VOLUME – IA
Part I & II

TECHNICAL CONDITIONS OF CONTRACT (TCC)

BHARAT HEAVY ELECTRICALS LIMITED

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VOLUME-IA PART-I CHAPTER-I
PROJECT INFORMATION

BHEL is going to set up Flue Gas Desulphurisation (FGD) System Package in existing 1 x 800 MW North Chennai Thermal Power Plant Stage-III, Chennai, Tamilnadu, India for TANGEDCO (Tamilnadu Generation and Distribution Corporation). The Bidder shall acquaint himself by a visit to the site, if felt necessary, with the conditions prevailing at site before submission of the bid. The information given here in under is for general guidance and shall not be contractually binding on BHEL/Owner. All relevant site data /information as may be necessary shall have to be obtained /collected by the Bidder.

1.1	Project Title	:	1 x 800 MW North Chennai Coal Based Super Critical Thermal Power Project Stage III.
1.2	Plant capacity	:	800 MW
1.3	Type of project	:	Brown field
1.4	Owner	:	Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)
1.5	Plant site location	:	In the premises of North Chennai Thermal Power Station (NCTPS)
1.6	Location co-ordinates	:	80° 19' E to 80° 20' E Longitude 13° 13' N to 13° 18' N Latitude
1.7	Nearest Village	:	Ennore & Puzhudhivakkam Village
1.8	Nearest Town & City	:	Chennai (35 Km)
1.9	State Capital	:	Chennai (35 Km)
1.10	Nearest Railway Station	:	Athipattu Pudunagar (~ 5 Km) on Chennai –Vijayawada Line
1.11	Nearest Airport	:	Chennai (~ 60 Km)
1.12	Nearest Seaport	:	Ennore (~ 3 Km)
1.13	Nearest Road access	:	All weather road from Pattamandri on the Thiruvottiyur – Ponneri highway
2.0	**Meteorological Condition**		
2.1	Climate	:	Tropical, very dry and hot summer, dry and cold winter and good rain-fall in monsoon accompanied with strong wind
2.2	Site Elevation	:	(+) 10.0 Meter above Mean Sea Level
2.3	Ambient Temperature		
a.	Annual Maximum Mean Temperature	:	45 ºC

b.	Annual Minimum Mean Temperature	:	15 ºC
c.	Design ambient temperature	:	30 ºC
2.4	Relative Humidity		
a.	Maximum	:	90 %
b.	Minimum	:	36 %
c.	Design	:	75 %

VOLUME-IA PART-I CHAPTER-II
SCOPE OF WORKS

1.2.1 The scope of works covers Civil, Structural & Architectural works for Flue Gas Desulphurisation (FGD) System Package in existing 1 x 800 MW North Chennai Thermal Power Plant Stage-III, Chennai, Tamilnadu, India for TANGEDCO as mentioned below, including supply of all materials, labour, tools and plants (excluding Cement, MS round for earthing and Reinforcement & Structural steel and Borosilicate Lining material along with adhesive/membrane, primer paint & supervision for the application). The scope of work is indicative but not limited to the given below.

Major areas of work covered under FGD system are as mentioned below:

1. Absorber foundation
2. FGD control room
3. Ball mill building / Lime stone building
4. Gypsum dewatering building
5. RC pump & oxidation blower foundation
6. Limestone storage day silo supporting structure and foundation
7. Wet ball mill foundation
8. Booster fan foundation
9. SO2 analyser room foundation
10. ACW pump house
11. DG building
12. Reclaim Hopper Complex
13. BCN-1a/b
14. Tunnel-1a/b
15. Pent House
16. Limestone Crusher House
17. Limestone Silo
18. BCN-2a/b
19. Truck parking bay & Dozer shed
20. Lime storage shed
21. Gypsum storage shed
22. GHS-1a/b
23. Pump & Compressor House
24. Misc. tank foundation
25. Misc. pump/equipment foundations

26. Duct foundation
27. Pipe rack structure and foundation
28. Waste Water Building
29. Road/paving and drains
30. Misc. sumps
31. Plinth protection, paving & underground works
32. Sewage network, storm water drainage system, plumbing and sanitary works
33. Micro grading works
34. Pile and pile cap for all structures
35. Test piles installation and testing & report submission
36. Application of Borosilicate lining on the fluecan and duct up to flange near chimney shell in existing single steel flue Concrete Chimney of 275 meter height, including all minor civil, electrical works
37. Any other structures as per scope of works required for system completion

1.2.2 Note: The above provided list is indicative only for the bidder's guideline. **Any other building / structure / foundation not mentioned above, but required for completion of the package in total, deemed to have been included in the bidder's scope under this contract.** Such work will be executed under this contract by bidder as per the direction of Engineer in charge. If any item of work not available in the rate schedule of this contract, the rate will be fixed in line with clause 2.15.7 of GCC.

1.2.3 Cement, Reinforcement & Structural steel for civil & structural works & MS round for below ground earthing shall be provided by BHEL free of cost only for incorporation in the permanent work. Embedments /inserts required for the works in general shall be supplied by the bidder and payment shall be made as per corresponding item in BOQ. If BHEL provides Structural Steel for embedments/inserts from scraps (if available), payment shall be made as per corresponding item in BOQ.

1.2.4 The works to be performed under this contract consist of providing all labour, supervision, material, scaffolding, construction equipment's, tools and plants, temporary works, supplies including POL (Petroleum, oil & lubricants), transportation and all incidental items not shown or specified but reasonably implied or necessary for the proper completion of work in all respects. Testing of all materials, concrete, earthwork other allied works, preparation of bar bending schedules on the basis of construction drawings, preparation of fabrication drawings etc. are included in the rates of items of work.

1.2.5 The area of work shall be cleared of all vegetation, rubbish and other objectionable matter and materials removed shall be burnt or otherwise 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.

1.2.6 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.

1.2.7 The unit rates shall include all material equipment, fixtures, labour construction plant, temporary works and everything whether of permanent or temporary nature necessary for the completion of job in all respects.

1.2.8 The unit rates for various items of B.O.Q shall include all the stipulations mentioned in technical specifications and nothing extra over B.O.Q rates shall be payable.

1.2.9 Drawings indicating sufficient details for the construction as per the specification shall be furnished to the contractor in a phased manner.

1.2.10 The bidder should fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, local conditions, soil strata along with 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.

1.2.11 Commencement of test pile installation work and completion of all initial pile load test is very critical for this package. Hence, contractor has to mobilize minimum one hydraulic rotary rig for test pile works within 15 days of placement of LOI.

1.2.12 Special arrangements to be made for tackling pandemic – Contractor shall make arrangements for stay of workers within their premises as far as possible and/ or adjacent building and for implementation of STANDARD OPERATING PROTOCOL (SOP) as per government order. The transportation of workers to work place shall be arranged by the contractor in dedicated transport by ensuring social distance. Any person violating the pandemic measures published vide government order time to time will be liable to be proceeded for legal action as per the government order. Following shall be observed in work place:

1.2.13 All work places shall have adequate arrangements for temperature screening and provide sanitizers at convenient places.

1.2.14 Work places shall have a gap of one hour between shifts and will stagger the lunch breaks of staff, to ensure social distancing.

1.2.15 Use of AROGYA SETU will be encouraged for all employees both private and public.

1.2.16 Contractor shall sanitize their work place between shifts.

1.2.17 Large meetings to be prohibited. Spitting shall be strictly prohibited. Wearing of face cover is compulsory.

1.2.18 Government order (state/ center) being issued time to time for protective measures of pandemic shall be complied with strictly until government (state/ center) declares end of pandemic.

Standard operating procedure for social distancing for workplace and offices

The following measures shall be implemented by contractor for their office and workplaces:

1. All areas in the work premises including the following shall be disinfected completely using user friendly disinfectant mediums:
    a. Entrance gate of work place, office, if any
    b. Cafeteria and canteens, if any
    c. Meeting room, conference halls/ open area available/ verandah/ entrance gate of site, bunkers, porta cabins, buildings, etc.
    d. Equipments and lifts
    e. Washroom, toilet, sink, water points, etc
    f. Wall/ all other surfaces
2. For workers coming from outside, special transportation facility shall be arranged without any dependency on the public transport system. These vehicles should be allowed to work only with 30-40% passenger capacity.
3. All vehicles and machinery entering the premise should be disinfected by spray mandatorily.
4. Mandatory thermal scanning of everyone entering and exiting the work place to be done.
5. Medical insurance for the workers to be made mandatory.
6. Provision for hand wash & sanitizer preferably with touch free mechanism shall be made at all entry and exit points and common areas. Sufficient quantities of all the items should be available.
7. Work places shall have a gap of one hour between shifts and will stagger the lunch breaks of staff, to ensure social distancing.
8. Large gatherings or meetings of 10 or more people to discouraged. Seating at least 6 feet away from others on job sites and in gatherings, meetings and training sessions.
9. Not more than 2/4 persons (depending on size) will be allowed to travel in lifts or hoists.
10. Use of staircase for climbing should be encouraged.

11. There should be strict ban of gutka, tobacco, etc. and spitting should be strictly prohibited.
12. There should be total ban on non-essential visitors at sites.
13. Hospitals/ clinics in the nearby areas, which are authorized to treat pandemic patients, should be identified and list should be available at work place all the times.

VOLUME-IA PART-I CHAPTER-III

FACILITIES & CONSUMABLES IN THE SCOPE OF CONTRACTOR / BHEL

(SCOPE MATRIX)

Sl.No	Description PART I	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.1.1.0	**ESTABLISHMENT**			
1.3.1.1.1	FOR CONSTRUCTION PURPOSE:			
A	Open space for office	Yes		Free of charges as provided by Customer
B	Open space for storage	Yes		Free of charges as provided by Customer
C	Construction of bidder's office, canteen and storage building including supply of materials and other services		Yes	At bidder's own cost
D	Bidder's all office equipment's, office / store / canteen consumables		Yes	At bidder's own cost
E	Canteen facilities for the bidder's staff, supervisors and engineers etc.		Yes	At bidder's own cost
F	Firefighting equipment's like buckets, extinguishers etc.		Yes	At bidder's own cost
G	Fencing of storage area, office, canteen etc. of the bidder		Yes	At bidder's own cost
1.3.1.1.2	FOR LIVING PURPOSES OF THE BIDDER			
A	Open space		Yes	At bidder's own cost
B	Living accommodation		Yes	At bidder's own cost

Sl.No	Description PART I	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.1.2.0	**ELECTRICITY**			
1.3.1.2.1	Electricity For construction purposes	Yes		Chargeable to bidder as per prevailing rate of TANGEDCO
1.3.1.2.1.1	Single point source (In general) For detail, refer clause no. 1.3.4.1	Yes		Chargeable to bidder as per prevailing rate of TANGEDCO
1.3.1.2.1.2	Further distribution for the work to be done which include supply of materials and execution		Yes	At bidder's own cost
1.3.1.2.2	Electricity for the office, stores, canteen, & labour colony etc of the bidder which include:		Yes	
1.3.1.2.2.1	Distribution from single point including supply of materials and service		Yes	
1.3.1.2.2.2	Supply, installation and connection of material of energy meter including operation and maintenance		Yes	
1.3.1.2.2.3	Duties and deposits including statutory clearances for the above		Yes	
1.3.1.2.2.4	Demobilization of the facilities after completion of works		Yes	
1.3.1.2.3	Electricity for living accommodation of the bidder's staff, engineers, supervisors etc on the above lines. (in case BHEL provides this facility, the scope should be given without ambiguity)		Yes	

Sl.No	Description PART I	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.1.3.0	**WATER SUPPLY**			
1.3.1.3.1	For construction purposes:	Yes		Chargeable to bidder as per prevailing rate of TANGEDCO
1.3.1.3.1.1	Making the water available at single point	Yes		Chargeable to bidder as per prevailing rate of TANGEDCO
1.3.1.3.1.2	Further distribution as per the requirement of work including supply of materials and execution		Yes	At Bidder's own cost
1.3.1.3.2	Water supply for bidder's office, stores, canteen, and labour colony etc.		Yes	
1.3.1.4.0	**LIGHTING**			
1.3.1.4.1	For construction work (supply of all the necessary materials) At office storage area At the preassembly area At the construction site / area		Yes	At Bidder's own cost
1.3.1.4.2	For construction work (Execution of the lighting work / arrangements) At office storage area At the preassembly area At the construction site /area At the labour hutment		Yes	
1.3.1.5.0	**COMMUNICATION FACILITIES for site operations of the bidder**	**-**		
1.3.1.5.1	Telephone, Fax, internet, intranet, email etc		Yes	At Bidder's own cost

Sl.No	Description PART II	Scope to be taken care by		Remarks
		BHEL	Bidder	
	CONSTRUCTION FACILITIES			
1.3.2.1.0	**Engineering works for construction**			
1.3.2.1.1	Providing the construction drawings for all the equipment covered under this scope	Yes		Progressively
1.3.2.1.2	Detailing of drawings for construction		Yes	In consultation with BHEL
1.3.2.1.3	As-built drawings – wherever deviations observed and executed and also based on the decisions taken at site- example – routing of small bore pipes	Yes	Yes	”
1.3.2.1.4	Shipping lists etc for reference and planning the activities	Yes	Yes	”
1.3.2.1.5	Preparation of site construction schedules and other input requirements		Yes	In consultation with BHEL, As per requirement of BHEL targets
1.3.2.1.6	Review of performance (Form-14) and revision of site construction schedules in order to achieve the end dates and other commitments		Yes	
1.3.2.1.7	Weekly construction schedules based on Sl No 1.3.2.1.5		Yes	
1.3.2.1.8	Daily construction / work plan based on Sl No 1.3. 2.1.7		Yes	For daily monitoring meeting at site
1.3.2.1.9	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	
1.3.2.1.10	Preparation of preassembly bay, if any required		Yes	

Sl.No	Description PART II	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.2.1.11	Laying of racks for gantry crane if provided by BHEL or brought by the contractor / bidder himself			Applicable, if required at site

1.3.3 **OPEN SPACE**

1.3.3.1 Minimum Open space as made available by customer will be provided at free of charges to the contractor, for construction of temporary office shed, fabrication yard and storage area at the job site, contractor's stores shed(s).

1.3.3.2 BHEL shall not provide to the contractor any residential accommodation to any of his staff and the contractor has to make his own arrangements.

1.3.3.3 Contractor has to make his own arrangements for labour colony. The contractor shall provide adequate water arrangement for drinking/washing/bathing with required toilets, drainage system, and electrification etc. in labour colony at his own cost. Suitable paved area, as & if directed by customer based on hygiene requirement of labour, to be provided in the labour colony at the cost of contractor. The Contractor shall provide adequate arrangements for electricity requirements for labour colony.

1.3.3.4 Location and area requirement for office/storage sheds/ fabrication yard shall be discussed and mutually agreed to.

1.3.3.5 Any development of fabrication yard, storage area, etc shall be done by the contractor within the quoted rates of the contract.

1.3.4 **ELECTRICITY**

1.3.4.1 In general, Construction power will be provided to the contractor on prevailing rates of TANGEDCO on **chargeable basis** at one single point WITHIN THE PLANT AREA by BHEL. The contractor to Provide necessary energy meter for measuring the power consumption. The contractor shall make his own arrangement for further distribution with necessary isolator/LCB etc. However, based on request of Contractor and requirement of project, BHEL Site in charge, at his discretion, may provide construction power at multiple point (as close to work area as possible), for smooth execution of the work at site. If, BHEL provides electricity at more than one point (as close to work area as possible), it will be responsibility of the contractor to provide all the support necessary for enabling

BHEL for extending such provision to contractor. However, the Construction power provided to the contractor shall be on chargeable basis at prevailing rates of TANGEDCO. The contractor has to Provide necessary meter for measuring the power consumption. The contractor shall make his own arrangement for further distribution with necessary isolator/ LCB etc. Any dispute, BHEL engineer's decision shall be final and binding on contractor.

Construction power prevailing charges are as below,
The present LT tariff VI rate of TANGEDCO is

a) Consumption charges at Rs.12.00 per unit.
b) Maximum demand (MD) charges as applicable per month
c) Low Power Factor (LPF) charges
d) Electricity Tax on total amount
e) Any other miscellaneous charges charged by M/s TANGEDCO pertaining to construction power supply.

Note - The TANGEDCO tariff and tax may vary from time to time and the same is applicable for the bidder.

1.3.4.2 Necessary "Capacitor Banks" to improve the Power factor to a minimum of 0.9 shall be provided by the contractor at his cost. Penalty if any levied by customer on this account will be recovered from contractor's bills.

1.3.4.3 Any duty, deposit involved in getting the Electricity shall be borne by the bidder. As regards contractor's office shed also all such expenditure shall be borne by the contractor.

1.3.4.4 Provision for distribution of electrical power from the given single central common point to the required places with proper distribution boards, approved cables and cable laying including supply of all materials like cables, switch boards, pipes etc., observing the safety rules laid down by electrical authority of the State / BHEL / their customer with appropriate statutory requirements shall be the responsibility of the tenderer / contractor.

1.3.4.5 BHEL is not responsible for any loss or damage to the contractor's equipment as a result of variations in voltage / frequency or interruptions in power supply.

1.3.4.6 Contractor has to make their own arrangements for electricity requirement for labour colony at his own cost.

1.3.4.7 As there are bound to be interruptions in regular power supply, power cut/ load shedding in any construction sites, contractor should make his own arrangement for alternative source of power supply through deployment of adequate number of DG sets at their cost during the power breakdown / failure

to get urgent and important work to go on without interruptions. No separate payment shall be made for this contingency.

1.3.5 **WATER**

1.3.5.1 Water (Raw water) required for construction purposes will be provided at one single point WITHIN THE PLANT AREA on chargeable basis to contractor at the prevailing rates of TANGEDCO (tapping of water for construction is near Stage-I of North Chennai TPS as provided by M/s TANGEDCO). The contractor to Provide necessary meter for measuring the water consumption. The required pumps & accessories, pipes for drawing water from the given point and further distribution will be arranged by the contractor at their cost to go on without interruptions.

1.3.5.2 Successful Bidder to make his own arrangements for drinking water / water for sanitation for their labour & staff at bidders cost.

1.3.5.3 The water charges may vary from time to time as per TANGEDCO/ Metro conditions. However, the prevailing water charge is Rs 145.00 per Kilo litres and may be liable to changes. Any dispute regarding consumption, the BHEL engineer decision will be final. The TANGEDCO tariff and tax may vary from time to time and the same is applicable for the successful bidder.

1.3.5.4 Incase non-availability of water or the TANGEDCO is not able to supply the water, the contractor shall make his own arrangements of water suitable for construction purpose to have uninterrupted work (from M/s TANGEDCO approved source of water). No separate payment shall be made for any contingency arrangement made by contractor, due to delay / failure for providing water supply. Contractor has to make his own arrangements for their water requirement for their labour colony at their own cost**.**

1.3.6 **MATERIAL SUPPLY**

1.3.6.1 Supply / providing coarse aggregate, fine aggregate and all other materials required (except free supply materials i.e. cement, reinforcement steel, structural steel for structural works, structural steel for embedments/inserts from scraps (if available), foundation bolts & inserts/embedments supplied by manufacturing units of BHEL) for the work are in the scope of the contractor. BHEL shall provide Cement, reinforcement steel for civil works, structural steel for structural works and MS rounds for below ground earthing only for incorporation in the permanent work AS FREE SUPPLY. Embedments /inserts required for the works in general shall be supplied by the bidder and payment shall be made as per corresponding item in

BOQ. If BHEL provides Structural Steel from scraps (if available), payment shall be made as per corresponding item in BOQ.

1.3.6.2 Only for test pile installation work, supply of cement and reinforcement steel is in the scope of contractor for which payment shall be made as per corresponding item in BOQ.

