Joints

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete certain predetermined stages. These joints will be formed in a manner specified in the drawings/Instruction.

Vertical construction joints will be made with rigid stop-board forms having slots for allowing passage of reinforcement rods and any other embedments and fixtures that may be shown. Next stage concrete shall be placed against construction joint as per clause 3.12.

Where the location of the joints are not specified, it will be in accordance with the following:

a) In a column, the joint shall be formed 75 mm below the lowest soffit of the beam framing into it.

b) Concrete in a beam shall preferably be placed without a joint, but if Provision of a joint is unavoidable, the joint shall be vertical and at the middle of the span.

c) A joint in a suspended floor slab shall be vertical and at the middle of the span and at right angles to the principal reinforcement.

d) Feather-edges in concrete shall be avoided while forming a joint.

e) A construction joint should preferably be placed in a low-stress zone and at right angles to the direction of the principal stress.

f) In case the Contractor proposes to have a construction joint anywhere to facilitate his work, the proposal should be submitted well in advance to the Engineer for study and approval without which no construction joint will be allowed.

3.13.02 Cold Joint

An advancing face of a concrete pour, which could not be covered by fresh concrete before expiry of initial setting time (due to an unscheduled stoppage or delay on account of breakdown in plant, inclement weather, low rate of placement or any other reason), is called a cold joint. The Contractor should always remain vigilant to avoid cold joints.

If, however, a cold joint is formed due to unavoidable reasons, the following procedure shall be adopted for treating it:

a) If the concrete is so green that it can be removed manually and if vibrators

can penetrate the surface without much effort, fresh concrete can be placed directly against the old surface. The old concrete should be covered by fresh concrete as quickly as possible and the joint thoroughly and systematically vibrated.

b) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface will be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. A rich mortar layer 12 *mm* in thickness, will be placed on the cold joint fresh concrete shall be placed on the mortar layer and the joint will be thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not raise inspite of extensive vibration, the joint, will be left to harden for at least 12 - 24 hrs. It Will then be treated as a regular construction joint, after cutting the concrete to required shape and preparing the surface as described under clause 3.12.

3.14.00 Repairs, Finishes, and Treatment of Concrete surfaces

3.14.01 Adequate and sound concrete surfaces, whether formed or unformed, can be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing, and consolidation by experienced workmen.

Unsound concrete resulting from improper mix design, incompetent methods, equipment and formwork, poor workmanship and protection will not be accepted and will have to be dismantled, removed and replaced by sound concrete at the Contractor's cost. The Engineer may, at his sole discretion, allow to retain concrete with minor defects provided the Contractor is able to repair it by approved methods at no extra cost to the Owner, All concrete work shall be inspected by the Contractor immediately after the forms are removed & he will promptly report occurrence of any defects to the Engineer. All repair works will be carried out as per the instructions and in the presence of the Engineer or his representative. Generally, repair work will consist of any or all of the following operations:

a) Sack rubbing with mortar and stoning with carborundum stone.

b) Cutting away the defective concrete to the required depth shape.

c) Cleaning of reinforcement & embedments. It may be necessary to provide an anti-corrosive coating on the reinforcement.

d) Roughening by sand blasting or chipping.

e) Installing additional reinforcement/welded mesh fabric.

f) Dry packing with stiff mortar.

g) Plastering, guniting, shotcreting etc.

h) Placing and compacting concrete in the void left by cutting out defective concrete.

i) Grouting with cement sand slurry of 1:1 mix.

j) Repairing with a suitable mortar either cement or resin modified mortars.

k) Polymer modified patching and adhesive repair& mortar for beams & columns.

3.14.02 Finishing unformed Surface

The contractor shall provide normal finishes in unformed surfaces which can be achieved by screeding, floating, trowelling etc. A few typical and common cases of treatment of concrete surface are cited below

a) Floor

Whenever a non-integral floor finish is indicated, the surface of reinforced concrete slab shall be struck off at the specified levels and slopes and shall be finished with a wooden float fairly smooth removing all laitance. No over trowelling, to obtain a very smooth surface, shall be done, as it will prevent adequate bond with the subsequent finish. If desired by the Engineer, the surface shall be scored and marked to provide better bond.

Where monolithic finish is specified or required, concrete shall be compacted and struck off at the specified levels and slopes with a screed, preferably a vibrating type and then floated with a wooden float. Steel trowelling is then started after the moisture film and shine have disappeared from the surface and after the concrete has hardened enough to prevent excess of fines and water to rise to the surface but not hard enough to prevent proper finishing of aberrations. Steel trowelling properly done will flatten and smoothen sandy surface left by wooden floats and produce a dense surface free from blemishes, ripples, and trowel marks.

A fine textured surface that is not slick and can be used where there is likelihood of spillage of oil or water can be obtained by trowelling the surface lightly with a circular motion after initial trowelling keeping the steel trowel flat on the surface.

To provide a better grip the Engineer may instruct marking the floor in a regular geometric pattern after initial trowelling.

b) Beans, Columns & Walls

If on such or any other concrete structure it is intended to apply plaster or such concrete surfaces against which brickwork or other allied works are to be built, the Contractor shall hack the surface adequately as soon as the form is stripped off so that proper bond can develop. Pattern, adequacy, and details of such hacking shall meet with the approval of the Engineer, who shall be informed to inspect such surfaces before they are covered up.

3.15.00 Protection and Curing of concrete

Newly placed concrete shall be protected by approved means from rain, sun, and wind. Concrete placed below the ground level shall be protected against contamination from falling earth during and after placing. Concrete placed in ground containing deleterious substances, shall be protected from contact with such ground, or with water draining from such ground, during placing of concrete and for a period of at least three days, or as otherwise instructed by the Engineer. The ground water around newly poured concrete shall be kept to an approved level by pumping out or other adequate means of drainage to prevent floatation or flooding. Steps, as approved by the Engineer, shall be taken to protect immature concrete from damage by debris, excessive 'Loadings, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently, it shall be covered either with sand, hessian, canvas, or similar materials and kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water will be allowed if the Engineer is satisfied with the adequacy of the arrangements made by the Contractor. Quality of water for curing shall be as per IS: 456.

If permitted by the Engineer, liquid curing compound may be used for prevention of premature water loss in concrete and thereby effecting curing of concrete. This type of curing compound shall be sprayed on newly laid concrete surfaces to form a thin film barrier against premature water loss without disturbances to normal setting action. The curing compound shall be emulsified paraffin based and shall comply with ASTM requirements for acceptance.

The curing compound shall be applied following the final finishing operation and immediately after disappearance of water from concrete surface. It is important not to apply the curing compound when standing water is still present on concrete.

The contractor shall arrange for the manufacturer's supervision at no extra cost.

The Contractor shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. The Engineer's decision regarding the adequacy of curing is final. In case the Engineer notices any lapse on the part of the Contractor, he will inform the Contractor or his supervisor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the Contractor within 3 (three) hours of issuance of such instruction, the Engineer will be at liberty either to employ sufficient means through any agency to make good the deficiency and recover the cost thereof from the Contractor, or deduct certain amount from contractor's payment for the part where inadequate curing was noticed entirely at the discretion of the Engineer.

3.16.00 Reinforcement

Mild steel round bars, TMT bars, Hot rolled deformed bars or cold twisted deformed bars as medium tensile or high yield strength steel, plain hard drawn steel wire fabric etc, will be used as reinforcement as per drawings and directions. In an aggressive environment an anti-corrosive coating on the reinforcement may be provided as per IS: 9077, as shown on the drawing or as directed by the Engineer.

3.16.01 Bar Bending Schedules

The Contractor shall prepare **optimized** Bar Bending Schedules showing clearly the arrangements proposed by the Contractor to match available stock of reinforcing steel, progressively, starting within one week of receipt of approval on corresponding design of RCC structure. As decided by the Engineer, some or all the detailed drawings and schedules will have to be submitted for approval. Approval of such detailed drawings by the Engineer shall not relieve the Contractor of his responsibility for correctness nor of any of his obligations to meet the other requirements of the contract. The contractor for record and distribution shall submit six prints of the final drawings & schedules with one reproducible print.

3.16.02 Cleaning

All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

3.16.03 Bending

Unless otherwise specified, reinforcing steel shall be bent in accordance with the procedure specified in IS: 2502 or as approved by the Engineer. Bends and shapes shall comply strictly with the dimensions corresponding with the

final Bar Bending Schedules. Bar Bending Schedules shall be rechecked by the Contractor before any cutting, bending is done.

No reinforcement shall be bent when already in position in the work, without approval of the Engineer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Engineer. Reinforcing bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved. Bending hot at a cherry-red heat (not exceeding 845°C) may be allowed under very exceptional circumstances except for bars whose strength depends on cold working. Bars bent hot shall not be cooled by quenching.

3.16.04 Placing in Position

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings by such approved and adequate means like mild steel chairs and/or concrete spacer blocks. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by No. 20 G annealed soft iron wire or by tack welding in case of Bar larger than 25 mm dia., as may be directed by the Engineer. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be spaced such that the main bars do not sag perceptibly between adjacent spacers. Before actual placing, the Contractor shall study the drawings thoroughly and inform the Engineer in case he feels that placement of certain bars is not possible due to congestion. In such cases he should not start placing any bar before obtaining clearance from the Engineer.

3.16.05 Welding / Coupler for Splicing

Lapping shall normally do splicing of reinforcement. For M.S. reinforcement bars, butt-welding may be done, if permitted by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction as per IS: 2751 and IS: 456. For High yield strength deformed bars, lap welding may be done, if permitted by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian Standards as per IS: 9417. Welding of High yield strength deformed bar shall not be allowed.

Splicing of reinforcement using mechanical coupler may be done, if permitted by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian standards for "Reinforcement couplers for mechanical splices of bars in concrete" as per IS: 16172. Corrosion test in the coupler-bar connections exposed to marine or

severe environmental conditions to rule out any risk of galvanic corrosion will be done by the contractor at no extra cost. Proper fitting & fixing of mechanical coupler to rebar shall be ensured at site for each coupled joint as per inspection testing plan developed at site in consultation with manufacturer of coupler. If so required at site, coupler/ threading on rebar shall be such that two bars can be coupled by moving couplers not rebar (as being heavy reinforcement weight and L shaped, it is not feasible to rotate the rebar for fixing up the coupler) at no extra cost.