1.3.6.3 Ordinary Portland Cement (OPC) shall be used for all structures except for foundations, underground structures & structures coming in contact with sea water including trenches & channels, wherein sulphate resistant cement with C3A content limited to 5% or Ordinary Portland cement with C3A content 5% to 8% shall be used depending on the presence of sulphate and chlorides in water/soil. Grade of cement shall be 43 conforming to IS:269 (latest version).

1.3.6.4 Regarding supply of cement, the cement shall be provided normally in bulkers and shall be unloaded in the silos (2 Nos minimum 100MT each per 30 / 60 Cum batching plant) to be installed by the bidder nearer to their batching plants. This is only minimum requirement and the number of cement silos shall be increased based on the site requirement. Making arrangement for unloading of cement into the silo and provision of necessary manpower support is in the scope of successful bidder within the quoted price. On advance request of the bidder, the cement shall be supplied in Bags for other than RCC works like masonry, flooring works etc. Advance request for supply of cement in bags shall be minimum two months. Provision of necessary storage arrangement for cement received in bags is in the scope of successful bidder within the quoted price.

1.3.6.5 The steel material will be issued from BHEL stores, within the plant premises. Collection and transporting to the place of work is in contractor's scope without any extra cost to BHEL. The steel will be issued to the agency in standard lengths. In some instances, for 8mm, 10mm &12mm dia reinforcement steel will be supplied in coil form. No extra claims will be entertained against issue of Non-standard lengths of steel and de coiling of 8mm, 10mm &12mm dia. steel.

1.3.6.6 If any matching sections of steel are not available with BHEL, contractor may arrange these sections from customer approved manufacturers on certification of BHEL and the landing cost of sections to site will be reimbursed based on the prevailing rate at SAIL at the time of procurement at the nearest SAIL outlet with the freight charges against supporting document.

1.3.6.7 **Fine aggregate**

1) Fine aggregate source shall be manufactured crushed stone or rock sand, excluding fines which are by products/rejects of coarse aggregate

production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

2) The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone or 4% for natural sand.

3) The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

Crushed stone sand

i. Concrete subject to abrasion 1% by weight

ii. All other concrete 3% by weight

iii. There shall be no clay or fine silt present.

iv. The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on a IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

v. Fine aggregate shall not contain appreciable amounts of flaky and/or elongated particles.

vi. The water absorption of fine aggregate, shall be as per relevant standards.

vii. Fine aggregate subjected to five cycles of the soundness test, specified in IS: 2386 (part-5), shall not show a loss exceeding 10% when sodium sulphate solution is used and 15% when magnesium sulphate solution is used, except where approved otherwise.

4) Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS:383.

5) The grading of the aggregates should be such as to produce a concrete of the specified proportions which will work readily into position without segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

6) A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of salt adhering to the aggregate is found to be unacceptably high.

1.3.6.8 **Coarse aggregate**

1) Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The specific gravity of the

coarse aggregate shall not be less than 2.5 t/m3. Aggregate of crushed natural stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm2 when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

2) The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

3) Samples of aggregates shall be submitted to the purchaser, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the purchaser have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

1.3.6.9 **BOROSILICATE GLASS BLOCKS**

1.3.6.6.1 Borosilicate glass blocks will be supplied by BHEL free of cost. However, handling of Borosilicate Glass blocks procured by BHEL for this tender scope, at site, including transportation from BHEL Stores/ Contractor's Stores to work/ erection area will be in the scope of contractor. No Extra payment shall be made for this work.

1.3.6.6.2 BHEL shall supply borosilicate glass block lining system, including closed cell borosilicate glass blocks, adhesive membrane and compatible primer. BHEL shall also arrange for onsite QA supervision/ expert supervision by borosilicate glass manufacturer during installation of borosilicate glass blocks by the Bidder in the flue can.

1.3.6.6.3 The borosilicate glass blocks shall be of thickness 51 mm. Nominal adhesive/ membrane thickness shall be minimum 3 mm behind & between each block. A 1.5 mm thick layer should be troweled onto the liner as well as to the sides and back of each block before installation. Double buttering technique shall be used to ensure full bond of each block to the liner and to each other. Installation of blocks shall be carried out as per specification, drawings, direction of engineer in charge, in expert supervision by borosilicate glass manufacturer and accepted by the customer. Contractor shall prepare the installation procedure taking into consideration the requirements of Borosilicate glass block manufacturer/ supplier and get the same approved by TANGEDCO & BHEL before installation including verification of installation procedure & workmanship standards of the lining system.

1.3.6.6.4 The surface preparation (before priming) by blast cleaning to Sa 2 1/2 of internal surface of flue can, application of suitable primer as per manufacturer specification, surface cleaning (after priming) using hot air, application of adhesive membrane and installation of borosilicate glass block at any height on ground or over erected position in flue can including cost of skilled labour, material, tools & tackles, equipment etc. all complete required to complete the job at any height in the scope of the bidder.

1.3.6.6.5 Installation of borosilicate glass block lining shall be performed strictly under supervision of BOROSILICATE GLASS BLOCK supplier's representative. Supervisory person of borosilicate glass block supplier shall be arranged by BHEL. However, in addition to the above, continuous supervision by the bidder's engineer is very essential at all stages of installation of borosilicate glass blocks.

1.3.6.6.6 The bidder shall follow the instruction & guidance of the Borosilicate Glass Block supplier from the time the material is issued to the Contractor, during handling, transportation till completion of installation of Borosilicate Glass Block & handing over of the flue can with borosilicate lining system.

1.3.7 CONSUMABLES

All consumables, like gas, electrodes, chemicals, lubricants etc. required for the scope of work, shall be arranged by the contractor at his own cost unless otherwise specifically mentioned in the contract. Prior approval from BHEL Engineer In-Charge/ TANGEDCO shall be obtained for all the consumable to be used in permanent work.

In the event of failure of contractor to bring necessary and sufficient consumables, BHEL may arrange for the same at the risk and cost of the contractor. The entire cost towards this along-with overhead shall be paid by the contractor or deducted from the contractor's bills.

1.3.8 LIGHTING FACILITY

Adequate lighting facilities such as flood lamps, hand lamps and area lighting shall be arranged by the contractor at the site of construction, and contractor's material storage area etc. at his cost.

1.3.9 CONTRACTOR'S OBLIGATION ON COMPLETION

On completion of work, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and leveled and debris shall be removed as per instructions of BHEL by the contractor at his cost. In the event of his failure to

do so, the expenditure towards clearance of the same will be recovered from the contractor. The decision of BHEL Engineer in this regard is final.

1.3.10 DEWATERING

Contractor shall ensure at all times that his work area & approach/ access roads are free from accumulation of water, so that the materials are safe and the erection/ progress schedule are not affected. No separate claim in this regard shall be admitted by BHEL. No separate payments for dewatering of subsoil, surface water or catchments water, if required, at any time during execution of the work including monsoon period shall be considered by BHEL. Dewatering required for control of sub-soil water for construction of various foundations for the package shall be paid under relevant item(s) available in the price schedule. Situation of flood shall be dealt separately and situation of flood shall be accounted upon certification of Engineer In-Charge or as per announcement of local administrative body. Necessary temporary drains and approach roads shall be provided during rainy season (as per site requirement) to ensure free movement of vehicle, machinery and man power.

1.3.11 BID DRAWINGS

Bid drawings enclosed for information and this may get revised during execution.

VOLUME-IA PART-I CHAPTER-IV
T&Ps TO BE DEPLOYED BY CONTRACTOR

1.4.1 All the tools and plants required for satisfactory completion of the work have to be arranged by the contractor.

1.4.2 The contractor is required to arrange the following tentative Major T&Ps and other T&Ps for the satisfactory completion of the work.

A. Structural works		
Sr No	**Major T&Ps**	**Mobilizing time from the date of start of work**
A1	1 Nos. 150 T capacity crawler crane for erection.	As per BHEL requirement at site.
A2	1 Nos. 100 T/ 75 T capacity crawler crane for erection.	As per BHEL requirement at site.
A3	1 Nos. 75 T capacity crawler crane for Fabrication	As per BHEL requirement at site.
A4	1 Nos. 45 T capacity Tyre mounted crane	As per BHEL requirement at site.
Sr No	**Other T&Ps**	**Mobilizing time from the date of start of work**
A5	2 nos. hydra (10/ 12 T cap)	1 no. – Within 90 days. Balance progressively as per site requirement
A6	2 Nos. Radial drill machine	As per BHEL requirement at site.
A7	1 no. magnetic base drill machine	As per BHEL requirement at site.
A8	2 nos. submerged arc welding machine	As per BHEL requirement at site.
A9	4 nos. flux coated arc welding (FCAW) machine	As per BHEL requirement at site.
A10	10 nos. welding rectifier	6 Nos. within 120 days and balance as per site requirement.

A11	1 no. trailor – 15T	1 no. Within 120 days. Balance as per site requirement.
A12	2 no. power driven HSFG bolt tightening m/c	As per BHEL requirement at site.
A13	1 no. torque tightening m/c. (2 no. Capacity up to 30 dia HSFG bolt tightening)	As per BHEL requirement at site.
A14	Sufficient quantity of steel ladders for approach up to the top of each erected column to be required during erection of columns.	As per BHEL requirement at site.
A15	Power winch – 3T - 2 no's for structural erection	As per BHEL requirement at site.
A16	Power winch – 5T - 1 no's for structural erection	As per BHEL requirement at site.
A17	1 no ultra-sonography testing machine with printing facility for structural work.	As per BHEL requirement at site.
A18	1 nos. Painting equipment sets complete with compressor, hopper, screen, blasting hose pipe, nozzle airless/conventional spray (within CGI temporary cover shed)	As per BHEL requirement at site.
A19	1 no. Plate Bending Machine	As per BHEL requirement at site.
B. Civil works		
Sr No	**Major T&P**	**Mobilizing time from the date of start of work**
B1	Bored cast in situ hydraulic rig – 5 nos	1 no within 15 days and balance as per BHEL requirement in site
B2	2 nos. excavator equivalent to capacity of Pocklain CK90	1 no. within 90 days and balance in a progressive manner depending up on the requirement.
B3	1 no. 30 Cum/Hr & 1 No. 60 Cum/Hr automatic concrete batching plant with printing facility– and DG backup. With minimum 2 Nos of silo (100MT each)	1 no 30 Cum/Hr batching plant to be commissioned within 60 days.

		1 no 60 Cum/Hr batching plant to be commissioned as per site requirement.
B4	2 Nos Truck mounted concrete mixer cum pump along with placing boom minimum 36 m high Concrete boom placer (36m)	1 No within 120 days and balance as per BHEL requirement at site
B5	2 nos. concrete pump (60 cum/ hr min capacity & lift 90M)	1 No within 90 days and balance as per BHEL requirement at site
B6	4 nos. transit mixer (5/6 M3 capacity) with standby 1 no.	2 nos within 60 days. Balance progressively as per site requirement.
Sr No	**Other T&Ps**	**Mobilizing time from the date of start of work**
B7	4 No. Back hoe loader like JCB	2 no. within 90 days and balance as per site requirement.
B8	6 nos. dumper (Min 15 cum each)	2 nos. Within 90 days. 2 nos. within 120 days. Balance as per site requirement.
B9	2 nos. diesel Mixer machine of 0.5 cum capacity	As per BHEL requirement at site.
B10	3 nos. self-priming dewatering pump 5 HP (diesel)	Within 90 days.
B11	3 nos. self-priming dewatering pump 5 HP (electric)	Within 90 days
B12	4 nos. curing pump – 1.5 /2 HP (pump for curing at heights)	Within 90 days.
B13	4 nos. reinforcement bending machine	3 nos. within 90 days and balance progressively as per requirement
B14	1 no. vibro earth compactor or Vibromax or equivalent - 8/10T	As per BHEL site requirement.
B15	6 nos. reinforcement cutting machine	2 nos. within 90 days, 2 nos. within 120 days and balance progressively as per requirement

B16	Vacuum dewatered flooring machine – 1 nos	As per BHEL requirement at site
B17	MS scaffolding pipe / ACROW PIPE	As per BHEL requirement at site
B18	MS scaffolding pipe cup lock system /Doka D3 load bearing tower system.	As per BHEL requirement at site for various decks
B19	1 nos. power driven earth rammer (Roller Type 1/2 T)	As per BHEL requirement at site
B20	Civil laboratory equipment's as per list IN Sl 1.4.4.2 with temporary building one AC lab size 4.5mtrx6mtr and 1 non AC lab 4.5 mtrx4.5 mtr.	Within 90 days.
B21	2 nos. building hoist	As per BHEL requirement at site
B22	2 no total station with adequate arrangement for Surveyors.	1 no. Within 75 days. and balance progressively as per requirement
B23	2 no theodolite 1 second accuracy	1 no. within 75 days. and balance progressively as per requirement
B24	5 no's auto level & staff + 2 no's as required	2 nos. Within 75 days. And balance as per requirement.
B25	120 no's concrete cube moulds	60 nos with in 90 days and balance progressively as per requirement
B26	Various decks (fan decks, pump decks,etc.) scaffolding materials / structural steel	At the time of raft casting.
B27	Adequate no. of small trucks 2T/5T for shifting of reinforcement/cement/shuttering etc. within site	As per BHEL requirement at site
B28	3 nos. drinking water tank – 5000 lit.	1 nos. Within 90 days. Balance as per site requirement.

B29	4 nos. mobile toilet blocks for labour use.	1 no's within 90 days balance within 120 days.
B30	2 nos. truck mounted 125 KVA DG set	1 no. within 90 days and balance as per requirement at site.
B31	Construction power cable	As per Requirement
B32	Construction water Pipeline	As per Requirement
B33	1 no. Concrete Paver machine	As per Requirement
B34	1 no. trailor for shifting of crawler mounted equipment's like Poclain, Dozer	As per site requirement.
B35	2 nos. Motorized External Platforms (sky climber)	As per site requirement.
B36	Minimum 20 nos. Concrete vibrator with adequate needle (diesel/power nos.)	6 Nos (at least 3nos. diesel driven) within 90 Days. Balance as per site requirement.
B37	Portable fire extinguishers as below: Soda acid – 10 sets. Dry chemical powder – 10 sets CO2 – 10 sets. Water & sand bucket (4 buckets in one stand) – 10 sets. Fire hose with nozzle (50 M length) – 5 sets.	25% of each kind within 90 days and balance progressively within 120 days.
B38	2 no. compression testing machine (200 T cap)	1 No. within 90 days and balance as per requirement.
C. Chimney- Borosilicate lining application work		
C1	Passenger lift cabin along with Power winch for carrying min 6nos	As per site requirement.
C2	Platform (covering total flue can dimension) with winches for application of Borosilicate lining	As per site requirement.

C3	Shot Blasting Equipment	As per site requirement.
C4	Welding Rectifier	As per site requirement.
C5	Mixing Machine for mixing of adhesives	As per site requirement.

Note:

1. T&P shown in the above-mentioned list and the mobilization schedule is tentative requirement considering parallel working. However, mobilization schedule modification as well as no. of T&Ps as mutually agreed at site for major T&Ps, have to be adhered to. Numbers/ time of requirement will be reviewed time to time at site and contractor will provide required T&P/ equipment's to ensure completion of entire work within schedule/target date of completion without any additional financial implication to BHEL. Vendor shall give advance intimation & certification regarding capacity etc. prior to dispatch of heavy equipment's. Also on completion of the respective activity, demobilization of T&P in total or in part can be done with the due approval of engineer in charge. Retaining of the T&P's during the contract period will be mutually agreed in line with construction requirement.

2. All T&P and all IMTEs, which are required for successful and timely execution of the work covered within the scope of this tender, shall be arranged and provided by the contractor at his own cost in working condition.

3. In the event of non-mobilization of Tools, Plants, Machinery, Equipment, Material or non-availability of the same owing to breakdown and as a result progress of work suffered, BHEL reserves the right to make alternative arrangement (available or higher capacity) in line with SCC clause no. 4.2.1.7 and hire charges shall be applicable as under:

   Case 1: BHEL provides its own Capital T&P: In case the BHEL provides any T&P which is owned by BHEL, hire charges (as per BHEL norms) will be recovered from the contractor as per the prevailing BHEL corporate hire charges.

   - In case the T&P is specifically listed in "T&Ps to be deployed by Contractor", 'Rates of hire charges applicable to outside agencies other than contractors working for BHEL' will apply.
   - In case the T&P is not specifically listed in "T&Ps to be deployed by Contractor", 'Rates of hire charges applicable to contractors working for BHEL' will apply.

Case 2: BHEL provides hired T&P: In all cases other than that specified in Case 1 above, actual expenses incurred by BHEL along with applicable overheads will be back-charged to the contractor

4. In the event of need of change of type of any of major T&Ps, approval shall be taken from BHEL Engineer in-charge prior to mobilization. The decision of Number of T&P required due to replacing the enlisted T&P as per above table, shall be taken after analyzing the production capacity and suitability of both the T&Ps.

5. Clause no. 1.6.1 of this specification may please be referred for date of start of work.

6. Mobilization of concrete boom placer in place of concrete pump will be allowed based on site requirement of BHEL.

1.4.3 In addition to the above, any other tools and plants required for execution of the above work are in contractor's scope.

1.4.4 The Bidder shall establish and maintain a field laboratory with AC Facility on the site and this laboratory shall be available at all time for testing. Successful bidder shall submit scheme for lab arrangement within 7 days from date of commencement of work at site for approval of BHEL engineer in-charge.

1.4.4.1 The laboratory must have qualified technicians to carry out all tests and must be adequately equipped to ensure that all necessary testing work can carried out in compliance with the standards.

1.4.4.2 Field and laboratory testing procedures for materials follow Indian Standard Specifications with necessary equipment like as given in table below:

	CONCRETE TESTING EQUIPMENT			
SL NO	**NAME OF TEST**	**NAME OF EQUIPMENT**	**SIZE OF EQIPMENT**	**IS REF.**
1	Initial & final setting time, Consistency of cement	Vicat Apparatus with desk pot	Standard	IS 5513
2	Shrinkage of cement, Auto Clave Test	Le Chatelier's appratus Auto Clave Equipment	Standard	IS 5514
3	Abrasion value test	Los Angles Abrasion testing machine	Standard	IS 2386
4	Aggregate Impact value test	Aggregate Impact value testing	Standard	IS 9377

		machine with blow counter		
5	Aggregate crushing value test	Crushing value apparatus	Standard	IS 2386
6	Flakiness index	Thickness gauge for measuring flakiness index	Standard	IS 2386
7	Elongation Index	Elongation guage	Standard	IS 2386
8	Bulk density, voids and bulking apparatus	Measuring cylinders	3, 5,10 & 15 liters cylinders	
9	Workability of concrete	Slump cone	Standard, at least 04 no's	IS 456
10	Specific gravity of aggregates	Pycnometer	Standard, at least 02 no's	IS 383
11	Cement mortar cube vibrating	Motorised vibration machine for cement testing	Standard	IS 4031
12	Course aggregate Sieve analysis (Concrete & Road Works)	Sieve set	450mm dia GI Frames Size: 125 mm, 90 mm, 75 mm, 63 mm, 53 mm, 40 mm, 20 mm, 16 mm, 12.5 mm, 10 mm, 4.75 mm, Pan and cover	IS 383
13	Fine aggregate sieve analysis	Sieve set	200 mm dia Brass sieves; Size 4.75 mm, 2.36 mm,1.18 mm 600 micron, 300 micron, 150 micron, 75 micron, 75 micron, Pan and cover	IS 383
14	Sieve Shaker	Motorized Sieve shaker	Mfg. Catalogue	
15	Silt content check	Sand silt content beaker	Standard	

	Soil Testing Equipment			
1	Liquid limit test	Liquid limit apparatus	Standard	IS 2720
2	Core Cutter test	core cutter apparatus	Rammer, 6 no's of std. core cutter mould, dolly	IS 2720
3	Proctor density test	Std proctor Compaction apparatus	Standard	IS 2720
4	Moisture Content	Rapid moisture meter	Standard, at least 04 no's	IS 2720

1.4.5 Contractor shall have at all times experienced operators and technicians for routine and breakdown maintenance of the equipment. Any delay in rectification of defects will warrant BHEL rectifying the defect and charging the cost to the contractor.