3.16.06 Control

The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be examined by the Engineer for accuracy of placement and cleanliness. Necessary corrections as directed by him shall be carried out. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS: 456, unless otherwise specified. The laps shall be staggered as far as practicable and as directed by the Engineer. Arrangements for placing concrete shall be such that reinforcement in position does not have to bear extra load and get disturbed. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Engineer. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar not leaner than 1 (one) part cement to 2 (two) parts sand by –volume and cured in a pond for at least 14 (fourteen) days. The type, shape, size and location of the concrete blocks shall be as approved by the Engineer.

3.17.00 Cold Weather Concreting

When conditions are such that the ambient temperature may be expected to be 5°C or below during the placing and curing period, the work shall conform to the requirement of IS: 456 and IS: 7861.

3.18.00 Hot Weather Concreting

When depositing concrete in very hot weather, the Contractor shall take all precautions as per IS: 7861 and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 38°C while placing. Positive temperature control by precooling, post cooling or any other method, if required, will have to be done by the contractor at no extra cost.

3.19.00 Concreting under water

When it is necessary to deposit concrete under water it shall be done in accordance with the requirements of IS: 456.

3.20.00 Form Work

3.20.01 General

If it is so desired by the Engineer, the contractor shall prepare, before commencement of actual work, designs and working drawings for formwork and centring and get them approved by the Engineer. The formwork shall conform to the shape, grade, lines, levels and dimensions as shown on the drawings.

Materials used for the formwork inclusive of the supports and centring shall be capable of withstanding the working load and remain undistorted throughout the period it is left in service. All supports and scaffolds should be manufactured from structural or tubular steel except when specifically permitted otherwise by the Engineer.

The centring shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rakers are to be used where forms are to support inclined members. The forms shall be sufficiently strong to carry without undue deformation, the dead weight and horizontal pressure of the concrete as a liquid as well as the working load. In case the contractor wishes to adopt any other design criteria, he has to convince the Engineer about its acceptability before adopting it. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of slurry or mortar.

To achieve the desired rigidity, tie bolts, spacer blocks, tie wires and clamps as approved by the Engineer shall be used but they must in no way impair the strength of concrete or cause stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel and concrete of adequate strength shall be used. Bolts passing completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork shall not be used.

The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Engineer immediately and rectified as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion-resistant devices. Rigid care shall be exercised in ensuring that all column forms are in true plumb and thoroughly cross-braced to keep them so. All floor and beam centring shall be crowned

not less than 8 mm in all directions for every 5 metres span. The formwork should lap and be secured sufficiently at the lift joints to prevent bulges and offsets.

Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base vertical forms and at other places, where they are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed when required, during pouring operations without leaving any mark on the concrete.

3.20.02 Cleaning and Treatment of Forms

All parts of the forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish, loose concrete, chippings, shavings, sawdust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Compressed air jet and/or water jet along with wire brushes brooms etc. shall be used for cleaning. The inside surface of the formwork shall be treated with approved non-staining oil or other compound before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork. The oiling of the formwork will be inspected just prior to placement of concrete and redone wherever necessary.

3.20.03 Design

The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns, and walls are independent of the soffits of beams and can be removed without any strain to the concrete already placed or affecting the remaining formwork.

Removing any props or repropping shall not be done except with the specific approval of the Engineer. If formwork for column is erected for the full height of the column, one side shall be left open and built up in sections, as placing of concrete progress. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment and alignment of the formwork and to allow it to be removed gradually without jarring the concrete.

3.20.04 Inspection of Forms

Casting of' Concrete shall start only after the formwork has been inspected and approved by the Engineer. The concreting shall start as early as possible within 3 (three) days after the approval of the formwork and during this period the formwork shall be kept under constant vigilance against any interference. In case of delay beyond three days, a fresh approval from the Engineer shall be obtained.

3.20.05 Removal of Forms

Formwork shall be kept in position after casting of concrete for a minimum period as mentioned in IS: 456, however the period of retaining form in position can be extended as per drawing, instruction of Engineer or as required for satisfactory completion of work without any extra cost. Before removing any formwork, the Contractor must notify the Engineer well in advance to enable him to inspect the concrete if the Engineer so desires.

The Contractor shall record on the drawing or in any other approved manner, the date on which concrete is placed in each part of the work and the date on which the formwork is removed there from and have this record checked and countersigned by the Engineer regularly. The Contractor shall be responsible for the safe removal of the formwork and any work showing signs of damage through premature removal of formwork or loading shall be rejected and entirely reconstructed by him without any extra cost to the Owner, The Engineer may, however, instruct to postpone the removal of formwork if he considers it necessary.

If any other type of cement other than ordinary Portland cement and Rapid hardening cement is used, the time of removal of forms shall be revised such that the strength of this cement at the time of removal of forms match with strength of Portland cement at the time of removal of form.

3.20.06 Tolerance

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as shown on the drawings subject to the following tolerances unless otherwise specified in this specification or drawings or directed by the Engineer:-

For - a) Sectional dimension - ± 5 mm
b) Plumb - 1 in 1000 of height
c) Levels - ± 3 mm before any deflection has taken place

The tolerance given above are specified for local aberrations in .the finished concrete surface & should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Any error, within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

3.20.07 Re-use of Forms

Before re-use, all forms shall be thoroughly scraped, cleaned, joints and planes examined and when necessary repaired, and inside surface treated as specified hereinbefore. Formwork shall not be used/re-used if declared unfit or unserviceable by the Engineer.

3.20.08 Classification

Generally, the "ordinary" class formwork shall be used unless otherwise specified.

a) **Ordinary:** These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) **Plywood:** These shall be used in exposed surfaces, where specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. Re-use may only be permitted after special inspection and approval by the Engineer. He may also permit utilization of used plywood for the "ordinary" class, if it is still in good condition.

c) **Ornamental:** These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

3.21.00 Opening, Chases, Grooves, Rebates, Blockouts etc.

The Contractor shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings or as specified by the Engineer.

3.22.00 Anchor Bolts, Anchors, Sleeves, Inserts, Hangers/Conduits/Pipe and other misc. Embedded Fixtures

The Contractor shall build into concrete work all the items noted below and shall embed them partly or fully as shown on drawings and secure the same as may be required. The materials shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Engineer. Exposed surfaces of embedded materials are to paint with one coat of approved anti- corrosive paint and/or bituminous paint without any extra cost to the Owner. If welding is to be done subsequently on the exposed surface of embedded material, the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be

required or directed by the Engineer.

Items to be embedded

a) Inserts, hangers, anchors, frame around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.

b) Anchor bolts and plates for machinery, equipment and for structural steel work.

c) Steel structurals to be left embedded for future extension, special connection etc.

d) Dowel bars, etc. for concrete work falling under the scope of other contractors.

e) Lugs or plugs for door and window frames occurring in concrete work.

f) Flashing and jointing in concrete work.

g) Any misc. embedments and fixture as may be required.

Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.

3.23.00 Expansion and Isolation Joints

3.23.01 General

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Engineer. All materials are to be procured from reliable manufacturers and must have the approval of the Engineer. Where it is the responsibility of the Contractor to supply the material, the Engineer may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory free of cost to the Owner. Joints shall be formed true to line, level, shape, dimension, and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Engineer before starting the work.

3.23.02 Bitumen Board/ Expanded Polystyrene Board

a) Bitumen Board

Bitumen impregnated fibreboard of approved manufacturer as per IS: 1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

b) Expanded Polystyrene Boards

If required, commercial quality of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Engineer. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of Bitumen paint may have to be applied on the board against which concrete will be placed.

3.23.03 Joint sealing strips

Joint sealing strips may be provided at the construction, expansion, and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure. The sealing strips will be either metallic like G.I., Aluminums, or Copper, or non-metallic like rubber or P.V.C.

Sealing strips will not have any longitudinal joint and will be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Engineer. The Contractor is to supply all labour and material for installation -including the material and tools required for jointing, testing, protection, etc. If desired by the Engineer, joints in rubber seals may have to be vulcanized.

a) Metal Sealing Strips

Metal sealing strips shall be either G.I., Aluminium or Copper and formed straight, U shaped, Z shaped or any other shape and of thickness as indicated in the drawing. The transverse joints will be gas welded using brass rods and approved flux and will be tested by an approved method to

establish that it is leak proof. If required, longer lap lengths and different method of brazing which will render it leak proof, will be adopted by the Contractor. The edges shall be neatly crimped and bent to ensure proper bond with the concrete.

i) G.I. Strips

G.I. strips shall be minimum 1.5 mm thick and 150 mm in width unless specified otherwise. The standard of Galvanizing shall be as per relevant Indian Standards for heavy-duty work. At the joints, the overlapping should be for a minimum length of 50 mm.

ii) Aluminium Strips

Aluminium strips shall be minimum 18 SWG thick and 300 mm wide unless specified otherwise and shall conform to IS: 737 of 19000 grades or 31000 grade (Designation as per IS: 6051). A minimum lap of 50 mm length is required at the joints.

iii) Copper Strips

The Copper strips shall be minimum 18 SWC in thickness and 300 mm width unless specified otherwise and shall conform to the relevant Indian Standards. It should be cleaned thoroughly before use to expose fresh surface, without any reduction in gauge. A minimum lap of 50 mm in length is required at the joints.

b) Non-metallic Sealing Strips

These will be normally in Rubber or P.V.C. Rubber or P.V.C. joint seals can be of shape having any combination of the following features:

i) Plain

ii) Central bulb

iii) Dumb-bell or flattened ends

iv) Ribbed and Corrugated Wings

v) V shaped

As these types of seals can be easily handled in very large lengths unlike metal strips, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer. The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or as approved by the Engineer taking particular care to match the

central bulbs & the edges accurately.

c) Rubber Sealing Strips

The minimum thickness of Rubber sealing strips shall be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings or as directed by the Engineer. The material will be natural rubber and be resistant to corrosion, abrasion, and tear and also to attacks from the acids, alkalis and chemicals normally encountered in service. The physical properties will be generally as follows. The actual requirements may be slightly different as decided by the Engineer:

Specific Gravity	:	1.1 to 1.15
Shore Hardness	:	65A to 75A
Tensile Strength	:	25 - 30 N/Sq.mm
Maximum Safe Continuous Temperature	:	75°C
Ultimate Elongation	:	Not less than 350%

b) P.V.C., Sealing Strips

The minimum thickness of P.V.C. sealing strips will be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings or as directed by the Engineer. The material should be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion, and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows. The actual requirements, which will be directed by the Engineer, may vary slightly

Specific Gravity	:	1.3 to 1.35
Shore Hardness	:	60A to SOA
Tensile Strength	:	10 - 15 N/Sq.mm
Maximum Safe Continuous Temperature	:	70 Deg.C
Ultimate Elongation	:	Not less than 275%

3.23.04 Bitumen Compound

When shown in drawing or directed, the gap in expansion joints shall be

thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS: 1834.

3.23.05 Isolation Joints

Strong and tough alkathene sheet or equivalent, about 1 mm in thickness and as approved by the Engineer shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

3.23.06 Pad

Hard foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings. The rubber shall have a unit weight of 1500 Kg/Cu.m, a shore hardness - 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

3.24.00 Grouting under Machinery or Structural Steel Bases

If required, grouting under base plates of machines or structural steel etc. shall be carried out by the Contractor. In general, the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Engineer, 6 mm down stone chips may have to be used in the mix. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. If specified on drawings, admixtures like Aluminium powder, "Ironite" etc. may have to be added with the grout in required proportions. Premixed non-shrink grout of approved manufacture having proper strength shall be used with Engineer's approval for important machineries.

3.25.00 Precast Concrete

The Specification for precast concrete will be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer, casting will have to be done on suitable vibrating table. The yard,

lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven) days of curing and can be removed for erection after 28 (twenty-eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal. The yard shall preferably be fenced.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling, and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials, and men to the Engineer for checking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as per drawings. If centrings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement: sand mortar where called for in the drawings.

3.26.00 Waterproofing of Concrete Structure

3.26.01 General

Where required, waterproofing of concrete structures shall be ensured internally by suitable design of the concrete mix, addition of suitable admixtures in the concrete or mortar at the time of mixing and/or installing water bars at the joints. In addition to the above measures, the structures shall be made watertight by adopting "structural waterproofing" as per specification. The design, material, and workmanship shall conform to the relevant I.S. Codes where applicable. The Engineer's approval of the materials shall be obtained by the Contractor before procurement. If desired by the Engineer, test certificates for the materials and samples shall be submitted by the Contractor free of charge. The materials shall be of best quality available indigenously, fresh clean and suitable for the duties called upon.

3.26.02 Water Bar/Seal/Special Treatment of Construction Joint

Water bearing structures and underground structures may have water bar/seals installed at the joints. They may be metallic, rubber, or P.V.C. The materials and installation will be as described under Clause 3.23.3. Construction joint shall be provided as per clause 3.13.1 with or without water bar/seal as shown

on the drawing. In case of water bars being used at the construction joint, fixing of the same has to be done carefully, so that the water bar is not disturbed during concreting. The construction joint shall also be treated by any one of the following methods.

Method 1: A surface retarder in the form of a thixotropic gel shall be applied on the joint surface of the previous pour in case of joint on the wall and in case of floor the same shall be applied on the formwork against which previous pour of concreting shall be done. The retarder may be liquid or paste form depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting. In case of walls, the above bonding agent will be mixed with water, which will be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer's specification. In case of floor joint, however, after washing of retarder a solvent free two-component epoxy resin-bonding agent will be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days

Compressive strength	-	55 to 60 N/Sq.mm
Flexural strength	-	5 to 30 N/sq.mm
Tensile strength	-	15 N/Sq.mm (approx.)
Bonding strength to concrete	-	3 N/Sq.mm (approx.)
Bonding strength to steel	-	20 N/Sq.m (approx.)

The whole operation shall be done as per manufacturers specification. The contractor shall provide manufacturer's supervision at no extra cost to the owner.

Method 2: One row of threaded nozzles at regular intervals not exceeding l.5 m centre to centre shall be placed in concrete along the construction joint during casting. Injection of cement water together with a suitable waterproof expanding grouting admixture of approved quality shall be done through the nozzles after the concrete has set to seal the voids in concrete near the construction joint in walls and slabs. The injection shall be done under pressure of approximately 2 to 4 kg/sq.cm. The nozzles shall be sealed off with suitable admixture after the injection is over. The whole operation shall be carried out as per manufacturer's specification and supervision. The cost of such manufacturer's supervision shall be borne by the contractor.

3.26.03 Waterproofing Admixtures

The waterproofing admixture for concrete and cement mortar/plaster shall conform to IS: 2645. The admixture shall not cause decrease of strength of concrete/plaster at any stage and it shall be free from chlorides and sulphates. The admixture shall not affect the setting time by more than 5%. The maximum permissible dosage of admixture will be 3% (three percent) by weight of cement, but a lower dosage will always be preferred. The product shall be stored in strong moisture proof packings. However, in case of important structures where M25 or higher grade concrete is specified, the use of melamine based, high range water reducing concrete admixture shall be used to provide a waterproof concrete, For achieving high strength concrete having cement content around 400 kg/cu.m. a melamine based super plasiticizer will be preferable.

a) In concrete: The admixtures shall be procured from reliable and reputed manufacturers and approved by the Engineer. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer. The Contractor shall have the services of the manufacturer's supervisor at no extra cost to supervise the work, if desired by the Engineer.

b) In Plaster: The concrete surface, to be plastered, shall be hacked to Engineer’s satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture and laid in appropriate thickness and in layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the Engineer. If desired by the Engineer, the Contractor shall have the work supervised by the manufacturer's supervisor at no extra cost. On completion, the Plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

3.26.04 Structural waterproofing

a) Nozzles spaced as required after the concrete is completed shall be drilled into surfaces to be rendered watertight. Non-shrink cement grout with waterproofing compound as per manufacturers specifications shall be injected under pressure to seal all voids. Special care shall be taken at joints by providing additional nozzles. The pressure grouting shall be done on the internal surface.

b) External Treatment

Two layers of (1:4) plaster of 12 mm thick each with waterproofing compound as per manufacturer's specification shall be provided on outer

surface of concrete underground structures.

3.26.05 Protective coating on Inside Surface.

Two coats of cement based two components polymer modified flexible protective and waterproofing slurry having 1 mm thick for each coat shall be applied on the walls/floor after proper surface preparation as mentioned above. The slurry shall be applied by brush.

3.26.06 Bitumen Felt: Application for Tanking

This specification shall cover laying the waterproof course on the outside and inside of the walls and bases of structures.

The materials shall conform to IS: 1322, and the workmanship to IS: 1609. The bitumen felt should be hessian base and/or fibre base as specified in Drawing. If required by the Engineer, tests as specified in relevant IS Codes shall be arranged by the Contractor without charging any extra to the Owner.

The Contractor shall execute this work in direct collaboration with one of the well-known specialized firm approved by the Engineer.

Cleaning the surface, keeping it dry, providing, necessary corner fillets and cement rendering and cutting chases, etc. shall be done as per drawings and/or instructions. If any protective brickwork on/against concrete sub-bases or walls are required, the same shall be provided. A twenty (20) years guarantee for satisfactory performances shall be given by the Contractor as well as his specialist sub-contractor jointly and severally, for this work. Free rectification of any defects noted in the work within this guarantee period will be carried out by the Contractor even if it is beyond the specified maintenance period of the contract as a whole.

3.26.07 Polyethylene Films: Application in Walls or base of structures

Waterproof treatment shall be applied as outlined and as per sequence given hereunder

i) the concrete surface shall be made smooth with 12 mm cement plaster 1:6.

ii) apply hot bitumen 80/100 grade (IS: 73-1961) at the rate of 1.0 Kg/Sq.m minimum

iii) lay black polyethylene film 250-micron (IS: 2508-1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed, taking care not to puncture the film.

Alternatively, the overlaps shall be heat sealed by an electric iron having

three parallel sealing bars. A long piece of plywood is to be placed below the polyethylene film to be heat-sealed. On the plywood a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a cellophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another cellophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat-sealing, the cellophane tape is to be removed and the joints are to be tested for leaks.

iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen,

v) Lay hot bitumen 80/100 grade (IS: 73-1961) at 1.0 Kg/Sq.m minimum.

vi) Lay 250-micron polyethylene film as second layer similar to (iii)above.

viii) Lay second layer of 100 gm. brown craft paper laminated similar to (iv) above.

ix) Apply hot bitumen (straight run grade) to IS: 73-1961 at 1.0 Kg/Sq.m dusted with fine sand.

x) Protecting with a layer of 75 mm plain cement concrete M-10, or a layer of brick laid in cement mortar 1:6 in case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

3.27.00 Protective Coating on Concrete Surface

3.27.01 On Foundation

The outside faces of foundation of important structures will be protected from adverse effect of soil/underground water, if shown on drawing by using rubber/bitumen emulsion protective coating of approved manufacturer.

4.00.00 SAMPLING AND TESTING

4.01.00 General

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in this specification. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the teat results in triplicate within 3 (three) days after completion of the test.

4.02.00 Cement

Representative samples will be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths as per guidelines of IS: 269. Soundness Tests may also be required to be carried out if required by the Engineer. The Contractor shall carry out the tests without any expense to BHEL. No cement from a particular consignment/batch will be used on the works unless satisfactory 3 (three) days and 7 (seven) days test results for compressive strength are known. The Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the BHEL or the Contractor. These tests are of great importance, as their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

4.03.00 Aggregates

The contractor shall carry out any or all the tests on aggregates as may be required by the Engineer in accordance with IS: 2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

4.04.00 Water

Sampling and Testing of water being used for concrete works as per IS: 3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The acceptance criteria will be as per IS: 456.

4.05.00 Admixture

4.05.01 Air Entraining Agents

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cylinder cube crushing strength vis-a-vis quantity of A.E.A. used for all types of concrete will be established by the Contractor by carrying out sufficiently large number of tests. After that, at regular intervals and whenever directed by the Engineer, the Contractor will check up the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

4.05.02 Other Admixtures

Tests for establishing the various properties of any other admixtures, which may be required to be added, shall be carried out by the Contractor.

4.06.00 Concrete

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS: 516 and IS: 1199, the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Engineer may require other tests to be performed in accordance with IS: 516. Sampling procedure, frequency of sampling and test specimen shall conform to IS: 456. To control the consistency of concrete from every mixing plant, slump tests shall be carried out by the Contractor every two hours or as directed by the Engineer. Slumps corresponding to the test specimens shall be recorded for reference. The acceptance criteria of concrete shall be in accordance with IS: 456. Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor at his own cost. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Engineer.