1.4.6 In construction projects of this magnitude, all the areas / approaches may not be ready. In such cases consolidation of ground and arrangement of sleeper's / sand bag filling etc for safe operation / movement of equipment including cranes / trailers etc shall be the responsibility of the contractor at his cost. No compensation on this account shall be payable.

1.4.7 Crane operators deployed by the contractor shall be tested by BHEL before they are allowed to operate the cranes.

1.4.8 The age of contractor deployed cranes upto 150T should be within 15 years as on date of deployment. Contractor has to provide documentary proof for the age of the crane at the time of deployment to BHEL Engineer.

1.4.9 In case, cement is issued through bulkers being supplied from manufacturer/ stockiest, the same shall be emptied in cement silos of batching plant and necessary assistance shall be provided by contractor without any additional financial implication to BHEL. Contractor to note that batching plant being established at site shall be as mentioned in the list of Tools & Plants to be deployed by the contractor.

1.4.10 **CRANE OPERATOR FOR CRANES PROVIDED BY CONTRACTOR**

1.4.10.1 Must be capable of independently operating hydraulic/ mechanical crawler/ tyre mounted cranes of respective categories.

1.4.10.2 Must have minimum 2 years' experience in operation of hydraulic/ mechanical crawler/ tyre mounted cranes in respective categories & hold valid HMV/ TRANS license. Should be able to read and interpret the operation and maintenance manual, boom load chart, boom angle and other indicating devices.

1.4.10.3 Operator shall have latest physician's certification for their physical fitness in vision with/ without lenses & adequate hearing with or without hearing aid.

VOLUME-IA PART-I CHAPTER-V
T&Ps PROVIDED BY BHEL

1.5.1 BHEL will provide suitable higher capacity cranes above 150T capacity to the contractors as per the requirement at the discretion of BHEL on free of hire charges on shareable basis. The cranes of 150MT and below 150MT is in the scope of bidder. Before requesting BHEL for higher capacity crane, agency has to ensure that all cranes of their scope 150MT and below should be available at site.

1.5.2 Besides the T & P mentioned above, which is being made available to the contractor on free of hire charges, any additional crane and other T & P which may be required for successful and timely execution of the work covered within the scope of this tender shall be arranged and provided at site by the contractor at his cost.

1.5.3 BHEL's Crane is only for erection purpose and shall not be available for material handling or transportation purpose. Contractor shall make their own arrangements for material transportation to erection site.

1.5.4 BHEL may provide either BHEL owned cranes or hired cranes at the discretion of BHEL.

1.5.4.1 In the event of providing BHEL Cranes:

1.5.4.1.1 For all BHEL's own cranes of capacity greater than 150T, BHEL shall provide operators, free of charges.

1.5.4.1.2 Fuel, lubricants and consumables for BHEL's own cranes of capacity greater than 150T, are to be arranged by the contractor within the quoted rates.

1.5.4.1.3 Tentative List of consumables required to be provided by contractor is as below:

1.5.4.1.3.1 Engine Oil 15 W 40
1.5.4.1.3.2 Fuel Filters
1.5.4.1.3.3 Air Filters
1.5.4.1.3.4 Hydraulic Filters
1.5.4.1.3.5 Hydraulic Oil –Servo 68
1.5.4.1.3.6 Gear Oil- Servo 90
1.5.4.1.3.7 Engine oil Filter
1.5.4.1.3.8 Oil Separator Filter
1.5.4.1.3.9 Rope- CRG 100 Grease
1.5.4.1.3.10 Grease- Servo Multi-Purpose Grease

1.5.4.1.4 Maintenance for the BHEL crane shall be carried out by BHEL. Bidder shall extend support (if required) for routine maintenance works.

1.5.4.2 In the event of providing hired Cranes:

1.5.4.2.1 Crane operators for hired cranes will be provided by BHEL, on free of charges.

1.5.4.2.2 The fuel for the crane is to be arranged by the contractor.

VOLUME-IA PART-I CHAPTER-VI
TIME SCHEDULE

1.6.1 TIME SCHEDULE

1.6.1.1 The date of commencement of contract period shall be the date of commencement of work at site which shall be within 15 days from the date of Letter of Intent (LOI). In case of discrepancy, the decision of BHEL engineer is final.

1.6.1.2 Work of Application of Borosilicate lining in existing Chimney shall be started within 15 days of placement of LOI.

1.6.1.3 Test pile work shall be commenced within 15 days of placement of LOI.

1.6.1.4 The entire scope of work as detailed in the Tender Specification shall be completed within 25 (Twenty five) months from the date of commencement of work.

1.6.1.5 During the total period of contract, the contractor has to carry out the activities in a phased manner as required by BHEL and the program of milestone events.

1.6.1.6 The contractor is required to refer Form 15 in Volume 1- BOOK 2 for all the instructions to be taken immediately after receipt of LOI.

1.6.2 MOBILISATION

The Contractor has to subsequently augment his resources in such a manner to achieve the COMPLETION SCHEDULES.

The above time allowed for completion of work including Sundays and Holidays is from the date of commencement of work. Detailed program to be prepared by the tenderer taking in to consideration of the COMPLETION SCHEDULES /site decision on drawings flow (latest) and submitted for BHEL's approval.

1.6.3 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.

1.6.4 In case the project is to be advanced, the works in the scope of the contractor is to be advanced to meet the project requirement. No extra payment whatsoever shall be paid on this account.

1.6.5 SUBMISSION OF L3 SCHEDULE

The contractor shall submit and a detailed area/structure wise L3 schedule within 15 days from date of issue of LOI, in consultation with BHEL based on the

tentative schedule provided as per the clause 1.6.7. The detailed L3 schedule shall be approved by BHEL and same shall be implemented. Bidder shall submit L3 schedule in MS Projects (or any suitable format as agreed between contractor and BHEL engineer in-charge) to meet the agreed project schedule covering various mile stone activities and their split up details such as construction, procurement of materials, fabrication & execution activities. This schedule shall also clearly indicate the interface facilities/inputs to be provided by BHEL/Customer and the dates by which such facilities/inputs are required. The schedule shall be acceptable to BHEL for meeting their mile stone targets/schedule.

1.6.6 GUARANTEE PERIOD FOR THE PACKAGE

Guarantee period of 12 months shall commence from the date of completion of the whole work certified by the BHEL Engineer.

1.6.7 CONSTRUCTION SCHEDULE

Tentative construction schedule for the scope of works is as mentioned below. Overall completion period for the completion of works and submission of final bill is 25 months.

Sl. No.	Area	Completion from the date of commencement of work
1.	Test piles installation	Progressively by 1st Month
2.	Load testing on test piles and report submission	Progressively by 2nd month
3.	Completion of Application of Borosilicate Lining in existing Chimney	Progressively by 4th Month
4.	Job pile installation	Progressively by 8th month
5.	Absorber foundation	Progressively by 9th month
6.	Duct support foundation & structure	Progressively by 7th month
7.	Booster fan	Progressively by 8th month
8.	DG set	Progressively by 8th months
9.	Compressor house	Progressively by 12th months
10.	Ball mill foundation	Progressively by 8th months
11.	Tank foundations	Progressively by 9th months
12.	Lime stone silo foundations	Progressively by 9th months
13.	FGD control room foundation	Progressively by 7th months
14.	FGD control room	Progressively by 11th months

15.	ACW/ DMCW pump house	Progressively by 7th month
16.	Gypsum dewatering building	Progressively by 13th Month
17.	Lime stone handling system foundations	Progressively by 8th month
18.	Lime stone crusher deck	Progressively by 12th month
19.	Superstructure works of lime stone handling system	Progressively by 12th month
20.	Ball mill building	Progressively by 12th month
21.	Lime stone slurry pump house	Progressively by 10th month
22.	Lime stone silo foundation	Progressively by 8th months
23.	Oxidation blower foundation	Progressively by 9th months
24.	Gypsum shed	Progressively by 15th month
25.	Trestles, conveyor galleries	Progressively by 12th month
26.	Truck parking bay & Dozer shed	Progressively by 16th month
27.	Other miscellaneous foundations	Progressively upto 17th month
28.	Paving, roads & drains	Progressively upto 21th month
29.	Micro levelling and grading works in plant area as per site directions	Progressively upto 23th month
30.	Documentation, final reconciliation, final bill submission and contract closing	Progressively upto 25th month

1.6.8 **Intermediate Milestones** –

S.No.	Description	Completion month from the contractual date of start of work	Intermediate Milstone
1.	Completion of Absorber foundation	9th month	M1
2.	Completion of Gypsum dewatering building	13th month	M2

Note: Please refer Sl No. 6 Part II Chapter-1 of Technical Conditions of Contract (Volume 1A of Volume I Book I) for Penalty for Intermediate Milestones

1.6.9 The above schedule is tentative. In case the activities in the schedule are to be advanced, the related civil/ structural activities in the scope of the contractor are to be advanced to meet the project requirement. No extra

payment whatsoever shall be paid on this account.

1.6.10 The above schedule is for entire completion and handing over the structure/ Building to BHEL.

1.6.11 The foundations, pedestals, floors, etc, required for the mechanical equipment erection/ structural erection shall be handed over to BHEL progressively within the scheduled period given in the above table, as per the BHEL site requirement.

1.6.12 The left out minor finishing works shall also be completed and handed over to BHEL within the contract period.

1.6.13 The bidder must submit a detail schedule (area wise) for completion of work to meet the work schedule given in clause no. 1.6.7 within 15 days from the date of issue of LOI.

1.6.14 The major activities as mentioned against the work schedule given in clause no.1.6.7 are to be indicated in detailed schedule which shall be prepared by the bidder.

1.6.15 **RECORDS TO BE MAINTAINED AT SITE**

1.6.15.1 Record of Quantity of FREE/Chargeable items issued by BHEL must be maintained during contract execution. Also reconciliation statement to be prepared at regular intervals.

1.6.15.2 The under mentioned Records/ Log-books/ Registers applicable to be maintained.

i. Hindrance Register.
ii. Site Order Book.
iii. Test Check of measurements.
iv. Cement Supply and Consumption Daily Register
v. Records of Test reports of Field tests.
vi. Records of manufacture's test certificates.
vii. Records of disposal of scraps generated during and after the work completion.
viii. List of T&Ps and MMEs

VOLUME-IA PART-I CHAPTER-VII
TERMS OF PAYMENT

1.7.0 TERMS OF PAYMENT

1.7.1 Secured Advance

Not applicable

1.7.2 Advance for Mobilization

1.7.2.1 Interest bearing advance for Mobilization, limited to 5% of the contract value will be paid against submission of bank guarantee of at least 110% of the advance valid for the contract period, which will be recovered from the first running bill onwards. The advance for mobilization shall be paid as under.

1.7.2.2 2% of contract value after receipt of initial Security Deposit, security deposit for consortium as applicable, as per relevant clauses in the GCC/TCC along with unqualified acceptance of detailed letter of intent.

1.7.2.3 1.5% of contract value on completion of site Mobilization of Machinery & T&P as given below and on certification by site in-charge for compliance provided clause no. 1.7.2.2 as mentioned above is also complied with.

i) Back hoe loader like JCB – 1 No.

ii) Excavator equivalent to capacity of Pocklain CK90 or higher to suit the requirement of work at site – 1 No.

iii) Dumper (Min 15 CUM each)– 3 Nos.

iv) Concrete pump (60 CUM/ hr min capacity & lift 90M) – 1 No.

Note: Concrete pump can be replaced by concrete boom placer in addition to those mentioned above in sl. no. (iv) with due approval of Engineer In- Charge

1.7.2.4 1.5% of contract value on completion of site mobilization of Machinery & T&P as given below in addition to the above, and on certification by site in-charge for compliance.

i) Automatic concrete batching plant with printing facility (minimum capacity of 30 CUM/Hr each) with DG backup with minimum 2 Nos. of silo per batching plant (100MT each)-1 No.

ii) Self-priming dewatering pump 5 HP (diesel/electric)- 5 Nos.

iii) Transit mixer (5/6 M^3 capacity) – 2 Nos.

iv) Truck mounted concrete mixer cum pump along with placing boom minimum 36 m high i.e. Concrete boom placer (36m) – 1 No.

1.7.2.5 Payment of the advance as specified herein and recovery of the advance will be

as per clause 2.13 of GCC. Option of availing the interest-bearing mobilization advance is left with the bidder.

1.7.3 Interim Payment

1.7.3.1 Interim bills in the form of monthly running bills prepared by the contractor in soft as well as Hard copies shall be based on the quantities executed and measured.

1.7.3.2 95% item rate shall be released after completion of works certification by Engineer in charge.

1.7.3.3 5% of the item rate shall be released after submission of the quality check formats as per the quality plan for the quantum of work billed and duly certified by engineer.

1.7.3.4 Retention amount shall be as per GCC.

1.7.3.5 Royalty/seigniorage charges (if any) for excavation inside plant premises as applicable as per Govt of Tamilnadu shall be reimbursable to the bidder by BHEL for the quantum of earth work done on submission of necessary proof of payments as required by M/s TANGEDCO for reimbursement.

1.7.4 Royalty for construction materials:

Payment of royalty for construction materials viz. coarse aggregates, fine aggregates, borrowed earth, etc. is to be made by contractor and challan of deposit of royalty/ seigniorage fee shall be submitted to BHEL along with RA bill.

In absence of production of challan following methodology shall be adopted:

Sl. No.	Construction Material	Rate of seigniorage/ royalty per cum (In rupees) to be withheld in RA bill	Volume to be considered for calculation	Remarks
1	Coarse aggregate	45.00	A. For RCC: (As per approved design mix proportion + wastage as specified in IS 383) x	Rate mentioned herein is indicative and for information. Actual prevailing rate
2	Fine aggregate	45.00		

			(Total volume of concrete claimed in RA bill) B. For PCC: (As per DSR recommendation + wastage as specified in IS 383) x (Total volume of concrete claimed in RA bill)	for seigniorage fee / royalty fee shall be considered for operation in RA bills/ Final bill. The amount so calculated shall be withheld from RA bill and on production of challan, payment of relevant portion will be released.
3	Borrowed earth	20.00	Actual volume of filling shall be considered	

1.7.5 BHEL Site Engineer, at discretion, may operate the part rate of the items in line with GCC clause no. 2.23.1 (v). Payment for supply portion (subjected to approval of Engineer In-Charge) shall be made only after receipt of material at site.

1.7.6 METHOD OF MEASUREMENT

Mode of measurement shall be as per relevant IS 1200 in conjunction of IS code 3385. In case the same is also not available, the standard procedure adopted in CPWD shall be adopted. In case, the same is also not available in CPWD, the measurement of the work done will be based on the mutual agreement between BHEL and contractor. In all the above cases, the interpretation of BHEL will be final and binding to the contractor. Measurement guidelines as a ready reference is also available in the technical specification.

1.7.7 NO CLAIM WHAT SO EVER MAY BE, WILL BE ENTERTAINED UNDER THIS CONTRACT, AFTER DULY SIGNING THE FINAL BILL ALONG WITH MEASURMENT BOOKS AND ACCEPTED BY BHEL.

1.7.8 Bidder to refer General Conditions of Contract Volume IC Book II reg. PVC, ORC, Retention Amount and Sl. No. 7 of Chapter 1 of Part II of Technical Conditions of Contract (Volume-IA Book-I) for Base Date of PVC.

VOLUME-IA PART – I CHAPTER-VIII

TAXES AND DUTIES

1.8.1 Goods and service Tax (GST) & Cess

1.8.1.1 The successful bidder shall furnish proof of GST registration with GSTN Portal in the State in which the Project is being executed, covering the services under this contract. Registration should also bear endorsement for the premises from where the billing shall be done by the successful bidder on BHEL for this project/ work.

1.8.1.2 Contractor's price/rates shall be exclusive of GST & Cess (if applicable) (herein after termed as GST). Contractor shall submit to BHEL the GST compliant tax invoice/debit note/revised tax invoice on the basis of which BHEL will claim the input tax credit in its return. Since this is a works contract, the applicable rate shall be @ 18% GST, as applicable presently.

1.8.1.3 Bidder shall note that the GST Tax Invoice complying with GST Invoice Rules wherein the 'Bill To' details will be as below:

BHEL GSTN : 33AAACB4146P2ZL

NAME : BHARAT HEAVY ELECTRICALS LIMITED

ADDRESS : BHEL Site Office, North Chennai Thermal Power Station, Stage III, Athipattu Pudunagar, Chennai - 600 120

1.8.1.4 GST charged in the tax invoice/debit note/revised tax invoice by the contractor shall be released separately to the contractor only after contractor files the outward supply details in GSTR-1 on GSTN portal and input tax credit of such invoice is matched with corresponding details of outward supply of the contractor and has paid the GST at the time of filing the monthly return.

1.8.1.5 In case BHEL has to incur any liability (like interest / penalty etc.) due to denial/reversal / delay of input tax credit in respect of the invoice submitted by the contractor, for the reasons attributable to the contractor, the same shall be recovered from the contractor.

1.8.1.6 Further, in case BHEL is deprived of the Input tax credit due to any reason attributable to contractor, the same shall not be paid or Recovered if already paid to the contractor.

1.8.1.7 Tax invoice/debit Note/revised tax invoice shall contain all such particulars as prescribed in GST law and comply to the timelines for issue of the same. Invoices shall be submitted on time to the concerned BHEL Engineer In Charge.

1.8.1.8 TDS under GST (if/ as & when applicable) shall be deducted at prevailing rates on gross invoice value from the running bills.

1.8.1.9 E-way bills / Transit passes / Road Permits, if required for materials / T&P etc.,

bought into the project site is to be arranged by the Contractor only.

1.8.1.10 BHEL shall not reimburse any amounts towards any interest / penalty etc., incurred by contractor. Any additional claim at a later date due to issues such as wrong rates / wrong classification by contractor shall not be paid by BHEL.

1.8.2 All taxes and duty other than GST & Cess

The contractor shall pay all (except the specific exclusion viz GST & Cess) taxes, fees, license charges, deposits, duties, tools, royalty, commissions, Stamp Duties, or other charges / levies, which may be levied on the input goods & services consumed and output goods & services delivered in course of his operations in executing the contract and the same shall not be reimbursed by BHEL. In case BHEL is forced to pay any of such taxes, BHEL shall have the right to recover the same from his bills or otherwise as deemed fit.

1.8.3 Statutory Variations

Statutory variations are applicable under the GST Acts, against production of proof. The changes implemented by the Central / State Government during the tenure of the contract viz. increase / decrease in the rate of taxes, applicability, etc. and its impact on upward revision / downward revision are to be suitably paid/ adjusted from the date of respective variation. The bidder shall give the benefit of downward revision in favour of BHEL. No other variations shall be allowed during the tenure of the contract.

1.8.4 New Taxes/Levies –

In case Government imposes any new levy / tax after submission of bid during the tenure of the contract, BHEL shall reimburse the same at actual on submission of documentary proof of payment subject to the satisfaction of BHEL that such new levy / tax is applicable to this contract.

1.8.5 Direct Tax

BHEL shall not be liable towards Income Tax of whatever nature including variations thereof arising out of this contract as well as tax liability of the bidder and their personnel. Deduction of tax at source at the prevailing rates shall be effected by BHEL before release of payment as a statutory obligation, unless exemption certificate is produced by the bidder. TDS certificate will be issued by BHEL as per the provisions of Income Tax Act.