5.00.00 ACCEPTANCE CRITERIA

5.01.00 Standard Deviation

Standard deviation shall be based on test results and determination of Standard deviation shall conform to IS: 456.

5.02.00 Acceptance Criteria

The strength requirements and acceptance criteria shall conform to IS: 456.

5.03.00 Inspection and Core Tests

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to IS: 456.

5.04.00 Load Test

Load tests of structural members as per IS:456 may be required by the Engineer, when the strength of test specimen results falls below the required strength.
If the member shows evident failure, the Contractor shall make the structure adequately strong free of cost to BHEL.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification. The entire cost of dismantling and replacement and restoration of the site being borne by the Contractor.

If, in the course of dismantling, any damage is done to the embedded items

and or other adjacent structures, the same will be made good, free of charge by the Contractor to the satisfaction of the Engineer.

6.00.00 RATES AND MEASUREMENTS

6.01.00 Cast-in-situ Concrete

6.01.01 Rates

a) The unit rates shall include the cost of labour, materials, equipment, handling, transporting, botching, mixing, placing in position, vibrating, compacting, finishing, curing, testing, etc. at all elevations. This shall include the cost of curing by regular wetting or by using curing compound.

b) The unit rates shall include for all working conditions including at locations under water, liquid, mud, in or under foul positions and extreme weather conditions.

c) The unit rates for exposed concrete works (including machine foundations) shall include all incidentals, rendering, smoothening with carborandum stone, finishing with a paste of cement sand mortar, curing, etc.

d) The unit rates shall include all arrangement for maintaining stability of structure during execution.

e) Nothing extra shall be payable for the handling/mixing of extra cement on account of any reason or pouring of second stage concrete.

f) Nothing shall be payable to the Contractor on account of facilities and arrangement provided by him for conducting ultrasonic pulse velocity (UPV) tests or other relevant tests to ascertain grade and quality, etc. of the concrete in case the concrete quality is in doubt and contractor has to establish the quality by further tests. In case of any defects, the Contractor shall rectify the same by cement/epoxy grout at his own cost.

However, mandatory UPV test as specified in the drawings shall be carried out including arrangement of all its facilities, staging, etc. and shall be payable to the contractor as per BOQ item.

g) The unit rates for controlling of the temperature of concrete shall include storing and mixing of ice, water, cooling of aggregate etc.

h) The quoted rate shall include the cost of MIX design, making of all trial mixes using admixtures and mixing in concrete etc. complete.

6.01.02 Measurements

a) Actual volume of concrete work as executed or as per drawings issued, whichever is less shall be measured in cubic metres to the nearest two decimals.

b) No deductions shall be made for the following:

i) Ends of dissimilar materials embedded inside for example, beams, posts, girders, rafters, purlins, trusses, corbels and steps upto 500 sqcm in cross section;

ii) Opening upto 0.1 sq.m.

iii) Volume occupied by reinforcement, sleeves, anchor bolts, and similar items.

iv) Volume occupied by pipes, conduits, sheathing, etc. not exceeding 100 sq.cm. each in cross sectional area.

c) The concrete works of different grades; below and above ground floor finished level shall be measured separately, unless otherwise specified in the schedule of items. Accordingly rates shall be applied for concrete in foundation for concrete below ground floor finished level and concrete in superstructure for concrete above ground floor finished level.

d) For temperature control measures, measurement shall be done in terms of quantity of concrete in cum. in concreting of which the ice have been used or cooling of aggregates has been done to keep the temperature of freshly laid concrete to less than 23^0C.

6.02.00 Reinforcement

6.02.01 Rates

a) The unit rates shall include for cover block, providing binding wire, welding, separator pieces between two or more layers of reinforcement required for keeping the steel in position, etc. at all elevations.

b) No extra will be paid for transportation from stores, cleaning, straightening of steel, cutting, bending, binding with annealed wire, welding, tack welding, placing the reinforcement modification of already embedded reinforcement, if required, due to faulty fabrication or placement and other cost of tools and plants, materials, labours, return of unused steel to the store, etc. If reinforcement steel issued is by BHEL to the contractor for use in reinforcement steel work, the unit rate shall include stacking of cut pieces/ scrap steel generated out of reinforcement steel work as per size (dia) for easy retrieval for further use.

c) However, lap welding of reinforcement steel if permitted shall be paid under separate item as provided in the BOQ and no deduction for labour and binding wire saved for not providing lap length shall be made. Similarly, splicing of reinforcement bars using mechanical couplers if permitted shall be paid under separate item as provided in the BOQ and no deduction for labour and binding wire saved for not providing lap length shall be made.

d) No extra shall be paid for preparing and getting approved bar bending schedules (including all revisions).

e) Generally members are straight and have straight edges. However, for bending, binding, placing of reinforcement in any curved member in length or cross section or both, no extra payment shall be made.

6.02.02 Measurements

a) Bar or any other type of reinforcement used like hard drawn steel wire fabric etc. for reinforced concrete shall be measured by weight in tonnes. The weight shall be arrived at by multiplying the actual or theoretical length measured alongwith standard hooks, cranks, bends, authorized laps, etc. whichever is less by the sectional weights. Claims for payment for this item shall be submitted with supporting documents giving the schedule of bars with sketches. The sectional weight to be adopted shall be IS Section weight. Nothing extra will be payable to the Contractor on account of, difference in weight, if any, due to different methods adopted for issue and measurement.

b) Standard hooks, cranks, bends, authorised laps, supports, hangers and chairs which are covered in approved bar bending schedule shall be measured in tonnes.

6.03.00 Formwork and Staging

6.03.01 Rates

a) The unit rates shall be inclusive of all staging, scaffolding, making the formwork watertight, etc. for all elevations and in all types of works.

b) No separate payment shall be made for providing fillets, for rounding or chamfering at junctions, comers, etc.

c) The unit rates shall include the cost of labour, materials etc. and the extra time, which shall be required for the removal of shuttering/ support for satisfactory completion of work.

d) No extra payment shall be made on account of difficulty, wastage etc. for placement/removal of formwork between the network of closely placed steel beams or for the lacing/bracing portions and ribbed slab constructions.

e) Payment for curved shuttering shall be made for curved members/wall whose centerline radius in plan is less than 6m.

f) If the contact surface area in pockets is less than or equal to 0.1 sq.m. in each case, payment shall be done under item for providing formwork in pockets.

6.03.02 Measurements

a) Formwork for different classes (types) shall be measured separately as the actual surface in contact with the concrete and paid on area basis unless included in the rate for concrete. The unit of measurement shall be in sq.m.

b) Openings upto 0.1 sq.m or boxing left for inserts etc. for facility of Contractor's work, shall be neglected as if nonexistent for the purpose of formwork measurement of surface in which the openings occur.

For suspended floor, no deduction shall be made for flange area of secondary steel beams.

d) No measurement shall be taken for the formwork in pockets, openings, chases, blockouts, etc. in concrete, the contact surface area is less than or equal to 0.1 sq.m. in each case.

e) For pockets, if the contact surface area is less than or equal to 0.1 sq.m. in each case, measurement shall be done under item for providing formwork in pockets.

e) Formwork, if required, for joints shown on drawing or instructed by the Engineer, shall be paid for the 'leading side' only.

6.04.00 Embedded Parts

6.04.01 Rates

a) The unit rate for erection of embedded steel parts, supplied by Engineer shall include transportation from Owner's store to the place of work, erection & installation including setting material in concrete, etc. complete.

b) The unit rate for MS pipe embedments and PVC pipe embedments shall include cutting, welding, fabrication, erection, embedding, and transportation to site. Unit rate shall also include the cost of the pipes.

c) Rate for expansion fasteners shall include cost of fasteners, installation, and fixing including cost of washers and nuts and site testing if required.

6.04.02 Measurements

a) The measurement of the embedded steel parts fabricated and installed by the Contractor shall be based on the calculated weight of steel sections in tonne corrected to second place of decimal.

b) Embedded steel parts supplied by Owner and installed by Contractor Measurement shall be done for the net weight of the embedments installed in tonnes correct to second place of decimal.

c) For PVC pipes/conduits, measurements shall be in quintals correct to second place of decimal for the net weight.

d) For mild steel pipes, measurement shall be in quintals, correct to second place of decimal, for the net weight of the steel pipe supplied, fabricated, and installed.

e) The lugs shall be measured in Kg. correct to second place decimal for the net weight.

f) The expansion fasteners shall be measured in number according to tension capacity.

g) The rails shall not be treated as embedded steel part and the track shall be measured in running metres along the centre line and paid for under separate item of work as specified in schedule of items. Other related civil items associated with the laying of track shall be measured separately and paid under respective items of works.

6.05.00 Groutings

6.05.01 Rates

Rate shall include the cost of surface preparation, admixtures, and curing.

6.05.02 Measurements:

a) Measurement shall be in cubic decimeters.

b) Measurement for grouting shall be by volume of the block out, pockets or bolt hole upto the top surface of foundation concrete and shall be calculated from the dimensions shown on the drawings.

c) Measurement for underpinning shall be by volume between the top surface of the foundation concrete and the underside of the base plate, the plan dimensions being as indicated on the drawings.

d) No deduction shall be made for shims, bolts, shear keys and such other embedments.

f) Pressure injection grouting with cement based grout if required as per drawing shall be applied at appropriate spacing to cover the desired surface area and measurement shall be made for the surface area grouted in sqm as per BOQ item. However in water retaining structures, the structural grouting if required to ensure water tightens shall not be payable separately as deemed to be covered in water retaining concrete item of BOQ.

6.06.00 Joints

6.06.01 Rates

The unit rate shall include all the activities described in the schedule of items.

6.06.02 Measurements

a) Bitumen Board/Expanded polystyrene.

The measurement for bitumen board shall be based on actual finished surface area in square meters nearest to second decimal, for the specified thickness.

b) Water Stops

The measurement for water stops shall be in running metres of actual length of the joint covered, for specified thickness, width, and shapes. No separate measurement shall be made for laps/splices for cross-joints and mitered joints.

c) Metal Cover Strips

The measurement for Metal Cover Strips shall be based on actual finished surface area in square metres for the specified thickness.

d) Vibration Damping Resilient Pads

The measurement for this item shall be in square metres for the specified thickness, measured correct to the second place of decimal, of the actual finished surface area.