VOLUME-IA PART-I CHAPTER-IX
BILL OF QUANTITY

1.9.1 Bill of Quantities

As mentioned in the Volume II, Price bid

VOLUME-IA PART-I CHAPTER-X GENERAL

The scope of the work will comprise of but not limited to the following:

(All the works mentioned hereunder shall be carried out within the accepted rate unless otherwise specified.)

1.10.1 Contractors are requested to furnish the following documents at PSSR-HQ, Chennai immediately after release of Letter of Intent (LOI).

i) Security Deposit and additional Security Deposit.
ii) Unqualified Acceptance for Detailed LOI / Work Order.
iii) Rs.100/- Stamp Paper for preparation of Contract Agreement.

1.10.2 Contractors are requested to furnish the proof of documents for the following at PSSR- Site

i) Provident Fund Registration Number.
ii) Labour License Number.
iii) Workmen Insurance Policy Number.

1.10.3 **In addition to the clause 2.8 of General Conditions of Contract (Volume-1C of Book-II) the contractor shall comply with the following.**

1.10.3.1 **BOCW Act & BOCW Welfare Cess Act**

1.10.3.1.1 The Contractor should Register their Establishment under BOCW Act 1996 read with rules 1998 by submitting Form I (Application for Registration of Establishment) and Form IV (Notice Of Commencement / Completion of Building Other Construction Work) to the respective Labour Authorities i.e.,

a) Assistant Labour Commissioner (Central) in respect of the project premises which is under the purview of Central Govt.–NTPC, NTPL etc.
b) Appropriate State authorities in respect of the project premises which is under the purview of State Govt.

1.10.3.1.2 The Contractor should comply with the provisions of BOCW Welfare Cess Act 1996 in respect of the work awarded to them by BHEL.

1.10.3.1.3 The contractor should ensure compliance regarding Registration of Building Workers as Beneficiaries, Hours of work, welfare measures and other conditions of service with particular reference to Safety and Health measures like Safety Officers, safety committee, issue of Personal protective equipments, canteen, rest room, drinking water, Toilets, ambulance, first aid centre etc.

1.10.3.1.4 The contractor irrespective of their nature of work and manpower (Civil, Mechanical, Electrical works etc) should register their establishment under

BOCW Act 1996 and comply with BOCW Welfare Cess Act 1996.

1.10.3.1.5 Contractor shall make remittance of the BOCW cess as per the Act **in consultation with BHEL** as per the rates in force (presently 1%). BHEL shall reimburse the same upon production of documentary evidence. However, BHEL shall not reimburse the fee paid towards the registration of establishment, fees paid towards registration of Beneficiaries and contribution of Beneficiaries remitted.

1.10.3.1.6 Non-compliance to Provisions of the BOCW Act & BOCW Welfare Cess Act is not acceptable. In case of any non-compliance, BHEL reserves the right to withhold any sum as it deems fit. Only upon total compliance to the BOCW Act and also discharge of total payment of Cess under the BOCW Cess Act by the Contractor, BHEL shall consider refund of the Amounts

1.10.3.2 **PROVIDENT FUND**

1.10.3.2.1 The contractor is required to extent the benefit of Provident Fund to the labour employed by you in connection with this contract as per the Employees Provident Fund and Miscellaneous Provisions Act 1952. For due implementation of the same, you are hereby required to get yourself registered with the Provident Fund authorities for the purpose of reconciliation of PF dues and furnish to us the code number allotted to you by the Provident Fund authorities within one month from the date of issue of this letter of intent. In case you are exempted from such remittance an attested copy of authority for such exemption is to be furnished. Please note that in the event of your failure to comply with the provisions of said Act, if recoveries therefore are enforced from payments due to us by the customer or paid to statutory authorities by us, such amount will be recovered from payments due to you.

1.10.3.2.2 The final bill amount would be released only on production of clearance certificate from PF / ESI and labour authorities as applicable.

1.10.3.3 **OTHER STATUTORY REQUIREMENTS**

1.10.3.3.1 The Contractor shall submit a copy of Labour License obtained from the Licensing Officer (Form VI) u/r25 read with u/s 12 of Contract Labour (R&A) Act 1970 & rules and Valid WC Insurance copy or ESI Code (if applicable) and PF code no. along with the first running bill.

1.10.3.3.2 The contactor shall submit monthly running bills along with the copies of monthly wages (of the preceding month) u/r78(1)(a)(1) of Contract Labour Rules, copies of monthly return of PF contribution with remittance Challans under Employees Provident Fund Act 1952 and copy of renewed WC Insurance policy or copies of monthly return of ESI contribution with Challans under ESI Act 1948 (if applicable) in respect of the workmen engaged by them.

1.10.3.3.3 The Contractor should ensure compliance of Sec 21 of Contract Labour (R&A) Act 1970 regarding responsibility for payment of Wages. In case of "Non-compliance of Sec 21 or non-payment of wages" to the workmen before the expiry of wage period by the contactor, BHEL will reserve its right to pay the workmen under the orders of Appropriate authority at the risk and cost of the Contractor.

1.10.3.3.4 The Contractor shall submit copies of Final Settlement statement of disbursal of retrenchment benefits on retrenchment of each workmen under I D Act 1948, copies of Form 6-A (Annual Return of PF Contribution) along with copies of PF Contribution Card of each member under PF Act and copies of monthly return on ESI Contribution – Form 6 under ESI Act 1948 (if applicable) to BHEL along with the Final Bill.

1.10.3.3.5 In case of any dispute pending before the appropriate authority under ID act 1948, WC Act 1923 or ESI Act 1948 and PF Act 1952, BHEL reserve the right to hold such amounts from the final bills of the Contractor which will be released on submission of proof of settlement of issues from the appropriate authority under the act.

1.10.3.3.6 In case of any dispute prolonged / pending before the authority for the reasons not attributable to the contractor, BHEL reserves the right to release the final bill of the contractor on submission of Indemnity bond by the contractor indemnifying BHEL against any claims that may arise at a later date without prejudice to the rights of BHEL.

1.10.3.4 DEPLOYMENT OF SKILLED / SEMI-SKILLED TRADESMEN

The following clause is applicable in case the contract value / contract price is Rs. Five crores and above.

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.

1.10.3.5 **RECOVERY OF COMPENSATION PAID TO VICTIMS BY BHEL IN CASES OF DEATH/ PERMANENT INCAPACITATION OF PERSON DUE TO AN ACCIDENT DURING THE WORKS**

BHEL shall recover the amount of compensation paid to victim(s) by BHEL towards loss of life / permanent disability due to an accident which is attributable to the negligence of contractor, agency or firm or any of its employees as detailed below.

a) **Victim:** Any person who suffers permanent disablement or dies in an accident as defined below.

b) **Accident:** Any death or permanent disability resulting solely and directly from any unintended and unforeseen injurious occurrence caused during the manufacturing / operation and works incidental thereto at BHEL factories/ offices and precincts thereof, project execution, erection and commissioning, services, repairs and maintenance, trouble shooting, serving, overhaul, renovation and retrofitting, trial operation, performance guarantee testing undertaken by the company or during any works /during working at BHEL Units/ Offices/ townships and premises/ Project Sites.

c) **Compensation in respect of each of the victims:**
In the event of death or permanent disability resulting from Loss of both limbs: Rs. 10,00,000/- (Rs. Ten Lakh)
In the event of other permanent disability: Rs. 7,00,000/- (Rs. Seven Lakh)

d) **Permanent Disablement**: A disablement that is classified as a permanent total disablement under the provisoN to Section 2 (I) of the Employee's Compensation Act, 1923."

1.10.4 **GENERAL**

1.10.4.1 **Site Visit by the Bidder**

The bidder shall, prior to submitting his tender for the work, visit, examine and acquire full knowledge & information and necessary conditions prevailing at the site and its surroundings of the plant premises together with all statutory, obligatory, mandatory requirements of various authorities about the site of works at his own expense, and obtain and ascertain for himself on his own responsibility that may be for preparing his tender and entering into a contract, and take the same into account in the quoted contract price for the work.

1.10.4.2 The bidder shall satisfy themselves about the following factors:

i). Site conditions including access to the site, existing and required roads and

other means of transport/communication for use by him in connection with the work including diverting and re-routing of services.

ii). Requirement and availability of land and other facilities of his enabling works, establishment of his nursery, office, stores etc.

iii). Ground conditions including those bearing upon transportation, disposal, handling and storage of materials required for the work or obtained there-from.

iv). Source and extent of availability of suitable materials, including water etc., and labour (skilled and unskilled) required for work, and laws and regulations governing their use and employment.

v). Geological, meteorological, topographical and other general features of the site and its surroundings as are pertaining to and needed for the performance of the work.

vi). The limit and extent of surface and subsurface water to be encountered during the performance of the work, and the requirement of drainage and pumping.

vii). The type of equipment and facilities needed, for and in the performance of the work;

viii). The extent of lead and lift required for the work in complete form over the entire duration of the contract, and

ix). All other information pertaining to and needed for the work including information as to the risks, contingencies and other circumstances which may influence or affect the work or the cost thereof under this contract.

1.10.4.3 The bidder should note that information, if any, in regard to the local conditions, as contained in these tender documents, has been given to tenderer merely for guidance and is not warranted to be complete.

1.10.4.4 A bidder shall be deemed to have full knowledge of the site, whether he inspects it or not, and no extra charges consequent on any misunderstanding or otherwise shall be allowed.

1.10.4.5 The bidder and any of his personnel or agents will be granted permission by the Site-In-Charge or his authorized nominee, on receipt of formal application in respect thereof a week in advance of the proposed date of inspection of site, to enter upon his premises and lands for purpose of such inspection, but only on the express condition that the tenderer (and his personnel and agents) will relieve and indemnify the Employer (and his personnel and agents) from and against all liability in respect thereof and will be responsible for personal injury (whether fatal or otherwise), loss of or damage to property and any other loss, damage, costs and expenses however caused which, but for the exercise of such permission, would not have arisen.

1.10.4.6 The work covered under this specification is of highly sophisticated nature, requiring the best quality workmanship, engineering and construction management. The contractor must have adequate quantity of tools, construction aids, equipments etc., in his possession. He must also have on his rolls adequate trained, qualified and experienced supervisory staff and skilled personnel.

1.10.4.7 It is not the intent to specify herein all details of all material. Any item related this work not covered by this but necessary to complete the system will be deemed to have been included in the scope of the work.

1.10.4.8 All the necessary certificates and licenses required to carry out this scope of work are to be arranged by the contractor then and there at no extra cost.

1.10.4.9 Site testing wherever required shall be carried out for all items / materials installed by the contractor to ensure proper installation and functioning in accordance with drawings, specifications and manufacturer's recommendations.

1.10.4.10 The contractor shall carry out additional tests, if any, which the Engineer feels necessary because of site conditions and also to meet system specification.

1.10.4.11 The work shall be executed under the usual conditions without affecting power plant construction / operation and in conjunction with other operations and contracting agencies at site. The contractor and his personnel shall co-operate with the personnel of other agencies, co-ordinate his work with others and proceed in a manner that shall not delay or hinder the progress of work as a whole.

1.10.4.12 All the work shall be carried out as per instructions of BHEL engineer. BHEL engineer's decision regarding the correctness of the work and method of working shall be final and binding on the contractor.

1.10.4.13 Wherever Construction sequences are furnished by BHEL, the contractor shall follow the same sequence. Contractor shall execute the supply and works as per sequence prescribed by BHEL at site engineer. No claims for extra payment from the contractor will be entertained on the grounds of deviation from the methods of execution of similar job in any other site or for any reasons whatsoever.

1.10.4.14 If required by BHEL, the contractor shall change the sequence of his operation so that work on priority sectors can be completed within the projects schedule. The contractor shall afford maximum assistance to BHEL in this connection without causing delay to agreed completion date.

1.10.4.15 Contractor shall, transport all materials to site and unload at site / working area for inspection and checking. All material handling equipment required

shall be arranged by the contractor.

1.10.4.16 Contractor shall retain all T&P / Testing instrument / Material handling equipment's etc. at site as per advice of BHEL engineer and same shall be taken out from site only after getting the clearances from engineer in charge.

1.10.4.17 The contractor at his cost shall arrange necessary security measures for adequate protection of his machinery, equipment, tools, materials etc. BHEL shall not be responsible for any loss or damage to the contractor's construction equipment and materials. The contractor may consult the Engineer-in-Charge on the arrangements made for general site security for protection of his machinery equipment tools etc.

1.10.4.18 The Contractor may have to execute work in such a place and condition where other agencies also will be under such circumstances. However, completion time for construction, agreed will be subject to the condition that contractor's work is not hampered by the agencies.

1.10.4.19 Contractor has to work in close co-ordination with other agency at site. BHEL engineer will co-ordinate area clearance. In a project of such magnitude, it is possible that the area clearance may be less / more at a particular given time. Activities and Construction program have to be planned in such a way that the milestones are achieved as per schedule/ plans. Contractor shall arrange & augment the resources accordingly.

1.10.4.20 The contractor must obtain the signature and permission of the security personnel of the customer / BHEL for bringing any of their materials inside the site premises. Without the Entry Gate Pass these materials will not be allowed to be taken outside. Surplus materials including steel item brought at site by the contractors with proper documentation and Gate pass, shall be allowed to taken out of the project premises after completion of relevant works, on certification by BHEL in charge.

1.10.4.21 Contractor shall remove all scrap materials periodically generated from his working area and collect the same at one place earmarked for the same. Load of scraps is to be shifted to a place earmarked by BHEL. Failure to collect the scrap is likely to lead to accidents and as such BHEL reserves the right to collect and remove the scrap at contractor's risk and cost if there is any failure on the part of contractor in this respect.

1.10.4.22 The contractor shall ensure that his premises are always kept clean and tidy to the extent possible. Any untidiness noted on the part of the contractor shall be brought to the attention of the contractor's site representative who shall take immediate action to clean the surroundings to the satisfaction of the Engineer-in-Charge.

1.10.4.23 The contractor is strictly prohibited from using BHEL's regular components like angles, channels, beams, plates, pipe / tubes, and handrails etc. for any temporary supporting or scaffolding works. Contractor shall arrange himself all such materials. In case of such misuse of BHEL materials, a sum as determined by BHEL engineer will be recovered from the contractor's bill. The decision of BHEL engineer is final and binding on the contractor.

1.10.4.24 No member of the already erected structure / buildings, other component and auxiliaries should be removed / modified without specific approval of BHEL engineer.

1.10.4.25 Contractors shall ensure that all their Staff / Employees are exposed to periodical training programme conducted by qualified agencies/ personnel on latest ISO 9001 Standards.

1.10.4.26 Sometimes, it may be required to re-schedule the activities to enable other agencies to commence/ continue the work so as to keep the overall project schedule.

1.10.4.27 The terminal points decided by BHEL are final and binding on the contractor for deciding the scope of work and effecting the payment for the work done up to the terminals.

1.10.4.28 Crane operators deployed by the contractor shall be tested by BHEL before he is allowed to operate the cranes.

1.10.4.29 On Completion of work, all the temporary buildings, structures, pipe lines, cable 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, the expenditure towards clearance of the same will be recovered from the contractor. The decision of BHEL Engineer in this regard is final.

1.10.4.30 It is the responsibility of the contractor to do the checking, testing etc. if necessary, repeatedly to satisfy BHEL Engineer with all the necessary tools and tackles, manpower etc. without any extra cost. The testing will be completed only when jointly certified so, by the BHEL Engineer.

1.10.4.31 If any item not covered but requires being executed, same shall be carried out by the contractor. Equivalent or proportional unit rate shall be considered wherever possible from the BOQ. The rates quoted by the contractor shall be uniform as far as possible for similar items appearing in rate schedule.

1.10.4.32 The contractor's work shall not hinder other work, either underground or over ground, such as electrical, phone lines, water or sewage lines, etc. In areas of overlap, the contractor shall work in coordination with other related contractors. Any damage by the landscape contractor's team to such utilities

will be penalized and contractor shall be responsible for cost for such damages.

1.10.4.33 The contractor will be responsible for the safe custody and proper accounting of all materials in connection with the work. If the contractor has drawn materials in excess of design requirements, recoveries will be effected for such excess drawls at the rate prescribed by manufacturing units.

1.10.4.34 Contractor has to clear the front, expeditiously and promptly as instructed by BHEL Engineer for other agencies, like Boiler, piping, Turbine, Generator erection, Cabling, instrumentation, insulation etc., to commence their work from / on the equipments coming under this scope.

1.10.4.35 For the purpose of planning, contractor shall furnish the estimated requirement of power (month wise) for execution of work in terms of maximum KW demand.

1.10.4.36 RECORDS TO BE MAINTAINED AT SITE:

Record of Quantity of FREE/Chargeable items issued by BHEL must be maintained during contract execution. Also reconciliation statement to be prepared at regular intervals.

The under mentioned Records/ Log-books/ Registers applicable to be maintained.

(i) Hindrance Register
(ii) Site Order Book.
(iii) Test Check of measurements.
(iv) Cement Supply and Consumption Daily Register
(v) Records of Test reports of Field tests.
(vi) Records of manufacture's test certificates.
(vii) Records of disposal of scraps generated during and after the work completion.
(viii) List of T&Ps and MMEs

1.10.4.37 SITE INSPECTION

1.10.4.37.1 The Owner or his authorized agents may inspect various stages of work during the currency of the contract awarded to him. The contractor shall make necessary arrangements for such inspection and carry out the rectification pointed out by the Owner or his authorized agents without any extra cost to the Owner or his authorized agents. No cost whatsoever such duplication of inspection of work be entertained.

1.10.4.37.2 BHEL / Owner will have full power and authority to inspect the works at any time, either on the site or at the contractor's premises. The contractor shall arrange every facility and assistance to carry out such inspection. On no

account will the contractor be allowed to proceed with work of any type unless such work has been inspected and entries are made in the site inspection register by Owner / BHEL.

1.10.4.37.3 The contractor shall maintain at site a joint protocol for recording actual measurement of work carried out at site, inspection and witnessing of various tests conducted by the contractor.

1.10.4.37.4 Field Quality Assurance (FQA) Formats:-

It is the responsibility of the contractor to collect and fill up the relevant FQA log sheets of BHEL and present the same to BHEL after carrying out the necessary checks as per the log sheets and obtaining the signature of BHEL and Owner as token of their acceptance. Payment to the contractor will be inked with the submission of these FQA log sheets.

1.10.4.37.5 Site testing wherever required shall be carried out for all items / materials installed by the contractor to ensure proper installation and functioning in accordance with drawings, specifications and manufacturer's recommendations.

Contractor shall, transport all materials to site and unload at site / working area for inspection and checking. All material handling equipment required shall be arranged by the contractor

VOLUME-IA PART – I CHAPTER – XI
PROGRESS OF WORK

The scope of the work will comprise of following but not limited to the following:

1.11 PROGRESS AND MONITORING OF WORK

1.11.1 Refer forms F -14 and F-15 furnished in Volume 1A, Part II, Chapters 8 & 9 as well as to forms F-16, F-17, F-18 of volume I D (Forms & Procedure) of volume - I Book-II. Plan and review will be done as per the formats.

1.11.2 Contractor is required to draw mutually agreed monthly construction programs in consultation with BHEL well in advance monthly as per the Form-14. Contractor shall ensure achievement of agreed program and shall also timely arrange additional resources considered necessary at no extra cost to BHEL. Progress review meetings will be held at site during which actual progress during the week vis-a-vis scheduled program shall be discussed for actions to be taken for achieving targets. Contractor shall also present the program for subsequent week. The contractor shall constantly update / revise his work program to meet the overall requirement. All quality problems shall also 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 nonconformities.

1.11.3 The contractor shall submit daily, weekly and monthly progress reports, manpower reports, materials report, consumables (gases / electrodes / ferules / lugs) report, T&Ps availability report and other reports as per Performa considered necessary by the Site Engineer as per the BHEL formats.

1.11.4 The contractor shall submit weekly / fortnightly / monthly statement report regarding consumption of all consumables for cost analysis purposes.

1.11.5 The monthly report ending on 24th of every month shall be submitted as a booklet and shall contain the following details:-

a) Colour Progress photographs to accompany the report should be submitted.

b) Construction progress in terms of quantity, CUM, etc., completed as relevant to the respective work areas against planned.

c) Site Organization chart of engineers & supervisors as on 24th of the month with further mobilization plan

d) Category- wise man hours engaged during the previous month under the categories like fitters, electricians, welders, riggers, khalasis, grinder-men, gas-cutters, crane operators, store keepers, lab technicians, helpers, security etc. Data will be spilt up under the work area .

e) Consumables report giving consumption of all types of gases and electrodes during the previous month.

f) Availability report of cranes/T&Ps

g) Safety implementation report in the format

h) Pending material and any other inputs required from BHEL for activities planned during the subsequent month.

1.11.6 The manpower reports shall clearly indicate the manpower deployed, category wise specifying also the activities in which they are engaged.

1.11.7 During the course of construction, if the progress is found unsatisfactory, or if the target dates fixed from time to time for every milestone are to be advanced, or in the opinion of BHEL, if it is found that the skilled workmen like fitters, operators, technicians etc employed are not sufficient BHEL will induct required additional workmen to improve the progress and recover all charges incurred on this account including all expenses together with BHEL overheads from contractor's bills.

1.11.8 It is the responsibility of the contractor to provide all relevant information on a regular basis regarding construction progress, labour availability, equipment deployment, testing, etc.

1.11.9 The progress reports shall indicate the progress achieved against plan, indicating reasons for delays, if any. The report shall also give remedial actions which the contractor intends to make good the slippage or lost time so that further works can proceed as per the original plan the slippages do not accumulate and affect the overall programme.

1.11.10 The contractor to reflect actual progress achieved during the month and will be submitted to BHEL, so that slippages can be observed and necessary action taken in order to ensure that the situation does not get out of control will update the construction schedule forming part of this contract each month.

VOLUME-IA PART-I CHAPTER-XII
MATERIAL HANDLING

1.12.1 Open land as available shall be provided by BHEL on free of cost basis. Contractor shall maintain one centralized fenced store cum bar bending yard. Hard surfacing of this yard and all round drain shall be carried out by the contractor at his own cost within the quoted rate. Batching plant area, shall be provided nearer plant premises and contractor shall make use of the area for installation and operation of the Batching Plant at his own cost. The bidder shall make complete arrangement of necessary security personnel, to safeguard all such materials in his custody. Materials issued will be used only for construction of permanent work. The contractor shall take care of material issued by BHEL and shall protect the same from theft, damage and weathering.

1.12.2 The system for receipt, storage & issue of materials shall be available with vendors for easy traceability.

1.12.3 Periodic audit of system of purchasing, storing and issue, etc. will have to be carried out by the vendors. BHEL will also audit the same.

1.12.4 The contractor shall construct waterproof cement store (capacity 200MT or as directed by engineer in-charge based on requirement at site) for initial period for storing and stacking of cement at his own cost, CGI/ asbestos roofing (slope) with brick masonry wall, PCC flooring. Materials required for the same shall be provided by contractor at his own cost. Cement has to be kept over wooden raised platform. Stacking of cement is to be done as per IS codes with proper illumination and locking arrangements. It is the responsibility of the contractor to maintain the stock register on daily basis and the same will be subject to verification by BHEL. Stacking of bags shall not be more than 8 bags in height. Fine and coarse aggregate shall be stocked on firm levelled ground to avoid mixing of earth / Mud and necessary surface preparation is in the scope of bidder.

1.12.5 The contractor shall in no case be entitled for any compensation or damages on account of any delay in supply or non-supply thereof for all or any such material.

1.12.6 Clotting of cement and excessive rusting of steel must be avoided. In case, due to any cause attributable to the contractor, rusting of steel for BHEL issued steel occur rendering the same unusable, then such quantity of steel shall be recovered from the interim payment at the penal rate specified in the tender.

1.12.7 The contractor shall maintain proper store account for all the BHEL issued materials and shall give three copies of once in two months computerized reconciliation statement of such account to the BHEL.

1.12.8 All TMT shall be stacked over sleeper's diameter wise.

1.12.9 All structural steel (issued for insert/ embedment) shall be stacked plate size wise and thickness wise. Beams, channels and angles shall be stacked separately on sleepers.

1.12.10 Materials shall not under any circumstances taken out of the project site unless otherwise permitted by BHEL.

VOLUME-IA PART –I CHAPTER –XIII
ACCOUNTING OF MATERIALS ISSUE

1.13 ACCOUNTING OF MATERIALS ISSUE

The materials issued to the contractor by BHEL will be accounted as follows:

1.13.1 CEMENT

1.13.1.1 ISSUE OF CEMENT

1.13.1.1.1 Cement as received from the manufacturer / stockiest will be issued **free of cost** to the contractor. The cement shall be provided normally in bulkers and shall be unloaded in the silos (2 Nos cement silo of 100 MT each per 30/ 60 CUM batching plant) to be installed by the bidder nearer to their batching plants. This is only minimum requirement of silos and the number of cement silos shall be increased based on the site requirement. Unloading arrangements shall be provided by the bidder at his own cost including provision of necessary manpower support.

1.13.1.1.2 On advance request of the bidder, the cement shall be supplied in 50kg tamper proof sealed Bags for other than RCC works like masonry, flooring works etc. The theoretical weight of each bag of cement for issued purposes will be considered as 50 kg, the contractor shall be accountable for the cement issued to him on this notional weight only. No claim whatsoever will be entertained because of difference between theoretical and actual weight of the bags of cement. The empty cement bags duly accounted for against issue shall be in the custody of the contractor and the same shall be disposed by the contractor as per statutory regulation prevailing in the project. Proper storage area/ shed shall be constructed by successful bidder at his own cost.

1.13.1.1.3 The contractor shall submit to the engineer, a statement indicating estimated quantity of cement required during a quarter, at least two months in advance of the quarter. In addition, the contractor shall also furnish the estimated requirement of cement during a month by the third week of the previous month indicating his requirement.

1.13.1.1.4 Bidder is responsible for unloading the cement as soon as the arrival of cement, either in silo, if received in bulker or in the weather proof cement storage sheds, if received bags. Bagged cement shall be stored in a weatherproof sheds having dense impervious bituminous or concrete floors which shall be kept swept clean at all times. The storage arrangements (to be made by the contractor at his own cost) shall be fully completed and approved by the owner (BHEL/ TANGEDCO) before any cement is delivered to site. The construction of cement storage sheds as per the requirement of BHEL, unloading of cement bags, stacking properly in the storage sheds, removal of the sheds after the completion of the work is in the scope of bidder

within the quoted price.

1.13.1.1.5 Bidder is responsible for sampling and testing of cement as per Indian Standard / Specification / approved quality plan in the testing laboratory established by the bidder.

1.13.1.1.6 Bidder is responsible for carrying out design mix as per IS 456/10262 Latest revision and specification, using the cement provided by BHEL and submit the design mix proportions for the approval of BHEL / TANGEDCO. The design / trial mix shall be carried out time to time on change of brand / type of cement supplied by BHEL and suitable adjustments on the quantity of ingredients (fine aggregates, coarse aggregates, admixture) of the concrete to get the required workability and durability, shall be the responsibility of the bidder without any extra cost to BHEL.

1.13.1.1.7 Following shall be limit for the maximum quantity of BHEL issue materials that would be with the contractor at any point of time when work is in progress (excluding what has already been incorporated in the works).

Sl. No.	Issue of materials	Max. Quantity in contractor's store
1.	Cement	Requirement of one month

1.13.1.2 **RETURN OF CEMENT**

1.13.1.2.1 Sealed cement bags remaining unused and in perfectly good condition at the time of completion or termination of the contract shall be returned promptly, (within 15 days from assessment) if BHEL / Engineer is satisfied of the physical condition of the cement. Return of such cement to the project stores/ place as identified within the project area by Engineer / BHEL will not be entitled to handling and incidental charges. Surplus sealed and good conditioned cement bags will be taken back on weighment basis.

1.13.1.3 **CEMENT CONSUMPTION AND WASTAGE**

The theoretical consumption of cement shall be based on the following.

i. For design mix concrete as per approved design mix.
ii. For nominal mix concrete work, as per minimum cement as specified or as approved by Engineer-in-charge. No extra payment is payable to the vendor.

For item of works, where volume mix is permitted in writing by BHEL, for masonry works, plaster other miscellaneous items, the cement consumption shall be governed by the "Statement of Cement Consumption" attached to the Delhi schedule of Rates of CPWD-DSR- LATEST REVISION unless otherwise specified in the specifications or the drawing of contract or mutually agreed by Engineer-in-charge and contractor.

Actual consumption= Issue – Surplus / unused quantity of cement returned in good condition by contractor to store. (No sweep cement will be taken back by BHEL).

1.13.1.4 **CEMENT WASTAGE**

Allowable wastage: One and half percent (+1.5%) of theoretical consumption of cement unless specified otherwise in the technical specification.

For any material issued by BHEL to the contractor free of cost, and which is not accounted by the contractor to BHEL, then recovery for such material shall be effected at penal rates.

Sl. No.	Cement consumption	Basis of issue & penal recovery
C-1	Theoretical consumption (without considering any wastage or loss).	Free
C-2	Actual consumption being limited to one and half percent (+1.5%) of aforesaid theoretical consumption towards allowable wastage.	Free
C-3	Actual consumption beyond one and half percent (+1.5%) of above (C-1).	Penal rate

1.13.2 STEEL MATERIAL

1.13.2.1 **ISSUE OF STEEL**

1.13.2.1.1 The steel shall be issued to the contractor on the following basis:

Sl. No.	Description	Basis
(a)	Structural Steel	Weighment basis (Unit – MT)
(b)	Reinforcement Steel and Earthing rod (MS round)	Weighment basis (Unit – MT)

1.13.2.1.2 All the steel (structural, reinforcement, earthing MS rod,) issued by BHEL shall be properly accounted for. The total quantity of steel required for the work will be calculated from the approved Bar Bending schedule, fabrication drawings, approved laps, chairs and lugs. The measurement for payment as well as for accounting shall be based on the sectional weights as indicated in the following IS specifications. No rolling tolerances shall be accepted in any case for issue, return of materials, reconciliation and payment purposes.

IS: 808 (Latest revision) Beams, Channels and Angles

IS: 1730 (Latest revision) Plates, Sheets and Strips / Flats

IS: 1732 (Latest revision) Rounds including deformed high yield strength bars

IS:1786 (Latest revision) Reinforcement steel

In case any such sectional weights are not available in the above documents,

the manufacturer recommendation shall be binding.

1.13.2.1.3 The steel issued to the contractor shall be mainly in standard length and sections as received from the supplier. However, the contractor shall be bound to accept the steel in length as available in the project stores. No claims for extra payment because of issue of non-standard length will be entertained.

1.13.2.1.4 The contractor shall satisfy himself of the quality and quantity of the materials at the time of taking delivery from BHEL stores. No claims whatsoever will be entertained by BHEL because of quality or quantity after the materials are taken by the contractor from BHEL stores.

1.13.2.1.5 The contractor shall submit to the engineer, a statement indicating estimated quantity of steel required during a quarter, at least two months in advance of the quarter. In addition, the contractor shall also furnish the estimated requirement of steel during a month by the third week of the previous month indicating his requirement.

1.13.2.1.6 Following shall be limit for the maximum quantity of BHEL issue materials that would be with the contractor at any point of time when work is in progress (excluding what has already been incorporated in the works).

SL. No.	ISSUE OF MATERIALS	MAX. QTY IN CONTRACTOR'S STORE.
1	Reinforcement Steel & Earthing rod MS round	Requirement of one month
2	Structural Steel	Requirement of one month

Bidders to ensure that no lamination materials are taken over by them from BHEL. Fabrication wastage, if any due to above, shall not be compensated by BHEL.

1.13.2.1.7 Bidder to note that steel materials required for MS Grating, Galvanised Grating, GI Handrail, Stainless Steel Handrail, Stop Lock Gate, Stationery Screen, fasteners like MS/HT/HSFG bolts/nuts, lock nuts, washers and foundation bolts, embedded items etc. other than those supplied by BHEL, shall be supplied by the bidder. However, Bidder shall use the scrap materials (if issued by BHEL) for their use in the permanent works as embedment/inserts etc. after necessary store issue formalities, and shall be accounted for monthly reconciliation.

1.13.3 RETURN OF MATERIALS

All surplus steel and all wastage materials will be taken back on weighment basis. Surplus, unused and untampered steel shall be sorted section-wise and returned separately to a place directed by BHEL / Engineer within the project area. Return of such materials will not be entitled to any handling and incidental charges.

All wastage / scrap (including melting scrap, wastage, unusable scrap) shall be promptly returned to the stores and a receipt obtained for material accounting purposes. Return of such material will not be entitled to any transportation and incidental charge.

1.13.3.1 **SCRAP & SERVICEABLE MATERAILS:**

a) All pipes measuring 2 M and above in length shall be treated as serviceable materials provided they are in good and acceptable condition. Pipe in less than 2 M length shall be treated as scrap.
b) All TMT measuring 3 M and above in length shall be treated as serviceable materials provided they are in good and acceptable condition. TMT in less than 3 M length shall be treated as scrap.
c) All Structural steel of length above 2 M except M.S. Plate shall be considered as serviceable materials provided the materials is in good and acceptable condition. Structural steel in length less than 2 M shall be treated as scrap.
d) MS Plates having both sides greater than 1 Metre OR if any side is less than 1 M but greater than 0.5 M and the total area is equal or greater than 2 Sq. Metre shall be considered as serviceable.

1.13.4 STEEL CONSUMPTION AND WASTAGE

1.13.4.1 **REINFORCEMENT AND EARTHING ROD MS ROUND STEEL CONSUMPTION AND WASTAGE**

a) CONSUMPTION.

The theoretical consumption of various sections and/or diameter of reinforcement and earthing rod steel shall be based on approved construction drawing and bar bending schedule. Weight shall be calculated considering the sectional weights as per Indian standards. No extra cost shall be payable to the contractor for any deviation in weights for the different procedures adopted for issue and calculation of the theoretical consumption including rolling tolerances.

i) Actual consumption = Issue – Surplus.

ii) Surplus = Un-tampered, unused. uncut quantity of steel and serviceable materials as stipulated under clause “Scrap and Serviceable Materials (Refer Clause 1.13.3.1 above)” returned by the contractor to BHEL store along with relevant documents.

iii) Wastage = Actual consumption – Theoretical consumption.

b) WASTAGE:

ALLOWABLE WASTAGE: (+3%) (Three percent) of the theoretical consumption shall be considered as allowable wastage. Invisible wastage (max limit to 0.5%), if any, shall be considered to be included in the specified 3 %

allowable wastage.

Sl. No.	CONSUMPTION OF REINFORCEMENT STEEL & EARTHING ROD MS ROUND	BASIS OF ISSUE
R-1	Theoretical consumption (without considering any wastage, scrap or loss) as per spec. & drg	Free
R-2	Wastage limited to plus THREE percent (+3%) of the aforesaid theoretical consumption (R-1) towards allowable wastage including invisible wastages (invisible wastages limited to 0.5% of theoretical consumptions).	Free
R-3	Wastage beyond THREE percent (+3%) of the aforesaid theoretical consumption (R-1).	Penal Rate

1.13.4.2 **STRUCTURAL STEEL, (ROLLED SECTION, PLATES ETC.) CONSUMPTION & WASTAGE:**

A) CONSUMPTION: -

The theoretical consumption of various sections shall be based on approved drawings. Weights shall be calculated considering the sectional weights as per Indian standard. No extra shall payable to the contractor for any deviation in weights for the two different procedures adopted for issue and calculation of the theoretical consumption including rolling tolerances.

i) Actual consumption = Issue – Surplus.

ii) Surplus = Un-tampered, unused, uncut quantity of steel and Serviceable materials as stipulated under clause “Scrap and Serviceable Materials (Refer Clause 1.13.3.1 above)” returned by the contractor to BHEL store along with relevant documents.

iii) Wastage = Actual consumption – Theoretical consumption.

B) WASTAGE

Allowable wastage: - 4% (FOUR percent) of the theoretical consumption shall be considered. Wastage shall be considered as cut pieces and scrap material, measured as per actual weighment basis. Invisible wastage (max limit to 0.5%), if any, shall be considered to be included in the specified 4% allowable wastage.

Sl.No.	CONSUMPTION OF STRUCTURAL STEEL (ROLLED SECTION, PLATES)	BASIS OF ISSUE
S-1	Theoretical consumption (without considering any wastage, scrap or loss) as per spec. & drg.	Free
S-2	Wastage limited to plus Four percent (+4%) of the aforesaid theoretical consumption (S-1) towards allowable wastage including invisible wastages (invisible wastages limited to 0.5% of theoretical consumptions)	Free
S-3	Wastage beyond Four percent (4%) of the aforesaid theoretical consumption (S-1).	Penal Rate

1.13.4.3 **RECONCILIATION OF MATERIALS**

a) The contractor shall submit a reconciliation statement of steel issued to him along with each RA Bill.

b) At the time of submission of bills, the contractor shall properly account for the material issued to him as specified herein to the satisfaction of BHEL certifying that the balance material is available in contractor's custody at site.

c) At the time of submission of bills by the contractor, if it is noticed by BHEL that the wastage is high and calls recovery at the penal rate, then, BHEL will proceed for recovery for the excess wastage as per penal recovery rates as specified.

d) The reference drawings for actual material consumption to be used for the purpose of reconciliation shall be drawings prepared by the BHEL and drawings approved by BHEL for fabrication works and such other drawings approved by BHEL. This shall also include the bar bending schedule prepared by the contractor and approved by BHEL.

1.13.5 BOROSILICATE LINING

1.13.5.1 The borosilicate lining material (including closed cell borosilicate glass blocks, adhesive/membrane and compatible primer paint) issued by the BHEL shall be properly accounted (issue and reconciliation) and issue shall be based on the Sq.m as indicated in the IS specifications.

1.13.5.2 The borosilicate lining material as received from the manufacturer / stockiest will be issued free of cost to the contractor.

1.13.5.3 Bidder is responsible for unloading the borosilicate lining material as soon as the arrival of material, in the weather proof air conditioned storage (as per supplier specification) sheds/container. The construction of storage sheds as per the requirement of BHEL, unloading of borosilicate lining material,

stacking properly in the storage sheds, removal of the sheds after the completion of the work is in the scope of bidder.

1.13.5.4 Necessary documents are to be submitted by the contractor to the BHEL stores for having received the materials.

1.13.5.5 Bidder is responsible for sampling and testing of borosilicate materials (if insisted by BHEL) as per Indian Standard / Specification / approved quality plan in the testing laboratory established by the bidder.

1.13.5.6 Consumption and wastage of Borosilicate Lining material:

A) CONSUMPTION: -

i. The theoretical consumption of Borosilicate Lining material shall be based on approved drawings.

ii. Actual consumption = Issue – Surplus

iii. Surplus = Un-tampered & unused quantity of material returned by the contractor to BHEL store.

iv. Wastage = Actual consumption – Theoretical consumption.

B) WASTAGE

Allowable wastage: - 1% (ONE percent) of the theoretical consumption shall be considered.