6.07.00 Dismantling/Demolishing Work – RCC and PCC and Chipping of Concrete

6.07.01 Rates

The unit rates shall include the cost of all necessary propping, shoring, underpinning scaffolding, safety measures, temporary enclosures, disposal/ stacking of serviceable/unserviceable materials, etc. for all types of work and for all grades of concrete.

In the case of dismantling/demolishing work, the cutting of reinforcement shall also be included in the rate.

In the case of chipping work, the cutting of reinforcement shall be paid separately.

If the serviceable material including reinforcement steel from dismantled structure is allowed to be used/taken out by bidder, suitable rebate shall be given by bidder.

6.07.02 Measurements

a) Dismantling of PCC and RCC work shall be measured in cu.m separately. Measurement of all work, except hidden work shall be taken before execution of work and no allowance for increase in bulk shall be allowed. Specifications for deductions of voids, openings etc, shall be done on the same basis as that applied for construction work.

b) Chipping of concrete, making holes/pockets etc. shall be measured in cubic decimeters (i.e. 0.001 cu.m.).

c) Cutting of reinforcement in chipping work for making of pockets and openings shall be measured in sq. cm. of cross-sectional area.

6.08.00 Precast Concrete

This clause shall be read in conjunction with relevant provisions specified elsewhere for cast in-situ Concrete.

6.08.01 Rates

a) The unit rate shall include cost of preparation of casting yard, formwork, concrete and its casting, finishing as specified, setting filling of gaps between adjacent pre-cast concrete units with concrete, or cement mortar, curing, handling, erection, grouting, welding, preparation of supporting surface, etc.

6.08.02 Measurements

The measurement of pre-cast concrete members shall be on the basis of volume of concrete in cubic metres nearest to second place of decimal. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings up to 0.1 sq.m. The setting of element with cement mortar shall not be measured separately The filling of concrete cement mortar between the gaps of adjacent precast units shall be considered while computing the volume of pre-cast concrete work and shall be paid for under this item itself.

7.00.00 LIST OF IS CODES AND STANDARDS FOR REFERENCE

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not specifically covered by Indian standard Specifications, any other standard practice, as may be specified by the Engineer, shall be followed:-

IS: 73 - Indian Standard Specification for Paving Bitumen

IS: 216 - Indian Standard Specification for Coal Tar Pitch

IS: 383 - Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete

IS: 432 - Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement

IS: 455 - Indian Standard Specification for Slag Cement

IS: 456 - Indian Standard Code of Practice for Plain and Reinforced Concrete

IS: 457 - Indian Standard Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive

Structures

IS: 516 - Indian Standard Specification for Methods of Test for Strength of Concrete

IS: 702 - Indian Standard specification for industrial bitumen.

IS: 1199 - Indian Standard Specification for Methods of Sampling and Analysis of Concrete

IS: 1322 - Indian Standard Specification for Bitumen Felts for Waterproofing and Damp-proofing

IS: 1489 - Indian Standard Specification for Portland Pozzolona Cement

IS: 1566 - Indian Standard Specification for hard drawn steel wire fabric for concrete reinforcement.

IS: 1609 - Code of Practice for Laying Damp-proof Treatment using Bitumen Felts

IS: 1786 - Indian Standard Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement.

IS: 1791 - Indian Standard Specification for Batch Type Concrete Mixers.

IS: 1838 - Indian Standard Specification for preformed fillers for expansion joints in concrete pavements and structures (non-extruding and resilient type.

IS: 2185 - Indian Standard Specification for Hollow Cement Concrete Blocks

IS: 2210 - Indian Standard Specification for Design of Reinforced Concrete shell Structures and Folded Plates

IS: 2386 - Indian Standard Specification for Methods of Test for Aggregates for Concrete - Part-I to VIII

IS: 2502 - Indian Standard Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement

IS: 2505 - Indian Standard Specification for Concrete Vibrators, Immersion Type

IS: 2506 - Indian Standard Specification for Screed Board Concrete Vibrators

IS: 2514 - Indian Standard Specification for Concrete Vibrating Tables

IS: 2571 - Code of practice for laying in-situ cement concrete floors.

IS: 2645 - Integral cement water proofing compound

IS: 2722 - Indian Standard Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket type)

IS: 2750 - Indian Standard Specification for steel scaffoldings.

IS: 2751 - Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction

IS: 2770 - Indian Standard Specification for Method of Testing Bond in Reinforced Concrete

IS: 3025 - Indian Standard specification for Methods of Sampling and Test (Physical and Chemical) for Water used in Industry

IS: 3067 - Code of practice for general design details and preparatory work for damp proofing and water proofing of building.

IS: 3201 - Indian Standard Specification for Design and Construction of Precast Concrete Trusses

IS: 3370 - Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids

IS: 3414 - Code of practice for design and installation of joints in buildings.

IS: 3550 - Indian Standard Specification for Method of Test for Routine Control for Water used in Industry

IS: 3558 - Code of Practice for use of Immersion vibrators for Consolidating Concrete

IS: 3696 - Safety Code for Scaffolding and Ladders

IS: 3812 - Indian Standard Specification for Fly Ash for Use as Admixture for Concrete

IS: 4014 - Code of practice for steel tubular scaffolding.

IS: 4031 - Indian Standard Specification for Method of Tests for

Hydraulic Cement

IS: 4082 - Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site

IS: 4090 - Indian Standard Specification for Design of Reinforced Concrete Arches

IS: 4634 - Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixes

IS: 4656 - Indian Standard Specification for Form Vibrators for Concrete

IS: 4925 - Indian Standard Specification for Concrete Batching and Mixing Plant

IS: 4926 - Indian Standard Specification for Ready Mixed Concrete

IS: 4990 - Indian Standard Specification for Plywood for Concrete Shuttering work

IS: 4991 - Indian Standard Specification for Blast Resistant Design of structure for Explosion above ground

IS: 4995 - Indian Standard Specification for Design of Reinforced Part-I & II Reinforced Concrete Bins for the Storage of Granular and Powdery Materials

IS: 4998 - Indian Standard Specification for Design of Reinforced Concrete Chimneys.

IS: 5256 - Code of practice for sealing joints in concrete lining on canals.

IS: 5512 - Indian Standard Specification for Flow Table for use in Tests of Cement and Pozzolanic materials

IS: 5513 - Indian Standard Specification for vacate Apparatus.

IS: 5515 - Indian Standard Specification for Compaction Factor Apparatus.

IS: 5525 - Recommendation for detailing of reinforcement in reinforced concrete works.

IS: 5624 - Indian Standard Specification for foundation bolts.

IS: 5751 - Indian Standard Specification for Precast Concrete Coping

Blocks.

IS: 5816 - Indian Standard Specification for Method of Test for Splitting Tensile strength of Concrete Cylinders.

IS: 5891 - Indian Standard Specification for Hand operated Concrete Mixers.

IS: 5892 - Indian Standard Specification for transit mixer and agitators.

IS: 6452 - Indian Standard Specification for High Alumina Cement for Structural Use

IS: 6909 - Indian Standard Specification for Super sulphated Cement

IS: 6923 - Indian Standard Specification for Method of Test for Performance of Screed Board Concrete Vibrators.

IS: 6925 - Indian Standard Specification for Method of Test for Determination of Water Soluble Chloride in Concrete Admixtures.

IS: 7242 - Indian Standard Specification for Concrete Spreaders.

IS: 7246 - Indian Standard Specification for Table Vibrators for Consolidating Concrete.

IS: 7251 - Indian Standard Specification for Concrete Finishers.

IS: 7293 - Safety code for working with construction machinery.

IS: 7320 - Indian Standard Specification for Concrete Slump Test Apparatus.

IS: 7861 - Indian Standard Specification for Recommended Practice Part-I&II for Extreme Weather Concreting.

IS: 7969 - Safety Code for Storage and Handling of Building Materials.

IS: 8041 - Indian Standard Specification for Rapid Hardening Portland cement.

IS: 8112 - Indian Standard Specification for high strength Ordinary Portland Cement.

IS: 8142 - Indian Standard Specification for Determining Setting time of concrete by Penetration Resistance.

IS: 8989 - Safety Code for Erection of Concrete Framed Structures.

IS: 9012 - Recommended method for shortcreting.

IS: 9013 - Indian Standard Specification for Method of Making, Curing, and determining compressive Strength of Accelerated-cured Concrete Test Specimens.

IS: 9077 - Code of Practice for Corrosion Protection of Steel Reinforcement in RB and RCC Construction.

IS: 9103 - Indian Standard Specification for Admixtures for Concrete.

IS: 10262 - Recommended Guidelines for Concrete Mix Design.

IS: 13311 - Non-destructive testing of concrete.

SP: 34 - Handbook of concrete, reinforcement and detailing.

VOLUME: II B

SECTION - D

SUB-SECTION – D21

BORED CAST-IN-SITU RCC PILES

SPECIFICATION NO. PE-TS-457-600-C021

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

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TECHNICAL SPECIFICATION FOR INSTALLATION OF BORED CAST-IN-SITU PILES

1.00.00 SCOPE

This specification covers the installation of bored cast-in-situ reinforced concrete vertical piles of specified load carrying capacity and diameter for various structures. This specification also covers carrying out initial and routine load tests on piles to assess their vertical, horizontal and pull out load carrying capacities.

2.00.00 GENERAL REQUIREMENTS

2.01.00 This specification along with specific requirements under Annexure-A covers the technical requirements for piling work.

2.02.00 The work shall include supplying and providing necessary materials, mobilization of all necessary equipments (Annexure-B), providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carryout the complete piling work, and submission of records as per schedule.

2.03.00 The Contractor shall carryout all works as mentioned in Scope above. All works shall be executed to the satisfaction of the Engineer.

2.04.00 Pile capacities in vertical compression, horizontal, pullout loads for various pile diameters are given in Annexure-A.

2.05.00 The Contractor shall confirm and guarantee the "Safe Load" capacities by conducting both initial and working load test on piles as mentioned in the specific requirements.

2.06.00 The Contractor shall submit along with tender documents his tender design of piles based on soil data furnished by the Owner along with this specification. The ultimate load capacity of a pile may be estimated using suitable static formula and the minimum factor of safety shall be 2.5. However, safe load carrying capacity shall be conformed and guaranteed by conducting initial and routine load tests.

2.07.00 In case of initial or routine load test piles, if the Contractor fails to establish the safe load capacity as per his design, the Owner has the right to either derate the pile capacity on prorata basis or insist the Contractor to modify the pile design, to achieve the desired safe load capacity at no extra cost to the Owner.