S.No	CONSUMPTION OF BOROSILICATE LINING MATERIAL	BASIS OF ISSUE
B-1	Theoretical consumption as per drg.	Free
B-2	Wastage limited to plus One percent (+1%) of the aforesaid theoretical consumption (B-1) towards allowable wastage	Free
B-3	Wastage beyond one Percent (1%) of the aforesaid theoretical consumption (B-1)	Penal Rate

1.8.1 **RECOVERY OF MATERIAL**

Recovery of wastages shall be made from the bills of contractor at the penal rate mentioned in the table below for the following cases:

a) If wastage exceeds the specified limit
b) If the wastage not exceeded specified limit, but not returned to BHEL store except invisible wastage
c) For not returning the surplus serviceable materials

1.13.6 RECOVERY OF MATERIAL

Recovery of wastages shall be made from the bills of contractor at the penal rate mentioned in the table below for the following cases:

a) If wastage exceeds the specified limit
b) If the wastage not exceeded specified limit, but not returned to BHEL store except invisible wastage
c) For not returning the surplus serviceable materials

1.13.7 PENAL RATE OF MATERIALS

A	**REINFORCEMENT STEEL** Cold rolled steel, high strength, deformed bar or mild steel round bars including earthing rod	**Rs. 58,065/- per MT** + GST and/or other taxes & duties
B	**STRUCTURAL STEEL – Long Products** Rolled steel Beams, channels, and angles etc in sizes and lengths as available	**Rs. 59,630/- per MT** + GST and/or other taxes & duties
C	**STRUCTURAL STEEL – Flat Products** MS plates, MS flats, MS pipes, Chequered Plates, etc in sizes and lengths as available	**Rs. 79,065/- per MT** + GST or other taxes & duties
D	**CEMENT (OPC/ PPC/PSC)**	**Rs. 5,906/- per MT** + GST and/or other taxes & duties
E	**BOROSILICATE LINING MATERIAL INCLUDING ADHESIVES/ MEMBRANE, PRIMER PAINT**	**Actual cost of procurement per sqm + 5 % overhead** + GST and/or other taxes & duties

VOLUME-IA PART –I CHAPTER –XIV
TEST PILE INSTALLATION AND LOAD TESTING

1.14.1 Approximate number of tests piles are 12. Diameter of pile is 600mm. Depth of pile is 17m & 26m. For details, drawings for test pile shall be referred, which is provided with the tender.

1.14.2 Arrangement of cement and reinforcement steel required for test pile work is in the scope of contractor. Cement shall be OPC 43 with C3A content limited to 5% to 8% as per IS 269 :2015. Reinforcement steel shall be of Fe 500 grade corrosion resistant steel and as per relevant IS specification as mentioned in the contract/ drawings/ instructions. All bars shall be of tested quality. Reinforcement steel brought to site shall be of prime steel manufacturer viz. SAIL, VIZAG, TATA STEEL or from other customer approved manufacturers. Prior to procurement of cement, approval shall be sought from BHEL/ Owner. For RMC, approval shall be taken for cement to be used by RMC supplier.

1.14.3 For casting of test piles, effort shall be made for making tie up with available RMC supplier within/ nearby plant premises for supply of ready-mix concrete for faster execution of test piles. Prior approval of RMC supplier shall be sought from BHEL/ Customer/ Owner. In connection to approval of RMC, all the relevant document of RMC supplier viz. source of aggregate, petrographic examination report of aggregates, initial tests and routine tests of aggregates (as per technical specification or IS:383), calibration certificate of batching plant, License for RMC production, water test report, etc. shall be submitted for BHEL/ Owner review.

1.14.4 Prior to use, trial mix at site shall be taken and to be tested by ACT (Accelerated curing test) method for establishment of concrete strength. Minimum number of cubes to taken are as follows:

a) For ACT – 6 nos

b) For 3 days testing – 6 nos

c) For 7 days testing – 6 nos

d) For 28 days testing – 6 nos

After establishment of concrete strength by ACT method, supply of RMC for test pile casting can be commenced.

1.14.5 Minimum one hydraulic rotary rig for test pile works shall be arranged within 15 days of placement of LOI.

1.14.6 Tie up with technically capable pile load testing agency shall be made within 20 days of placement of LOI and all relevant document shall be submitted to BHEL/ Owner for approval. Subsequently methodology for initial pile load testing shall be submitted to BHEL/ Owner for approval prior to commencement of initial load testing work.

VOLUME-IA PART –I CHAPTER –XV
CHIMNEY INSULATION

1.15.1 Specification for surface preparation of steel substrate

1.15.1.1 The steel surface shall be grit blasted to a cleanliness of SA 2 1/2 and approved by the supplier of the lining system.

1.15.1.2 The substrate shall thereafter be primed using a high performance epoxy primer within a short time window approved by the supplier

1.15.2 Wet stack properties of the lining system

1.15.2.1 The lining system (borosilicate glass block and adhesive) shall be tested for its wet stack surface properties by an independent approved institute, subject to acceptance by the Purchaser, and has during such testing been shown to allow, without any significant re-entrainment of flue gas condensate, a flue gas velocity of at least 18.3 m/s. Bidder shall provide a project specific "Wet Stack" study, performed by an independent approved institute, subject to acceptance by the Purchaser, indicating the correct placement and design of liquid collection gutters and liquid drains to ensure minimization of liquids and condensates entering the chimney.

1.15.2.2 The approximate estimated Surface area for Chimney flue and Borosilicate Lining including inlet flue gas duct, transition piece for flue duct, soot hopper etc. is furnished below. However, the surface area required for chimney lining shall be calculated by the bidder from the drawings furnished along with this tender and the lining shall be provided accordingly.

1.15.2.3 Surface Area for one flue – 10,300 m^2 { indicative minimum}

1.15.3 Surface Preparation & Surface Cleaning

1.15.3.1 The bidder shall carry out the following as a minimum to prepare the steel flue surface for the lining.

1.15.3.2 Sandblasting of flue for surface preparation. Near-white metal blast finish shall be provided by the bidder for preparing the steel surfaces to receive the lining.

1.15.3.3 All surfaces must be free from dust, dirt, and grease. Any foreign material which will interfere with adhesion must be removed.

1.15.3.4 All weld spatter slag and old anchor welds shall be removed from the substrate, and the area ground flush with the parent metal.

1.15.3.5 All edges and fillets and similar abrupt contours shall be rounded off smoothly.

1.15.4 Mixing of Adhesive Membrane

1.15.4.1 The Adhesive membrane shall be mixed according to the direction for the product use in the correct mixing ratio.

1.15.4.2 The temperature for mixing the main material and hardener shall be about 24 deg C.

1.15.4.3 Appropriate mixing method shall be used for equal mixing and should be blended for the required appropriate time.

1.15.4.4 Sufficient time shall be allowed for curing

1.15.5 Mixing machine

1.15.5.1 Mixing machine shall be used for preparing the 2 component Adhesive Membrane on site.

1.15.5.2 In order to ensure consistent, high quality mixing of the components of the lining system adhesive, (an) automated mixing machine(s) should be provided using a 3,200W mixer motor, with fail-safe protection against the operator error of mixing the main adhesive component without its hardener.

1.15.5.3 The mixing machine must be CE – approved.

1.15.5.4 The mixing machine shall have thermal motor protection to minimize failure and fire risk.

1.15.5.5 Adequate number of mixing machines shall be employed for completion of the installation works for the two units within the scheduled time.

1.15.6 Mixing of Epoxy Primer

1.15.6.1 Epoxy Primer shall be mixed according to the direction for the product use

1.15.6.2 Mixing ratio shall be as recommended by OEM

1.15.6.3 Epoxy Primer shall be blended by using Mechanical Mixer for the required minimum time.

1.15.7 Installation of Borosilicate Block

1.15.7.1 The Adhesive membrane shall be applied as per the instructions of OEM.

1.15.7.2 Arrange the borosilicate glass blocks such that there is no black space between the block and surface. The adhesive should fill the side joint and flow out to the edge. The block shall completely stick to adhesive applied on the surface.

1.15.7.3 Block whose edge is broken shall not be used.

1.15.7.4 All the equipments and tools required to install Borosilicate Glass Block lining system including Polyethylene film, Rag, Wire brush, Plastic sink, Electric drill, Jiffy Mixer Blade, Insulated saw, Float, Paint brush, hand cleaner, Cleansing glove, Hygrometer, Surface thermometer, white chalk, white spray etc as required shall be arranged by the bidder.

1.15.8 Inspection

1.15.8.1 Inspection and testing including adhesion shall be as per approved QAP.

1.15.8.2 The mixing, curing and adhesion characteristics of the adhesive membrane shall be evaluated by applying it onto a test area of the same material and surface preparation of the substrate. Work life and initial set time may be visually observed. Cure shall be uniform.

1.15.8.3 The installation procedure of the lining system shall be verified by installing the system on a transparent panel. Visual inspection shall be made of back, end and side joints.

1.15.9 Performance, safety and fire risk

1.15.9.1 The lining system (borosilicate glass block and adhesive) shall be tested and certified for fire risk by an approved institute subject to acceptance by the Purchaser, and through testing as per relevant ASTM standards.

1.15.10 Sample Point

1.15.10.1 Borosilicate block primer and high nickel steel bar will be applied to sample points to make it acid resistant.

1.15.10.2 The nozzle (Pipe tube) shall be of suitable alloy steel to withstand design operating environment.

1.15.10.3 Nozzle shall be fully seal-welded both inside and outside of the steel duct plate. The inside weld shall be ground smooth.

1.15.10.4 The nozzle shall be flanged and not threaded.

1.15.10.5 The Glass Blocks shall be Cut and shaped as required to fit. The block shall be fully bonded to the exterior surface of the nozzle with adhesive membrane.

1.15.10.6 The bidder shall coordinate with the BOP package contractor in order to ensure that the sample point is matching with the requirements for installing the flue gas analyser probes/equipments.

1.15.11 Manhole and Access doors

1.15.11.1 Manholes/Access doors shall be modified by application of borosilicate blocks.

1.15.11.2 High nickel alloy stop bars of 2mm thickness for protection from acidic condensate.

1.15.11.3 Fibre gaskets shall be used for sealing.

1.15.12 Collection gutter

1.15.12.1 The condensate generated in flue gas while FGD is under operation, shall be collected and discharged from bottom of the flue can.

1.15.12.2 The material of gutter including drain and base plates shall be made of suitable alloy steel to withstand design operating environment.

1.15.12.3 All welds shall be full seal welds.

1.15.12.4 The surfaces of the alloy materials which will be in contact with the lining system shall be blasted and primed with Epoxy Primer.

1.15.12.5 The Glass Blocks shall be fully bonded to the alloy steel.

1.15.13 Soot Hopper

1.15.13.1 Acid proof brick lining in soot hopper is not be required and instead borosilicate lining shall be provided resistant to acids.

1.15.14 Puddle Flange

1.15.14.1 Puddle flange located at the bottom of soot hopper shall be lined with High nickel alloy material for protection from acidic ash.

1.15.15 Expansion Joints

1.15.15.1 Expansion joints cannot withstand the acidic flue gas during FGD operation and hence shall be replaced by acid resistant elastomeric fabric bellows.

1.15.16 BATTERY LIMITS

1.15.16.1 Following are the battery limits.

a) Chimney Flue: Entire system from inlet flue gas duct to flue top.

b) Inlet flue gas duct:

VOLUME-IA PART-II CHAPTER-1

CORRECTIONS / REVISIONS IN SPECIAL CONDITIONS OF CONTRACT, GENERAL CONDITIONS OF CONTRACT AND FORMS & PROCEDURES

Sl No.: 1

Clause 4.1.11 of SCC is deleted.

Sl No.: 2

OCCUPATIONAL HEALTH, SAFETY & ENVIRONMENT MANAGEMENT/ QUALITY ASSURANCE PROGRAMME

The following clauses in Occupational Health, Safety & Environment Management / Quality Assurance Programme published in Chapter-IX of Special Conditions of Contract (Volume I Book-II) is revised as under.

Chapter IX Clause 9.1 is modified as below:

Contractor will comply with HSE (Health, Safety & Environment) requirements of BHEL as per the "HSE Plan for Site Operations by Subcontractor" (Document No. HSEP: 14 Rev 01) enclosed.

Chapter IX Clause 9.1.1 to 9.1.25 stands deleted.

Chapter IX Clause 9.2 to 9.62 stands deleted.

Sl No.: 3

Clause No. 10.5 on RA Bill Payments, in Special Conditions of Contract (SCC), Volume- IB, Book- II, is revised as under:

The payment for running bills will normally be released within 30 days of submission of running bill complete in all respects with all documents. It is the responsibility of the contractor to make his own arrangements for making timely payments towards labour wages, statutory payments, outstanding dues etc., and other dues in the meanwhile.

Sl No.: 4:

EARNEST MONEY DEPOSIT

The EARNEST MONEY DEPOSIT (EMD) clause 1.9 published in General Conditions of Contract (Volume IC Book-II) is revised as under.

Void (Explanation: EARNEST MONEY DEPOSIT is not applicable for this tender).

Bid Security Declaration: Bidders to submit Bid Security Declaration as per format provided in NIT.

Sl No. 5:

The following clause is added under clause 1.10 Security Deposit in General Conditions of Contract (Volume I Book II):

1.10.8 Bidder agrees to submit security deposit required for execution of the contract

within the time period mentioned. In case of delay in submission of security deposit, enhanced security deposit which would include interest (Base rate of SBI + 6%) for the delayed period, shall be submitted by the bidder. Further, if security deposit is not submitted till such time the first bill becomes due, the amount of security deposit due shall be recovered as per terms defined in NIT / contract, from the bills along with due interest

Sl No.: 6:

In addition to clause 2.7.9 of General Conditions of Contract (GCC), a New clause 2.7.9.1 is added as below.

2.7.9.1 Penalty for Intermediate Milestones

2.7.9.1.1 M1 and M2 shall be intermediate Milestones for this work.

2.7.9.1.2 In case of slippage of these identified Intermediate Milestones, Delay Analysis shall be carried out on achievement of each of these two Intermediate Milestones in reference to Form 14.

2.7.9.1.3 Incase delay in achieving M1 milestone is solely attributable to the contractor,0.5% per week of executable contract value* limited to Maximum 2% of executable contract value will be withheld.

2.7.9.1.4 Incase delay in achieving M2 milestone is solely attributable to the contractor,0.5% per week of executable contract value* limited to maximum 3% of executable contract value will be withheld.

2.7.9.1.5 Amount already withheld, if any, against slippage of M1 milestone, shall be released only if there is no delay attributable to contractor in achievement of M2 milestone.

2.7.9.1.6 Amount required to be withheld on account of slippage of identified intermediate milestone(s) shall be withheld out of respective milestone payment and balance amount (if any) shall be withheld @10% of RA Bill amount from subsequent RA bills.

2.7.9.1.7 Final deduction towards LD (if applicable), on account of delay attributable to contractor shall be based on final delay analysis on completion / closure of contract. Withheld amount, if any due to slippage of intermediate milestones shall be adjusted against LD or released as the case may be.

2.7.9.1.8 In case of termination of contract due to any reason attributable to contractor before completion of work, the amount already withheld against slippage of intermediate milestones shall not be released and be converted in to recovery.

Note: *Executable contract value-value of work for which inputs/fronts were

made available to contractor and were scheduled for execution till the date of achievement of that milestone.

Sl No.: 7

PRICE VARIATION COMPENSATION (PVC)

Clause 2.17.5 under The PRICE VARIATION COMPENSATION (PVC) clause 2.17 published in General Conditions of Contract (Volume IC Book-II) is revised as under.

"Base date shall be calendar month of the scheduled completion date (i.e. actual start date + scheduled contractual completion period as per letter of intent/ award and/or work order)".

Sl. No.: 8

Clause 2.14.1 in GCC regarding Quantity Variation in General Conditions of Contract (GCC), Volume-1C, Book- II is revised as under:

"The quantities given in the contract are tentative and may change to any extent (both in plus side and minus side). The quoted rates for individual items shall remain firm irrespective of any variations in the individual quantities. No compensation becomes payable in case the variation of the final executed contract value is within the limit of Minus (-) 30% of awarded contract value."

Sl No.: 9

Procedure 2.3 that forms the part of Forms and Procedures is published as Chapter 12 in Volume IA Part II of this booklet (Volume-I Book-I).

Sl No.: 10

The chapter Reverse auction procedure published in 'Forms and Procedures' of Volume I Book-II stands deleted. 'Guidelines for Reverse Auction-2021' available in the website http://www.bhel.com -> Supplier Registration, shall be applicable**.**

Sl No.: 11

Existing format for BANK GUARANTEE FOR SECURITY DEPOSIT, as available in Form No. F-11 (Rev 00) of Volume ID Forms and procedures stands deleted. Refer Proforma of Bank Guarantee (in lieu of Security Deposit)-Form WAM 22 provided in Chapter-11, Part-II of Volume-IA Technical Conditions of Contract.

Sl No.: 12

Existing format on Monthly Performance Evaluation of Contractor, as available in Form No F-14 of Volume ID Forms and procedure stands Deleted. Form No.- F-14 (Rev 01) is enclosed.

Sl No.: 13

Existing format on Monthly Performance Evaluation of Contractor, as available in Form No F-15 of Volume ID Forms and procedure stands Deleted. Form No.- F-15 (Rev 03) is enclosed.

Sl No.: 14

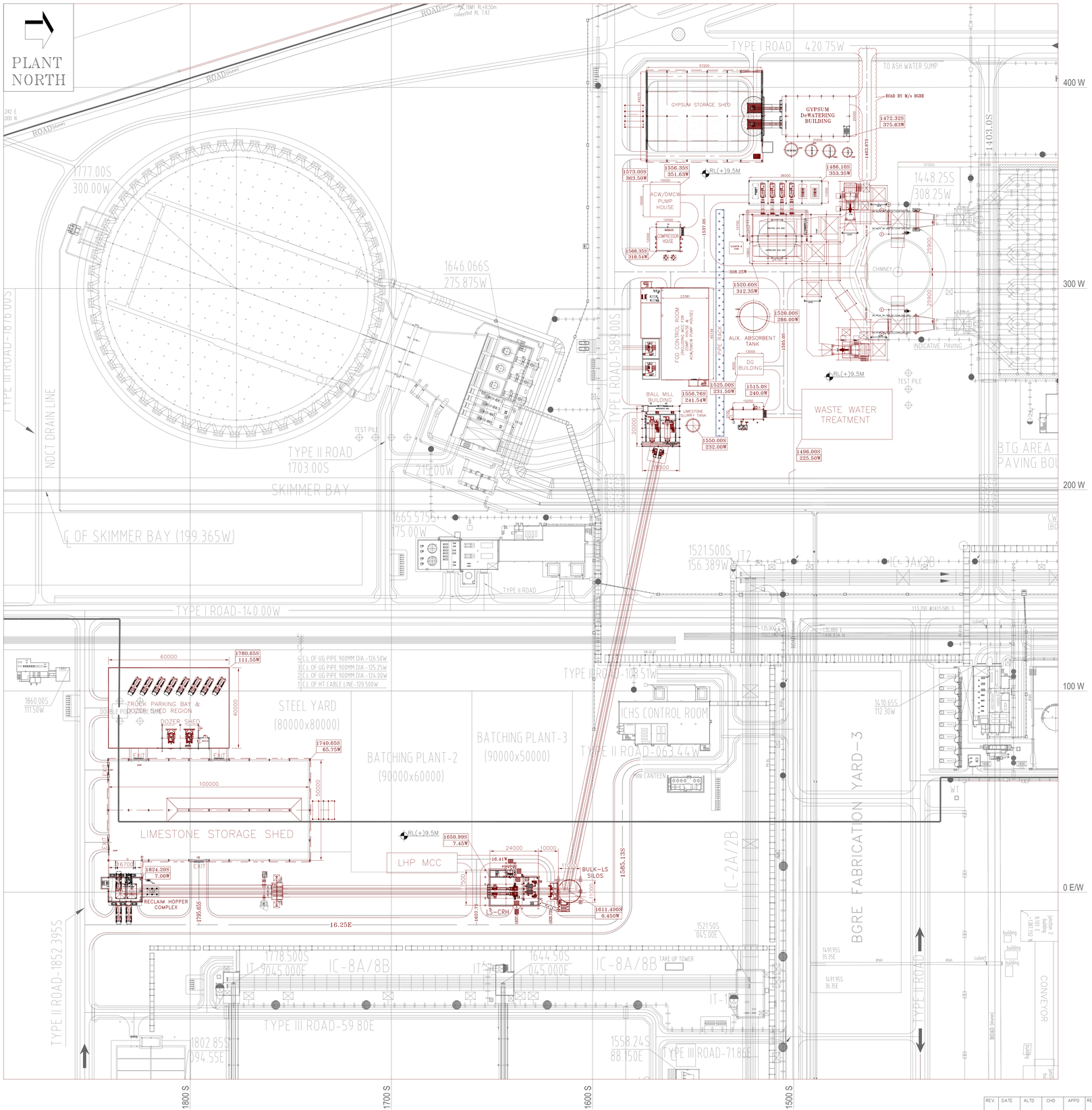
Existing format for Integrity Pact, as available in Volume ID Forms and procedure stands Deleted. Refer revised format for Integrity Pact provided in Annexure – 7 of Notice Inviting Tender (NIT).

VOLUME-IA PART – II

CHAPTER 2 to 12

Chapter 2 to 12 in next 1264 pages as below

2	Drawings Plot Plan- FGD Area (Drawing No. PE-DG-485-100-M001 (1 sheet) RC details for initial load test piles (Drawing No. PE-DG-485-607-C001) (2 sheets)	Chapter-2
3	Technical Specifications (i) Section – C (685 pages) (ii) Section – D (377 pages)	Chapter-3
4	Technical specification for Borosilicate Glass Block Lining of Flue Can (7 pages) Chimney- General Arrangement (Drawing No. GID-244-CV-UHN-RC-30201 Rev 0) (1 sheet)	Chapter-4
5	Geotechnical Investigation Report BOP Area	Chapter-5
6	T&P Hire Charges	Chapter-6
7	"HSE Plan for Site Operations by Subcontractor" (Document No. HSEP: 14 Rev01)	Chapter-7
8	Format for Form no.: F-14 (Rev 01); Monthly Plan and Review with Contractors	Chapter-8
9	Format for Form no.: F-15 (Rev 03); Monthly Performance Evaluation of contractor	Chapter-9
10	Proforma of Bank Guarantee (in lieu of Earnest Money)-Form WAM 23	Chapter-10
11	Proforma of Bank Guarantee (in lieu of Security Deposit)-Form WAM 22	Chapter-11
12	Procedure 2.3-Procedure for Conduct of Conciliation Proceedings	Chapter-12



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS IN METRES
2. FINISH FLOOR LEVEL = RL (+)10.0 M,CORRESPONDS TO PLANT EL 0.0M (GROUND FLOOR OF STG BUILDING). FINISHED GROUNG LEVEL OF BOP AREA AS MARKED.

LEGEND:–

FGL	– FINISHED GROUND LEVEL
FFL	– FINISHED FLOOR LEVEL
BMB	– BALL MILL BUILDING
GDW	– GYPSUM DEWATERING BUILDING
FWT	– FILTER WATER TANK
LSSST TANK	– LIMESTONE SLURRY STORAGE (REAGENT TANK)
AAT	– AUXILIARY ABSORBENT TANK
BUF	– BOOST UP FAN
WWT	– WASTE WATER TANK
SHFT FEED TANK	– SECONDARY HYDRO CYCLONE
PWT	– PROCESS WATER TANK
CLWT	– CLARIFIED WATER TANK

HOLDS:

1. GYPSUM DEWATERING BUILDING
2. TANKS
3. LIMESTONE HANDLING FACILITIES
4. ABSORBER GA
5. CONTROL ROOM GA
6. RECIRCULATION PUMP HOUSE GA

REFERENCE DRGS:

SL No.	TITLE	DRG. NUMBER	SCOPE
1	GA OF LIMESTONE STORAGE SHED	IS–1–GA–758–204–M004	ISG
2	GA OF RECLAIM HOPPER WITH LOAD DATA	IS–1–GA–758–204–M005	ISG
3	GA OF GYPSUM STORAGE AREA INCLUDING SHED	IS–1–GA–758–204–M006	ISG
4	GA & LOAD DATA OF LHP BELT CONVEYOR –1A/B ALONG WITH PENT HOUSE	IS–1–GA–758–201–M007	ISG
5	GA OF LIMESTOINE– CRUSHER HOUSE WITH LOAD DATA	IS–1–GA–758–204–M008	ISG
6	GA & LOAD DATA OF LIMESTONE STORAGE SILO & BLDG.	IS–1–GA–758–204–M011	ISG
7	GA & LOAD DATA OF LHP BELT CONVEYOR –2A/B	IS–1–GA–758–201–M012	ISG
8	GA & LOAD DATA OF LHP & GHP PUMP HOUSE	IS–1–GA–758–212–M013	ISG
9	GA OF TRUCK PARKING BAY AND DOZER SHED.	IS–1–GA–758–212–M013A	ISG
10	GA OF LIMESTONE DAY SILO BUILDING	–	HYD
11	GA OF FLUE GAS DUCT LAYOUT	–	TRY
12	GA OF ABSORBER AND RECIRC. PUMP HOUSE	–	TRY
13	GA OF CONTROL ROOM	–	PEM
14	GA OF TANKS	–	PEM
15	GA OF COMPRESSOR HOUSE	–	PEM
16	GA OF GYPSUM DEWATERING BUILDING	–	PEM
17	GA OF ACW/DMCW PUMP HOUSE	–	PEM
18	PIPE RACK LAYOUT	PE–DG–485–181–M002	PEM

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	DRAWING REVISED AS PER TANGEDCO COMMENTS AND REVISED GAs.			

JOB NO.	485
STATUS:	CONTRACT
DISTRIBUTION	

CUSTOMER: **TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED**
5th Floor, Western Wing, NPKRR Maaligai, 144, Anna Salai, Chennai–600002

CONSULTANT: **Fichtner Consulting Engineers (India) Pvt Ltd.**
Menon Eternity, 9th Floor, No.165, St. Mary's Road, Alwarpet, Chennai–600018

PROJECT: 1X800 MW TANGEDCO NORTH CHENNAI TPP STAGE III – FGD

BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA

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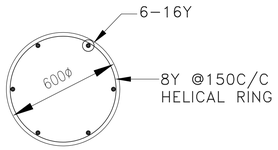
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	APPD	BKA	Sd/–	08.06.2021

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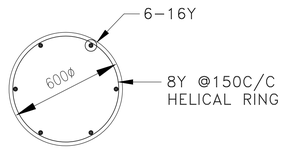
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SIGN | SHEET 1 OF 1 | REV. 1

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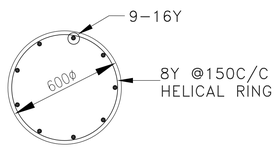
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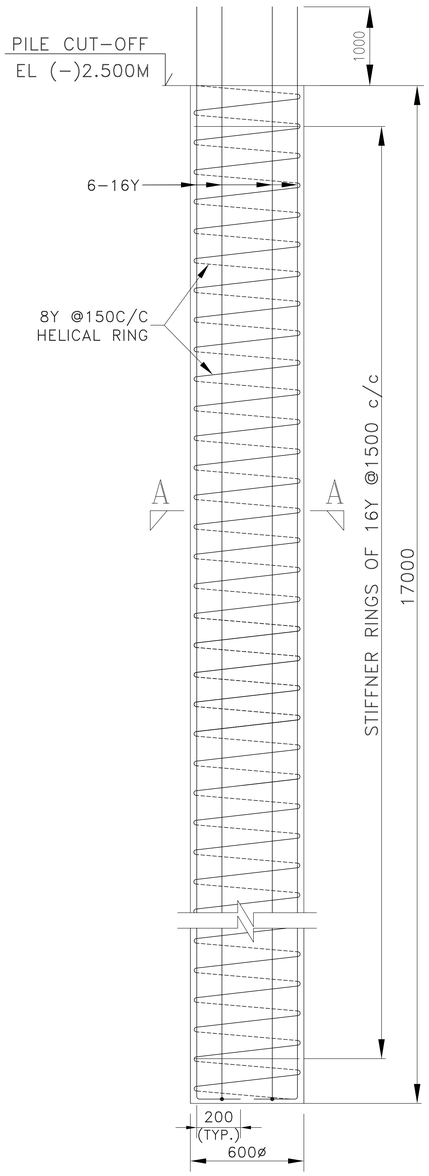
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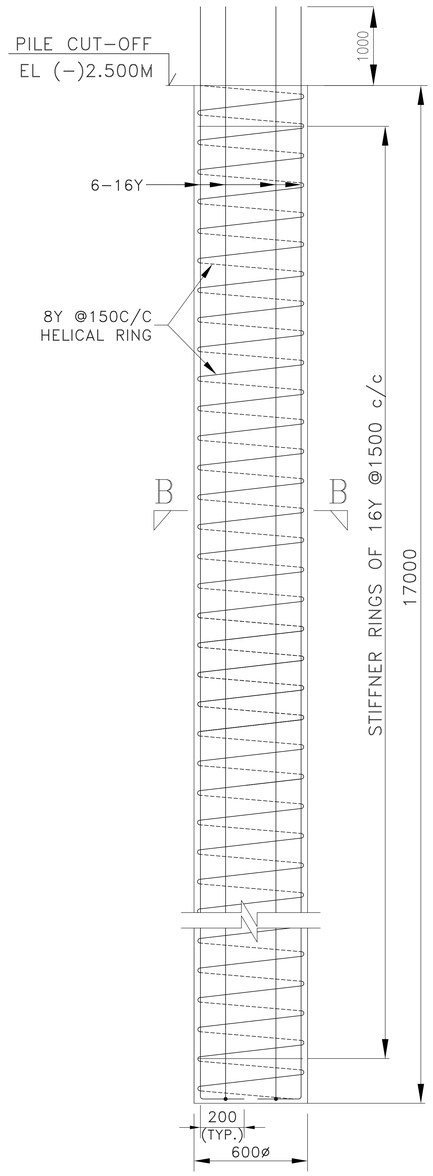
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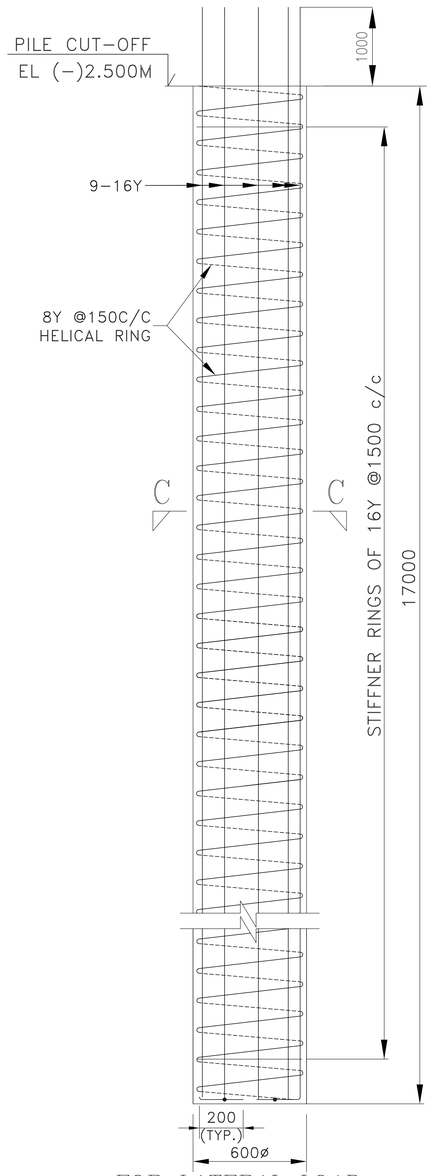
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FOR VERTICAL COMPRESSION



FOR PULL–OUT

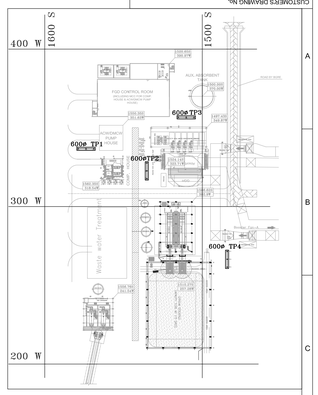


FOR LATERAL LOAD

REINFORCEMENT DETAILS OF 600MM DIAMETER BORED CAST–IN–SITU INITIAL LOAD TEST PILES

LOCATION OF TEST PILE (REF.NOTE–13)

TEST NO.	COORDINATES		DIA OF PILE (MM)	REMARKS
TPV1	1579 S	337 W	600	TPV–TEST PILE FOR VERTICAL COMPRESSION
TPP1	1574 S	337 W		TPP–TEST PILE FOR PULL–OUT
TPH1	1569 S	337 W		TPH–TEST PILE FOR LATERAL LOAD
TPV2	1535 S	328 W	600	
TPP2	1535 S	323 W		
TPH2	1535 S	318 W		



KEY PLAN

SAFE LOAD CARRYING CAPACITY OF BORED CAST–IN–SITU PILE

DIAMETER OF PILE (MM)	SAFE LOAD (MT)			
	VERTICAL COMPRESSION	PULL OUT	LATERAL	
			FREE HEAD CONDITION*	FIXED HEAD CONDITION**
600	75.00	15.00	2.75	7.00

"*" FOR INITIAL LOAD TEST PILE
"**" FOR JOB PILE

NOTES:

1. ALL DIMENSIONS ARE IN MM AND ELEVATION/LEVEL ARE IN METER UNLESS NOTED OTHERWISE.
2. EL.(±) 0.00M CORRESPONDS TO R.L. (+) 10.00M.
3. BORED CAST–IN–SITU CONCRETE PILE CONFORMING TO IS:2911 (PART–1/SEC.–2) SHALL BE USED.
4. GRADE OF CONCRETE SHALL BE M40 CONFORMING TO IS:456 WITH MINIMUM CEMENT CONTENT OF 400 Kg/CUM. ORDINARY PORTLAND CEMENT WITH C3A CONTENT LIMITED TO 5 TO 8% SHALL BE USED.
5. REINFORCEMENT STEEL SHALL BE CORROSION RESISTANT THERMO–MECHANICALLY TREATED REINFORCEMENT STEEL (HIGH STRENGTH DEFORMED STEEL BARS) CONFORMING TO GRADE Fe–500 OF IS:1786.
6. LAP LENGTH SHALL BE 50 TIMES DIAMETER OF BAR. LAPS SHALL BE STAGGERED ALTERNATIVELY.
7. CLEAR COVER TO LONGITUDINAL REINFORCEMENT SHALL BE 60MM.
8. INITIAL LOAD TEST SHALL BE CONDUCTED UPTO A MAXIMUM TEST LOAD OF TWO AND HALF TIMES THE SAFE LOAD CARRYING CAPACITY OF PILE. VERTICAL COMPRESSION TEST SHALL BE CARRIED OUT BY CYCLIC LOAD METHOD AS PER IS:2911 PART IV.
9. TEST SHALL BE CONDUCTED AT PILE CUT–OFF LEVEL.
10. CONCRETING SHALL BE DONE UPTO THE GROUND LEVEL TO PERMIT OVERFLOW OF CONCRETE FOR VISUAL INSPECTION OR TO A MINIMUM OF 1000MM ABOVE CUT OFF LEVEL.
11. TEST RESULTS SHALL BE SUBMITTED TO OWNER/OWNER'S CONSULTANT/BHEL–PEM IMMEDIATELY AFTER COMPLETION OF THE SAME.
12. TREMIE CONCRETING SHALL BE ADOPTED.
13. TEST PILE LOCATIONS ARE INDICATIVE ONLY. MINOR MODIFICATIONS (IF REQUIRED) IN TEST LOCATIONS MAY BE DONE AT SITE IN CONSULTATION WITH OWNER.
14. LOW STRAIN PILE INTEGRITY TEST SHALL BE CARRIED OUT ON ALL TEST PILES AS PER SPECIFICATION.
15. THE PILE SHALL BE TESTED FOR LATERAL LOAD UNDER FREE HEAD CONDITION.

REFERENCE:

1. CUSTOMER'S TECHNICAL SPECIFICATION.
2. DRAWING NO: PE–DG–485–100–M001, REV–00 TITLED "PLOT PLAN– FGD AREA".
3. DOCUMENT NO. PE–DC–485–607–C001 TITLED "DESIGN CALCULATION FOR INTIAL LOAD TEST PILES".

BHEL–PROJECT ENGINEERING MANAGEMENT[CIVIL]
THIS DRAWING MARKED [✓] IS RELEASED FOR
[✓] COMMENTS/APPROVAL
[ ] PLANNING/INFORMATION
[ ] CONSTRUCTION
STAMP ALL PREVIOUS REVISION AS SUPERSEDED

ISSUED BY	
NAME	VIJAY SINGH
SIGNATURE	–sd–
DATE	28.07.2021

NOTE :- BEFORE PROCEEDING WITH CONSTRUCTION PLEASE SCAN THE QR CODE TO KNOW THE LATEST REVISION

JOB NO. 485
STATUS CONTRACT
DISTRIBUTION

REV.	DATE	ALTD	CHD	APPD
01	28.07.21	YK	VS/VV	TMSR/DKM

DRG. REVISED TO INCORPORATE CUSTOMER COMMENTS VIDE Lr No: SE/C/TP/E6/NCTPS S–III BTG/F.Piles/D.381/21 DTD. 17.07.21. REVISION NO.01 THUS.