2.08.00 Derating is acceptable up to 90 percent. In such case, additional piles shall be installed as per the design requirements.

2.09.00 The Owner shall decide whether to derate or modify the design based on the design considerations such as providing additional piles in the designed pile cap, provision for extending the pile cap size, etc.

2.10.00 In case the Owner decides to modify the design instead of derating the pile, the contractor shall carry out the same and install separate test piles and test the same to guarantee the safe load at no extra cost to the Owner. However no extra shall be charged for the additional test piles as well as testing of these piles as per agreed contract conditions.

2.11.00 In case of working piles, if the pile does not meet the guaranteed capacity or rejected due to any other reason, the Contractor shall install extra piles at no extra cost to the Owner. Further, the extra cost, due to the increase in the pile cap size if any, on account of extra piles, shall be borne by the Contractor.

2.12.00 It is essential that all equipment and instruments are properly calibrated both at commencement and immediately after the completion of tests so that they represent true values. Certificates to this effect from an approved institution shall be furnished to the Engineer. If the Engineer so desires the Contractor shall arrange for having the instruments tested at an approved laboratory at no extra cost to the Owner and the test report shall be submitted to the Engineer. If the Engineer desires to witness such tests Contractor shall arrange to conduct the test in his presence.

2.13.00 The Contractor shall make his own arrangements for locating the coordinates and position of piles as per drawings supplied to him and for determining the Reduced Levels (RL) of these locations with respect to the benchmark indicated by the Engineer. Two established reference lines in mutually perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site all the required survey instruments to the satisfaction of the Engineer so that the work can be carried out accurately according to specifications and drawings.

2.14.00 The contractor shall assure the quality of piling work including cleaning of pile bore, quality of concrete, integrity of piles, etc.

2.15.00 **AVAILABLE SUB-SOIL DATA**

An abstract of the sub soil data is furnished in the tender document. However, the detailed soil investigation report shall be made available for reference of the bidder, if so required, at the office of the Owner. The soil data furnished is in good faith and only for the guidance of the Bidder, to arrive at design parameters and construction methods.

3.00.00 MATERIALS

3.01.00 General

All materials viz cement, steel, aggregates, water, etc. which are to be used for pile construction shall conform to relevant IS codes for properties, storage and handling of common building materials. However, aggregates more than 20 mm size shall not be used.

3.02.00 CONCRETE

Concrete shall be manufactured either by central batching plant or Ready Mix concrete. However, for initial test piles suitable method as approved by the Engineer may be used. Concrete shall conform to IS: 10262 & IS: 456.

3.02.01 Technical Specification for Cement Concrete (Plain and Reinforced) works along with IS: 2911 Part I/Sec 2 shall be followed for concrete works of piles. Use of plasticiser to control the water cement ratio shall be permitted on specific approval from the Engineer. Water cement ratio shall not be greater than 0.5.

3.02.02 Grade and minimum cement content
Minimum grade of concrete shall be as per Annexure-A conforming to IS: 456. Minimum cement content of 400 Kg/M³ of concrete shall be used for M-20 grade concrete.

3.02.03 Slump of concrete
The slump of concrete shall vary between 150 to 180 mm.

3.03.00 REINFORCEMENT

3.03.01 Longitudinal reinforcement in pile shall be high strength deformed steel bars conforming to IS: 1786 unless specified otherwise. Lateral reinforcement in pile shall be of mild steel conforming to IS: 432 Part-1 or HYSD bars as per IS: 1786.

3.03.02 The longitudinal reinforcement shall be provided considering the combination of vertical (compression and tension) and horizontal loads. However, the minimum longitudinal reinforcement shall be 0.4 percent of the sectional area calculated on the basis of nominal pile diameter. Minimum six numbers of bars shall be provided for longitudinal reinforcement. The diameter of longitudinal reinforcement bars shall not be less than 12mm. The stipulated minimum reinforcement shall be provided for the full length of pile.

3.03.03 The longitudinal reinforcement shall project 50 times its diameter above cut off level unless otherwise indicated.

3.03.04 The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing. The laterals may in the form of links or spirals. The minimum diameter of the links or spirals shall be 6 mm and the spacing of the links or spiral shall not be less than 150 mm and in no case more than 250 mm.

3.03.05 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/pilebore by providing necessary laps as per IS: 456.

3.03.06 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100 mm for the full depth of cage.

3.03.07 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction.

3.03.08 Laps shall be staggered as far as practicable and not more than 50% bars shall be lapped at a 'particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Centre to Centre).

3.03.09 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, cast specifically for the purpose.

3.03.10 Minimum clear cover to the longitudinal reinforcement shall be 50 mm, unless otherwise mentioned.

3.03.11 Bundling of bars is not permitted.

4.00.00 PILE INSTALLATION

Installation of piles shall be carried out as per pile layout drawings, installation criteria, and the direction of the Engineer.

4.01.00 Equipment and Accessories

4.01.01 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Engineer.

4.01.02 List and details of equipment and accessories proposed to be used for the job shall be submitted along with the bid.

4.01.03 The capacity of the rig shall be adequate so as to reach the specified founding level.

4.01.04 Provision shall be kept for chiselling within the pilebore, as specified elsewhere in this specification. Chiselling shall be carried out only with the approval of Engineer.

4.02.00 Installation Criteria

4.02.01 For determining the founding level of piles in soil as specified elsewhere, the Contractor shall have to perform Standard penetration test (SPT) as per IS: 2131 in a separate bore hole. The SPT shall be conducted at 1.0 m interval between the depths covering 5 metres each above and below the specified founding level. The bore shall be 100 mm diameter and method of boring shall conform to IS: 1892.

4.02.02 For determining founding level of piles in rock, as specified elsewhere socketing horizon shall be established by the Contractor by collecting rock cores of NX size in a separate borehole, and testing the same for uniaxial compressive strength (UCS). Cores shall be collected by double tube core barrel attached with diamond bit. Coring shall be done upto a depth as indicated in the "specific requirements." Coring in rock shall conform to IS: 6926.

4.02.03 In case it is not possible to test the cores so obtained for uniaxial compressive strength, cores shall be tested for point load strength index and correlated to obtain uniaxial compressive strength.

4.02.04 Number of boreholes for carrying out SPT in soil or uniaxial compressive strength in rock, shall vary from one in 100 to 150 piles or pile group of 150 Sqm depending on the site condition and as decided by the Engineer. However, at the location of initial load test piles, one such borehole shall be done.

4.02.05 A protocol between contractor and BHEL site shall be maintained regarding the strata at founding level. SPT value and UCS from the nearest borehole shall be indicated therein.

4.02.06 The founding level of the pile shall be decided based on the criteria elaborated in the specific requirements under Annexure-A. Concreting shall not be done until the above conditions for founding level are satisfied.

4.02.07 Approval of founding level by the Engineer shall in no way absolve the Contractor of his responsibility to guarantee the Safe load capacity of the piles as indicated in this document.

4.03.00 Control of position and alignment

4.03.01 Piles shall be installed as accurately vertical as possible. The permissible limits for deviation with respect to position and (inclination) alignment shall conform to IS: 2911 Part I/Sec. 2, which is reproduced below for ready reference.

a) The maximum deviation of vertical piles shall not exceed 1.5 per cent in alignment.

b) Piles shall not deviate more than 75 mm or D/4 whichever is less (75mm or D/10 whichever is more in case of piles having diameter more then 750mm) from their designed position at the working level.

4.04.00 Boring

4.04.01 Boring operations shall be done by rotary or percussion type drilling rigs using reverse mud circulation (RMC) method. Rotary hydraulic pulley shall be preferred.

4.04.02 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC (direct mud circulation) or RMC is used Bentonite slurry shall be pumped through drill rods by means of high-pressure pumps. The cutting tool shall have suitable ports for the bentonite slurry to flow out at high pressure. If on mobilisation, the Contractor fails to make a proper bore for any reason, the Contractor has to switchover to other boring methods as approved by the Engineer at no extra cost to the Owner.

4.04.03 Working level shall be above the cut off level. After the initial boring of about 1.0m a temporary guide casing of suitable length shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter, so as to give the necessary finished diameter of the concrete pile. The centre line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum of 1.0m length. Additional length of casing may be used depending on the condition of the strata, ground water level etc.

4.04.04 Use of drilling mud (bentonite slurry) for stabilizing the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in Annexure-C.

4.04.05 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry, shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is recirculated to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

4.04.06 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method is used the bentonite slurry shall be under constant circulation till start of concreting.

4.04.07 The size of cutting tools shall not be less than the diameter of the pile by more than 75mm. However, the pile bore shall be of the specified size.

4.05.00 Chiselling

4.05.01 Chiselling may be resorted to with the permission of the Engineer below the socketing horizon. The chiselling tool or bit shall be of adequate size and weight so as to reach the desired depth.

4.06.00 Cleaning of Pile bore

4.06.01 On completion of the pile bore upto the required depth, the bottom of the hole shall be cleaned very carefully before concreting work is taken up. Cleaning shall ensure that the pile bore is completely free from sludge/bored materials, debris of rock/boulder etc. Necessary checks shall be made as given in clause 5.0 to confirm the thorough cleaning of the pile bore.

4.06.02 Pile bore shall be cleaned by fresh drilling mud through tremie pipe after placing reinforcement and just before start of concreting.

4.06.03 Pile bore spoil along with used drilling mud shall be disposed off from site as directed by the Engineer.

4.06.04 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

4.07.00 Adjacent Structures

4.07.01 When working near existing structures care shall be taken to avoid any damage to such structures.

4.08.00 Concreting

4.08.01 The Contractor shall carry out concrete mix design in accordance with IS: 10262 and submit mix design calculations and get them approved from the Engineer well in advance for installation of piles. Adequate number of tests on cubes, etc. shall be carried out as mentioned in clause 5.0 to ensure concrete of the minimum specified strength in accordance with IS: 456 at requisite workability (slump).

4.08.02 Concreting shall not be done until the Engineer is satisfied that the bearing strata (soil/rock) met with at the termination level of pile.

4.08.03 The time interval between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs the pilebore shall be abandoned. However, the Engineer may allow concreting provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pilebore. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

4.08.04 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.

4.08.05 Concreting shall be done by tremie method as specified by IS: 2911 (Part I /Sec.2). The level of drilling mud shall be maintained sufficiently above the ground water level.

4.08.06 The concreting operations shall not be taken up when the specific gravity of bottom slurry is more than 1.2 and sand content more than 7%. The drilling mud sample shall be collected from the bottom of pilebore as mentioned in clause 5.

4.08.07 Consistency of the drilling mud suspension shall be controlled throughout the concreting operations in order to keep the bore stabilized as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

4.08.08 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

4.08.09 The temporary guide casing shall be withdrawn cautiously, after concreting is done upto the required level. While withdrawing the casing concrete shall not be disturbed.

4.09.00 Cut off level (COL)

4.09.01 Cut off level of piles shall be as indicated in drawings released for construction or as indicated by the Engineer.

4.09.02 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment in to pile cap.

4.09.03 When the pile cut off level is less than 1.0 metre below the working level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 metre below working level then concrete shall be cast to a minimum of one metre above COL.

4.10.00 Sequence of Piling

4.10.01 Each pile shall be identified with a reference number.

4.10.02 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

4.11.00 Building up of Piles

4.11.01 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the cast pile top level is less than the specified level or for any other reason, then the pile shall be built-up by using atleast one grade higher concrete than that used for concreting of the same pile, ensuring proper continuity with the existing concrete and to the satisfaction of the Engineer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

4.12.00 Breaking off of Piles

4.12.01 If any pile already cast, requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, not before seven days of casting without affecting the quality of existing pile such as loosening, cracking etc. and to the satisfaction of the Engineer.

4.13.00 Preparation of Pile head

4.13.01 The soil surrounding the piles shall be excavated upto the bottom of the lean concrete below the pile cap, with provision for working space, sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

4.13.02 The exposed part of concrete above the COL shall be removed/chipped off and made to a uniform level at COL, but not before seven days of casting of pile.

4.13.03 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap.

4.13.04 The pile top shall be embedded into the pile cap by 50mm or clear cover to reinforcement, whichever is higher.

4.13.05 All loose material, like debris due to chipping/breaking of pile head to the desired level, shall be removed and disposed off as directed by the Engineer.

4.14.00 Rejection and Replacement of Defective Piles

4.14.01 The Engineer reserves the right to reject any pile which in his opinion is defective on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in place as judged convenient by the Engineer, without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Engineer, at no extra cost to the Owner.

4.15.00 Recording of Piling Data

4.15.01 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data shall be as shown in Appendix D of IS: 2911 Part I/Sec.2. The pile data shall also include all the details as in Annexure-D. On completion of each pile installation, pile record in triplicate shall be submitted to Engineer within two days of completion of concreting of the pile.

5.00.00 SAMPLING, TESTING AND QUALITY ASSURANCE

5.01.00 Facilities required for sampling and testing of materials, concrete, etc. in field and in laboratory should be provided by the Contractor. The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and this Specification. Where no specific testing procedure is mentioned the tests shall be carried out as per the prevalent accepted engineering practice and as per the directions of the Engineer. Tests shall be done in the presence of the Engineer or his authorized representative. In case the Engineer requires additional tests, the Contractor shall arrange to get these tests done and submit to the Engineer the test results in triplicate within three days after completion of any test.

5.02.00 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Engineer. The Engineer at his discretion may waive some of the stipulations for small and unimportant concreting operations and other works.

5.03.00 Materials found unsuitable for acceptance shall be removed and replaced by the Contractor. The work done by this unsuitable material shell be redone as per specification requirements & and to the satisfaction of the Engineer at no extra cost to the Owner.

5.04.00 Quality Assurance Programme

a) The Contractor shall submit and finalize a detailed Field Quality Assurance Programme within 30 days from the date of award of the contract, according to the requirements of this specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment,

deployment of qualified/experienced manpower, preparation of field quality plan, etc. On finalized field quality plan, the Owner shall identify, customer hold points, beyond which work shall not proceed without written approval from the Engineer. The testing apparatus/equipment installed in the field laboratory shall be calibrated/ corrected by the qualified persons as frequently as possible to give accurate testing results.

b) Frequency of sampling and testing, etc. and Acceptance Criteria are given in Table - 1. The testing shall be done at field laboratory or any other laboratory approved by the Engineer. However, the testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications. The materials shall be tested to meet all the specified requirements before acceptance at manufacturers premises or at independent government approved laboratory. Tests indicated in the table are for cross checking at site the conformity of the materials to some of the specifications.

5.05.00 Testing of Concrete

5.05.01 Concrete and other materials shall be tested for quality, strength and other properties. Details of testing shall be as specified under technical specification for Cement concrete (Plain and Reinforced).

5.05.02 One sample consisting of six test cubes shall be made from the concrete used in each test pile, three to be tested after 7 days and three after 28 days.

5.05.03 For working piles, minimum one sample consisting of six test cubes shall be made from the concrete for the first ten piles, three to be tested after 7 days and three after 28 days. Thereafter, minimum one sample consisting of three test cubes for every 10 piles shall be tested for the 7-days & 28-days cube strength.

5.05.04 In preparation of test cubes or specimens vibrators shall not be used.

5.05.05 Concrete shall be tested for slump at every 1-hour interval during concreting of piles.

5.05.06 The frequency of sampling and testing of concrete and materials shall be done as per technical specification for cement concrete (Plain & Reinforced).

5.05.07 The acceptance criteria shall be as mentioned in Table-1.

5.06.00 Testing for position and alignment

5.06.01 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

5.06.02 Permissible limits for deviation shall be as specified under clause no. 4.03.

5.07.00 Properties of Drilling mud

5.07.01 Properties of drilling mud shall be checked as per requirement under Annexure C. Prior to the commencement of piling work and thereafter minimum once in a week or as found necessary by the Engineer, one sample consisting of 3 specimens shall be tested. Acceptance criteria applicable are as specified else where with 5% variation. This relaxation is not applicable for properties of drilling mud before concreting.

5.07.02 Density of the drilling mud shall be checked in each pile before concreting.

5.08.00 Check for Pile bore

5.08.01 On completion of boring and cleaning the bottom of each pilebore shall be checked from the sample collected from near the bottom of pile bore or by any other methods as approved by the Engineer, to ensure that it is free from pilebore spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Engineer.

5.08.02 For sampling of drilling mud from the pilebore the following method or any other suitable method shall be adopted.

a) A solid cone shall be lowered by a string to the bottom of pilebore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, and then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimize the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

b) Use of borehole camera for checking the pile bore spoil and strata is acceptable on approval of the Engineer.

5.09.00 Pile Integrity test

5.09.01 Low strain integrity test shall be conducted on 50% of the jobs piles and on all test piles or as directed by Engineer. The system shall have the computer readout facility and report on the findings of this shall be furnished to the Owner. This test shall be used to identify the job piles for routine load test.

Piles shall be trimmed to cut off level or sound concrete level. No pile cap blindage work should be undertaken prior to this test. The cast in-situ piles should not be tested before 14 days of casting.

5.09.02 The test shall be undertaken by persons trained and experienced and capable of interpreting the results with specific regard to piling. This test is limited to

testing the integrity of the shaft and is not intended to replace the use of static load testing.

5.09.03 Low Strain Integrity Test Methodology:

a) In this test, a low stress wave is set up in the pile shaft and is also known as Sonic Integrity or Sonic Echo test.

b) A small metal/hard rubber hammer is used to produce a light blow on top of the pile. The shock wave travelling down the length of the pile is reflected back from the toe of the pile and recorded through a suitable transducer/ accelerometer in a computer for subsequent analysis.

c) The primary shockwave, which travels down the length of the shaft, is reflected from the toe by the change in density between the concrete and sub strata. However, if the pile has any imperfections or discontinuities within its length these will set up secondary reflections, which will be added to the return signal.

d) By analysis of the captured signal and knowledge of the conditions of the ground, age of concrete, etc. a picture of the locations of pile shaft defects can be built up. The observed signals are amplified into digital display as velocity versus length records providing information on structural integrity of piles.

e) The stress wave velocity and approximate pile lengths are provided as input for the integrity testing. The stress wave velocity is dependent on the Young's Modulus and mass density of pile concrete.

f) More than one recording of signals shall be done until repeatability of signals is achieved on the same pile.

g) The tests shall be conducted at 3-6 locations to cover the entire cross section of the pile.

6.00.00 PILE TESTING

Pile load test shall be carried out as per IS:2911 Part-4 (latest edition) or as directed by Engineer.

6.01.00 INITIAL LOAD TEST

Initial load test shall be carried out on separately cast piles for confirmation of estimated pile capacities and to fix a more accurate driving criteria viz. set/bow, total number of blows and approximate depth etc. of founding level. At least 2 nos. of tests shall be conducted for each mode (vertical compression, pull out and lateral). The maximum test load shall be as

mentioned in bill of quantities.

6.02.00 ROUTINE LOAD TEST

Routine load tests shall be carried out on job (working) piles for 0.5% of total no. of piles (for each mode and type). Maximum test load shall be 1.5 times the design safe load capacity. Piles showing unsatisfactory results as per load test results shall be treated as defective piles. Defective piles shall be removed or left in place and replaced by additional piles as directed by Engineer at no extra cost to the owner. Any additional cost towards design implications, if any, due to above shall be born by the contractor.

7.00.00 CODES AND STANDARDS

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 432 (Part 1 & 11)	-	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS: 456	-	Code of practice for plain and reinforced concrete.
IS: 1200 (Part 23)	-	Measurement of Building and Civil Engineering works Piling.
IS: 1786	-	Code of practice for twisted steel high strength deformed bars for concrete reinforcement.
IS: 1892	-	Code of practice for Subsurface Investigation for foundation.
IS: 2131	-	Method of Standard Penetration Test for Soils
IS: 2911 Part I/Sec 2	-	Code of practice for design and construction of pile foundations - Bored cast-in-situ concrete piles.
IS: 2911 Part IV	-	Code of practice for design and construction of pile foundation - Load test on piles.
IS: 6926	-	Code of practice for Diamond core Drilling for Site Investigation for River Valley Projects.
IS: 10262	-	Recommended guidelines for concrete mix design.

8.00.00 RATES AND MEASUREMENTS

The clauses below shall apply for item rate contracts only. They shall not be applicable to turnkey/lump sum Contracts.

8.01.00 Rates

8.01.01 The items of work in the schedule of items, describe the work in brief. The various items in schedule of items shall be read in conjunction with the corresponding sections in the Technical Specifications, including amendments, and additions, if any. For each item in schedule of items, the unit rate shall include for the activities covered in the description of the item as well as for all necessary operations described in the specification and specific requirements.

8.01.02 The unit rates shall include for minor details which are obviously and fairly intended, and which may not have been included in the description in these documents, but are essential for the satisfactory completion of the work. Unit rates shall also include for all safety measures as required by codal provisions, local regulations, acts, bye-laws, etc. and for execution of work to the satisfaction of the Engineer.

8.01.03 The quoted rate for each item shall be inclusive of mobilization of all plant, equipment, scaffolding, labour, materials, skilled and unskilled labour, and demobilization after completion of work, supervision, establishing the level and coordinates at each work.

8.01.04 The quoted rate for piling for a particular diameter and capacity of pile shall remain valid for the actual lengths provided /to be provided irrespective of the minimum length specified elsewhere in this specification.

8.01.05 The quoted rate for piling as per description of item works shall be inclusive of providing all plant equipment, labour, materials, skilled and unskilled labour, making observations, establishing the ground level and coordinates at each location of pile by carrying levels from one established bench mark and distances from one set of grid lines furnished by the owner.

8.01.06 The quoted rate for piling shall be inclusive of bailing out all the pile bore spoil from the pilebore, keeping the borehole free from bored material/debris etc. and disposing the bored/chiselled material along with the drilling mud upto 2 Km. beyond plant boundary or as directed by Engineer, flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pilebore, transporting to laboratory, testing and reporting of results.

8.01.07 The quoted rate for piling shall include shifting of plant and equipment from one pile location to another pile locations, providing temporary casing pipe and removal of the same after completing, concreting, supply of necessary materials,

equipment and manpower, cost of boring by approved method as specified, circulation of bentonite slurry and cleaning of borehole free from sludge, as specified, etc.

8.01.08 The quoted rate for piling shall also include chiselling, if any, required for socketing the pile in rock.

8.01.09 The quoted rate for the piling shall include concreting by termite method, length of pile above COL, withdrawal of guide casing, cost for preparation of pile head and disposal of debris etc., resulting from breaking off of pile upto COL, upto a distance of 2 Km from the plant boundary or as directed by Engineer.

8.01.10 The quoted rate for piling shall also include providing reinforcement and its cleaning, straightening, cutting, bending, binding with annealed wire, welding, tackwelding, providing concrete cover blocks, spacers, placing the reinforcement cage in pile casing/bore and other cost of tools and plants, materials, labours, carting the steel from store to piling site and return of unused steel to the Owners storage point, etc.

8.02.11 Plasticiser/Admixture when used as directed by the Engineer shall be included in piling rates.

8.01.12 The quoted rate for piling shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.

8.01.13 The quoted rate for boring in separate borehole shall be inclusive of performing of SPT at regular intervals as specified and collecting rock cores from boreholes, upto the depth as specified shall be inclusive of transporting to laboratory, testing and reporting of the results.

8.01.14 Unit rate for low integrity test shall be inclusive of mobilization of the entire set of equipment, computer readout, printer, and equipment which may not lave been included in the description but are essential for the satisfactory completion of the work as per internationally accepted practice. The rate quoted shall be inclusive of repeatability of test, preparation of pile top surface etc.

8.02.00 Measurement

8.02.01 Piling length shall be measurement by linear measurement from pile cut-off level to the tip of pile in meters upto second place of decimal separately for each diameter and capacity of pile. The length of pile to be cast above cut off level, as per specification, and as approved by Engineer, shall be considered for cement reconciliation only. Theoretical diameter of piles shall be considered for reconciliation of cement consumption. No extra payment shall be made for the length from existing ground to cut-off level.

8.02.02 Reinforcement steel shall be measured for reconciliation purpose only and the measurement shall be done for providing and placing reinforcement in piles, by weight in tones, up to third place of decimal in the following manner:

i) The weight shall be arrived at by multiplying the actual length measured alongwith standard hooks, rings or spirals, spacers, cranks, bends, authorized laps, etc. by sectional weight. These shall be submitted with supporting documents giving the schedule of bars with sketches. The sectional weight to be adopted shall be IS code's sectional weight. Nothing extra shall be payable to the contractor on account of difference in weight, if any, due to different methods adopted for issue and measurement.

ii) Standard hooks, cranks, bend, authorized laps, supports, hangers and chairs which are covered in approved bar bending schedule shall be measured in tones.

iii) Dowels, neither shown on the drawings nor instructed by the Engineer, but required for construction facilities shall not be measured.

8.02.03 Breaking off of piles, due to subsequent change in design cut off level, shall be measured separately. This shall be measured in cubic metres upto second place of decimal. This will be payable only when the pile is cast and on the basis of written instruction of the Engineer for lowering of COL.

8.02.04 Measurements for the item of boring in a separate borehole shall be measured in metres from ground level upto the depth as specified, upto second place of decimal. Item of work of boring in soil and coring in rock shall be measured separately for the actual length of boring in soil and coring in rock.

8.02.05 The item for pile integrity test shall be measured in terms of no. of piles tested.

ANNEXURE-A

Specific Requirements for Bored Cast-in-situ RCC Piles

A1.0 Minimum cement concrete grade M-25

Minimum cement content 400 Kg/M³

A1.1 Safe load

Diameter of Pile

Diameter of Pile (mm)	Vertical/ Compression (MT)	**Horizontal/ Lateral (MX)**	**Pul lout/Tension (MT)**
*	*	*	*
*	*	*	*

A2. Installation criteria

The installed pile(s) shall satisfy the following criteria.

A2.1 In Soil/weathered Rock

a) Minimum length of the pile shall be _____* m below COL.

b) The pile shall be terminated after penetrating through the strata having SPT penetration less than __* cm for ____* blows, for a minimum length of _____* times the diameter of the pile.

A2.2 In Rock

a) Piles shall be installed and socketed into the rocks for a length (socketing length) equal to _____* times the pile diameter subject to a minimum of _____* meter below the socketing horizon.

b) Socketing horizon shall consist of rock strata having minimum uniaxial compressive strength of _____* kg/sq.cm.

A3. Average cut-off level for tender design and initial load test can be assumed as _____* m below ground level.

A4. A protocol shall be signed between BHEL site and contractor regarding,

Strata at the founding depth

Installation criteria

Socketing depth

Density of bentonite before concreting

Slump of concrete.

Time interval between end of boring and start of concreting,

* Values shall be indicated separately depending upon subsoil strata of the site.

ANNEXURE-B

List of Equipments

SI.No	Description	Capacity No.
1.	Piling Rigs	
2.	Chisel	3 T min 6 T max
3.	High pressure Mud Pumps	10 HP min 25 HP max
4.	Bentonite mixing plants	
5.	Concrete batching plant	
6.	Soil testing equipments	

Note:

1. The no. and capacity of the piling equipment varies for each work.
2. Additional equipments shall be mobilized if required as per the directions of the Engineer to match the work schedule at no extra cost to the Owner.

ANNEXURE-C

Bentonite suspension used for piling work shall satisfy the following requirements

a) Liquid limit of bentonite when tested in accordance with IS: 2720(Part V) shall be more than 300 percent and less than 450 percent.

b) Sand content of the bentonite powder shall not be greater than 7 percent.

c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.034 and 1.10 gm/ml depending upon the pile dimensions and type of soil in which the pile is to be installed. However, the density of bentonite suspension after mixing with deleterious materials in the pilebore may be upto 1.25 gm/ml.

d) The Marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

e) The differential free swell shall be more than 540 percent.

f) The pH value of the bentonite suspension shall be between 9 and 11.5.

ANNEXURE-D

PILE DATA

1. Reference No. Location (Co-ordinates) _____area.
2. Sequence of Piling
3. Pile diameter & Type
4. Working level (Platform level)
5. Cut off level (COL)
6. Actual length below COL
7. Pile termination level
8. Top of finished concrete level
9. Date and time of start and completion of boring.
10. Depth of Ground water table in the vicinity.
11. Type of soil at pile tip
12. Method of boring operation
13. Details of drilling mud as used:

    i) Freshly supplied mud
    Liquid limit -

    Sand content -

    Density -

    Marsh viscosity -

    Swelling index -

    pH value -

    ii) Contaminated mud
    Density -

    Sand content -

14. SPT* N values in soil (from the nearest bore hole).
+UCS** value in rock (from the nearest bore hole).

* Standard penetration Test
** Unconfined compression strength

15. Chiseling if any, from..….. m to ….... m

16. Date and time of start and completion of concreting.

17. Method of placing concrete

18. Concrete quantity
Actual

Theoretical

19. Ref. Number of test cubes

20. Grade and slump of concrete

21. Results of test cubes

22. Reinforcement details:

Main Reinforcement	Stirrups: Type
No._____	No._____
Dia. _____	Dia._____
Depth _____	Spacing _____

23. Any other information regarding obstructions, delay and other interruption to the sequence of work.

TABLE -1

FREQUENCY OF SAMPLING AND TESTING

SI. No	Type of material work	Nature of Test/ characteristics	Method of Test & frequency	No. of test	Acceptance Criteria
1.	Pilebore size a) diameter b) length		Physical measurement	each pile	as per specification
2.	Founding level	to establish socketing horizon/ and or founding level & upto depth 5m below founding level.	in separate borehole meant for the purpose a) SPT in soils/ weathered rock b) Core & UCS value of rock	1 borehole for 100-150 piles or group of 150 Sqm	Annexure - B
3.	Bentonite (Mud) properties. a) Basic properties of bentonite before use. b) Contaminated mud from pile bore bottom before concreting	Liquid Limit, Marsh Viscosity, Specific gravity, sand content, swelling index, pH value. Density, sand content	in lab in lab	As per Cl. 5.7 Each Pile	As per Annexure C As per annexure C
4.	Position and Alignment	-	Physical or any Approved method	Each Pile	As per Cl. 4.3
5.	Cleaning of pilebore	-	As per Cl. 5.8	Each Pile	Pilebore be free from bored materialcuttings debris/sludge
6.	Reinforcement (R/F) Spacing of longitudinal R/F cover laps binding of laterals		Physical inspection and measurement	each cage	As per approved design
7.	Concrete a) Workability b) Cubes	 Slump cone test Compressive Strength test	 Each pile As per spec.	 As per Cl. 5.5 As per Cl. 5.5	 As per specification. As per IS: 456
8.	Materials like aggregate, sand etc.	As per technical specification for concrete and relevant IS codes			
9.	Pile head		Physical	each pile	