CUSTOMER: TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED
5th Floor, Western Wing, NPKRR Maaligai, 144, Anna Salai, Chennai–600002

CONSULTANT: Fichtner Consulting Engineers (India) Pvt. Ltd.
Menon Eternity, 9th Floor, No.165, St. Mary's Road, Alwarpet, Chennai–600018

PROJECT: 1X800 MW TANGEDCO NORTH CHENNAI TPP STAGE III–FGD

BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA

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	DESN	VS	–sd–	24.07.2021
	CHD	VS/AKV	–sd–	24.07.2021
	APPD	TMSR/DKM	–sd–	24.07.2021

TITLE: RC DETAILS FOR INTIAL LOAD TEST PILES

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SIGN | SHEET 1 OF 2 | REV. 1

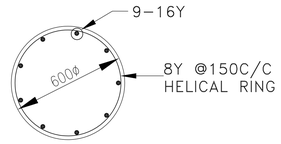
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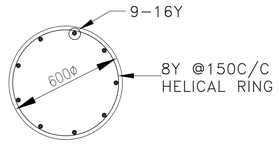
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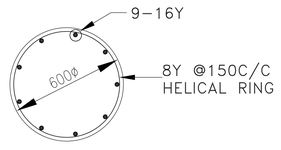
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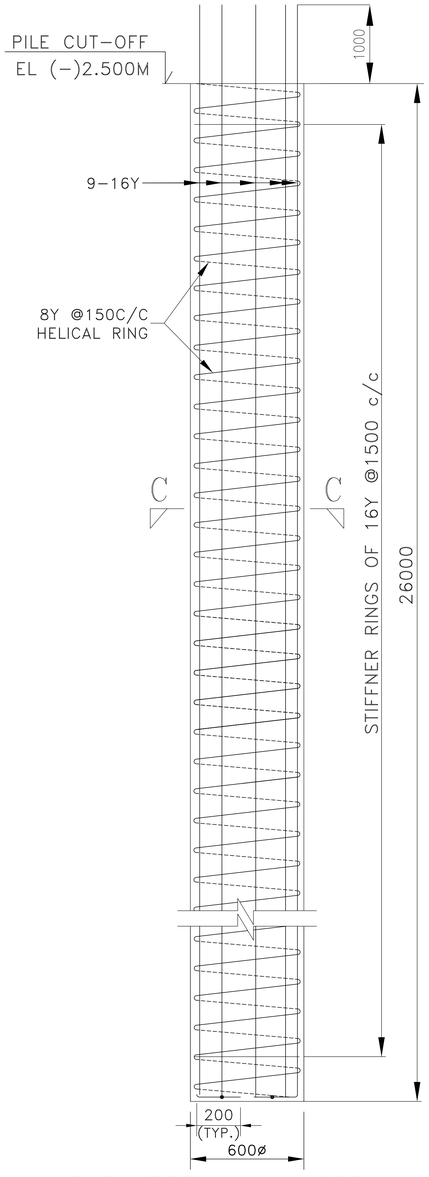
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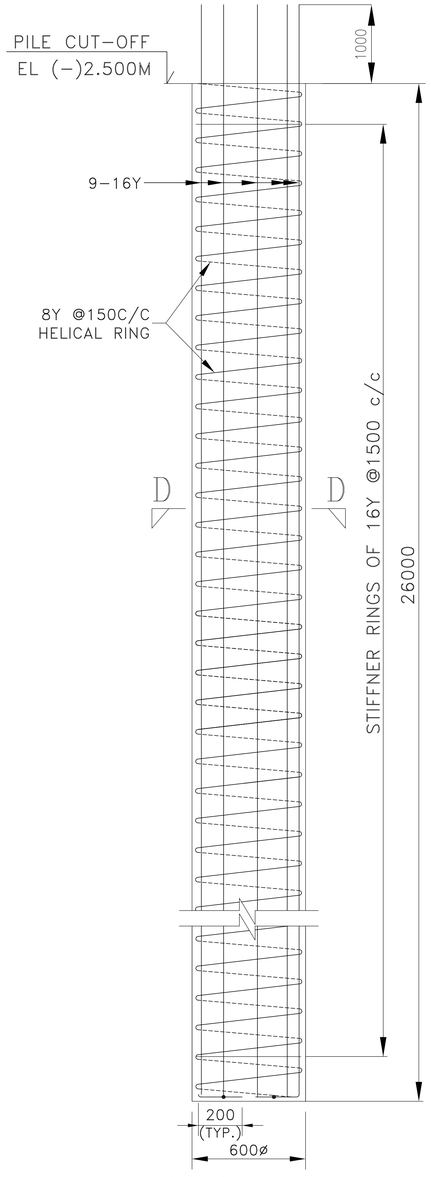
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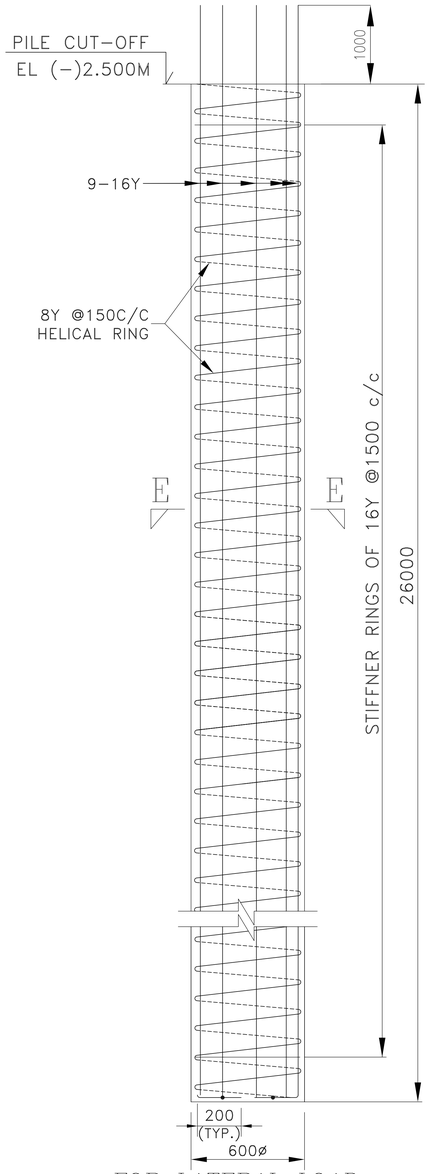
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FOR VERTICAL COMPRESSION



FOR PULL-OUT

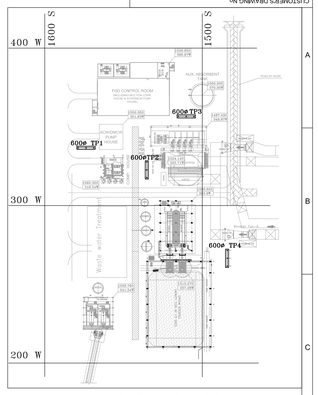


FOR LATERAL LOAD

REINFORCEMENT DETAILS OF 600MM DIAMETER BORED CAST-IN-SITU INITIAL LOAD TEST PILES

LOCATION OF TEST PILE (REF.NOTE-13)

TEST NO.	COORDINATES		DIA OF PILE (MM)	REMARKS
TPV3	1515 S	357 W	600	TPV-TEST PILE FOR VERTICAL COMPRESSION
TPP3	1510 S	357 W		
TPH3	1505 S	357 W		TPP-TEST PILE FOR PULL-OUT
TPV4	1484 S	272 W	600	
TPP4	1484 S	267 W		TPH-TEST PILE FOR LATERAL LOAD
TPH4	1484 S	262 W		



⚠KEY PLAN

SAFE LOAD CARRYING CAPACITY OF BORED CAST-IN-SITU PILE

DIAMETER OF PILE (MM)	SAFE LOAD (MT)			
	VERTICAL COMPRESSION	PULL OUT	LATERAL	
			FREE HEAD CONDITION*	FIXED HEAD CONDITION**
600	150.00	30.00	2.75	7.00

"*" FOR INITIAL LOAD TEST PILE

"**" FOR JOB PILE

NOTES:

1. ALL DIMENSIONS ARE IN MM AND ELEVATION/LEVEL ARE IN METER UNLESS NOTED OTHERWISE.
2. EL.(±) 0.00M CORRESPONDS TO R.L. (+) 10.00M.
3. BORED CAST-IN-SITU CONCRETE PILE CONFORMING TO IS:2911 (PART-1/SEC.-2) SHALL BE USED.
4. GRADE OF CONCRETE SHALL BE M40 CONFORMING TO IS:456 WITH MINIMUM CEMENT CONTENT OF 400 Kg/CUM. ORDINARY PORTLAND CEMENT WITH C3A CONTENT LIMITED TO 5 TO 8% SHALL BE USED.
5. REINFORCEMENT STEEL SHALL BE CORROSION RESISTANT THERMO-MECHANICALLY TREATED REINFORCEMENT STEEL (HIGH STRENGTH DEFORMED STEEL BARS) CONFORMING TO GRADE Fe-500 OF IS:1786.
6. LAP LENGTH SHALL BE 50 TIMES DIAMETER OF BAR. LAPS SHALL BE STAGGERED ALTERNATIVELY.
7. CLEAR COVER TO LONGITUDINAL REINFORCEMENT SHALL BE 60MM.
8. INITIAL LOAD TEST SHALL BE CONDUCTED UPTO A MAXIMUM TEST LOAD OF TWO AND HALF TIMES THE SAFE LOAD CARRYING CAPACITY OF PILE. VERTICAL COMPRESSION TEST SHALL BE CARRIED OUT BY CYCLIC LOAD METHOD AS PER IS:2911 PART IV.
9. TEST SHALL BE CONDUCTED AT PILE CUT-OFF LEVEL.
10. CONCRETING SHALL BE DONE UPTO THE GROUND LEVEL TO PERMIT OVERFLOW OF CONCRETE FOR VISUAL INSPECTION OR TO A MINIMUM OF 1000MM ABOVE CUT OFF LEVEL.
11. TEST RESULTS SHALL BE SUBMITTED TO OWNER/OWNER'S CONSULTANT/BHEL-PEM IMMEDIATELY AFTER COMPLETION OF THE SAME.
12. TREMIE CONCRETING SHALL BE ADOPTED.
13. TEST PILE LOCATIONS ARE INDICATIVE ONLY. MINOR MODIFICATIONS (IF REQUIRED) IN TEST LOCATIONS MAY BE DONE AT SITE IN CONSULTATION WITH OWNER.
14. LOW STRAIN PILE INTEGRITY TEST SHALL BE CARRIED OUT ON ALL TEST PILES AS PER SPECIFICATION.
15. THE PILE SHALL BE TESTED FOR LATERAL LOAD UNDER FREE HEAD CONDITION.

REFERENCE:

1. CUSTOMER'S TECHNICAL SPECIFICATION.
2. DRAWING NO: PE-DG-485-100-M001, REV-00 TITLED "PLOT PLAN- FGD AREA".
3. DOCUMENT NO. PE-DC-485-607-C001 TITLED "DESIGN CALCULATION FOR INTIAL LOAD TEST PILES".

BHEL-PROJECT ENGINEERING MANAGEMENT(CIVIL)
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NAME	VIJAY SINGH
SIGNATURE	-sd-
DATE	28.07.2021

CUSTOMER: TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED
5th Floor, Western Wing, NPKRR Maaligai, 144, Anna Salai, Chennai-600002

CONSULTANT: FICHTNER — Fichtner Consulting Engineers (India) Pvt. Ltd. Menon Eternity, 9th Floor, No.165, St. Mary's Road, Alwarpet, Chennai-600018

PROJECT: 1X800 MW TANGEDCO NORTH CHENNAI TPP STAGE III-FGD

BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA

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	DESN	VS	-sd-	24.07.2021
	CHD	VS/AKV	-sd-	24.07.2021
	APPD	TMSR/DKM	-sd-	24.07.2021

TITLE: RC DETAILS FOR INTIAL LOAD TEST PILES

DRAWING NO. PE-DG-485-607-C001
SHEET 2 OF 2 REV. 1
SIZE-A0

REV.	DATE	ALTD	CHD	APPD
01	28.07.21	YK	VS/VV	TMSR/DKM

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COMPUTER FILE NAME:

FLUE GAS DESULPHURISATION (FGD) SYSTEM PACKAGE FOR 1X800 MW TANGEDCO North Chennai TPP Stage-III

VOLUME: IIB

SECTION - C

SPECIFIC TECHNICAL REQUIREMNTS FOR CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

Bharat Heavy Electricals Limited

Project Engineering Management
Power Sector, BHEL

CONTENTS

PART-I : GENERAL CIVIL REQUIREMENT

PART-II : SPECIFIC TECHNICAL REQUIREMENTS - CIVIL

PART-I

GENERAL CIVIL REQUIREMENT

1. GENERAL

Two Volumes-Section C & Section D of this specification cover site survey, soil investigation, site development works, design and construction of Civil, Structural and Architectural works. The scope of works covers complete Civil, Structural and Architectural Works including supply of all materials, labour, tools and plants as required for successful execution of the packages. This Part-I of Section-C Lists Codes and Standards to be adopted and the principal structures of the plant, and briefly describes the basic concept, requirements and features pertinent to each. **If there is any ambiguity and/or contradiction between Section C and Section D, the provisions / requirements laid in Section C shall prevail. In case of ambiguity between BOQ and Section C former shall prevail**.

(Contractor shall read the parts of the specification relevant to the contract and shall ignore the other parts of the specification. Relevant clauses of this section as applicable for respective package to be followed.)

2. CODES AND STANDARDS

Following is a general listing of Codes and Standards to be used in the design of the Plant. Specific applicable codes and standards will be identified in System Design Descriptions/ Technical Specifications as appropriate. The latest editions/ revision of following codes and standards along with addendums/ amendments, if any, shall be followed:

2.1. Earthwork

a) IS-1498: Classification and identification of soils for General Engineering purposes.
b) IS-3764: Safety Code for excavation work.
c) IS-7293: Safety Code for working with construction machinery.
d) IS-4701: Code of practice for earth work on canals.
e) IS-9759: Guide lines for dewatering during construction.
f) IS-10379: Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.

2.2. Concrete

a) IS-269: Ordinary and low heat Portland cement.
b) IS-383: Coarse and fine aggregate from natural sources for concrete.
c) IS-432: (Part I & II) Mild Steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
d) IS-455: Portland Slag Cement.
e) IS-456: Code of Practice for Plain and reinforced concrete.
f) IS-457: Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
g) IS-460: Test Sieves (all parts).
h) IS-516: Methods of test for strength of concrete.
i) IS-1199: Methods of sampling and analysis of concrete.
j) IS-1566: Hard drawn steel wire fabric for concrete Reinforcement.
k) IS-1786: High strength deformed steel bars and wires for concrete Reinforcement.
l) IS-1791: General requirement for batch type concrete mixers.
m) IS-1834: Hot applied sealing compounds for joints in concrete.
n) IS-1838: Preformed fillers for expansion joints in concrete pavement and structures.

o) IS-2386: (Part I-VIII)	Methods of test for aggregates for concrete (all parts).
p) IS-2438:	Specification for roller pan mixers.
q) IS-2502:	Code of practice for bending and fixing of bars for concrete Reinforcement.
r) IS-2505:	Concrete vibrators - immersion type.
s) IS-2506:	General requirements for screed board concrete vibrators.
t) IS-2722:	Specification for Portable Swing weigh batchers for concrete (single and double bucket type).
u) IS-2750:	Steel scaffoldings.
v) IS-2751:	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
w) IS-3150:	Hexagonal wire netting for general purposes.
x) IS-3366:	Specification for pan vibrators.
y) IS-3370: (Part I-IV)	Code of practice for concrete structures for storage of liquids (all parts).
z) IS-3414:	Code of practice for design and installation of joints in buildings.
aa) IS-3558:	Code of practice for use of immersion vibrators for consolidating concrete.
bb) IS-4014: (Part I & II)	Code of practice for steel tubular scaffolding.
cc) IS-4656:	Form vibrators for concrete.
dd) IS-4925:	Concrete batching and mixing plant.
ee) IS-4948:	Welded steel wire fabrics for general use.
ff) IS-4990:	Plywood for concrete shuttering work.
gg) IS-5256:	Code of practice for sealing expansion joints in concrete lining on canals.
hh) IS-6452:	High Alumina Cement for Structural use.
ii) IS-6461:	Glossary of terms relating to cement concrete.
jj) IS-6494:	Code of practice for water proofing of underground reservoir and swimming pools.
kk) IS-6509:	Code of practice for installation of joints in concrete pavements.
ll) IS-7320:	Concrete slump test apparatus.
mm) IS-7861: (Part I & II)	Code of practice for extreme weather concreting.
nn) IS-8041:	Rapid Hardening Portland Cement.
oo) IS-8112:	High strength ordinary Portland Cement.
pp) IS-9012:	Recommended practice for shotcreting.
qq) IS-9103:	Admixtures for concrete.
rr) IS-9417:	Recommendations for welding cold worked bars for reinforced concrete construction.
ss) IS-10262:	Recommended guidelines for concrete mix design.
tt) IS-458:	Specification for precast concrete pipes.
uu) IS-3935:	Code of practice for composite construction.
vv) IS-4995:	Criteria for design of reinforced concrete bins for storage of granular (all parts) and powdery materials.
ww) IS-5525:	Recommendation for detailing of reinforced concrete works.
xx) IS-11384:	Code of practice for composite construction in structural steel and concrete.
yy) IS-11682:	Criteria for design of RCC staging for overhead water tanks.
zz) IS:12118:	Two parts polysulphide based sealants.
aaa) IS:12200:	Code of practice for provision of water stops at transverse construction joints in masonry and concrete dams.
bbb) IS:13311:	Non-destructive testing of concrete - methods of test.
Part I -	Ultrasonic pulse velocity.
Part II -	Rebound hammer.

ccc) IS-13920: Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces.
ddd) SP-16: Design codes for reinforced concrete to IS:456-1978.
eee) SP-23: Hand book of concrete mixes.
fff) SP-24: Explanatory handbook on Indian standards code for plain and reinforced concrete. (IS: 456)
ggg) SP-34: Hand book on concrete reinforcement and detailing.
hhh) ACI-318: American Concrete Institute code for structural concrete.
iii) IS-280: Mild steel wire for general engineering purpose.
jjj) IS-10297: Code of practice for design and construction of floors and roofs using precast reinforced/prestressed concrete ribbed or cored slab units.
kkk) IS-10505: Code of practice for construction of floors and roofs using pre-cast reinforced concrete waffle units.
lll) IS-15658: Pre-cast concrete block for paving.

2.3. Foundations

a) IS-1080: Code of practice for Design and Construction of shallow foundations on soils (other than raft, ring and shell)
b) IS-1904: Code of practice for Design and Construction of foundations in soils: General Requirements
c) IS-2314: Steel sheet piling sections.
d) IS-2911: Code of practice for Design and Construction of Pile foundations (all parts).
e) IS-2950: Code of practice for design and construction of raft foundations.
f) IS-2974: Code of practice for design and construction of machine foundations.
g) IS-4091: Code of practice for Design and Construction of foundations for transmission line towers and poles
h) IS-6403: Code of practice for determination of Bearing capacity of Shallow foundations.
i) IS-8009: Code of practice for calculation of settlement of foundations: (all parts)
j) IS-9556: Code of practice for Design and Construction of diaphragm walls.
k) IS-11089: Code of practice for Design and Construction of ring foundation.
l) IS-12070: Code of practice for design and construction of shallow foundations on rocks.
m) IS-13301: Guidelines for vibration isolation for machine foundation.
n) ISO 10816: Criteria for assessing mechanical vibrations of machines.
o) ISO 1940: Criteria for assessing the st of balance of rotating rigid bodies.
p) DIN: EN13906-1: Helical compression spring made of round wire and rod: calculation and design of compression.
q) DIN: 2096 Helical compression spring out of round wire and rod: Quality requirements for hot formed compression spring.
r) DIN: 4024 Flexible supporting structures for machine with rotating machines.

2.4. Loading

a) IS-875: Code of practice for Structural safety of buildings - loading standards.
b) IS-1911: Schedule of unit weights of building materials.
c) IRC-6: Standard specifications & Code of practice for road bridges.

2.5.Masonry

a) IS-712: Building limes.
b) IS-1077: Common Burnt Clay Building Bricks.

c) IS-1127: Recommendations for dimensions and workmanship of natural building stones for masonry work.
d) IS-1528: Methods of sampling and physical tests for refractory materials
e) IS-1597: Code of practice for construction of stone masonry (all parts).
f) IS-2212: Code of practice for brickwork.
g) IS-2116: Sand for masonry mortars
h) IS-2185: Concrete masonry units. (all parts - Hollow and Solid concrete blocks).
i) IS-2250: Code of practice for preparation and use of masonry mortars.
j) IS-2572: Code of practice for construction of hollow concrete block masonry.
k) IS-2691: Burnt clay facing bricks.
l) IS-3414: Code of practice for design and installation of joints in buildings.
m) IS-3495: Methods of tests of burnt clay building bricks.
n) IS-4441: Code of practice for use of Silicate type chemical resistant mortars.
o) IS-4860: Acid Resistant Bricks.
p) IS-1905: Code of practice for structural use of unreinforced masonry.
q) IS-10440: Code of practice for construction of reinforced brick and reinforced brick concrete floors and roofs.
r) SP-20: Hand book on masonry design and construction.
s) IS-1489: Portland-pozzolana cement.
t) IS-1542: Sand for Plaster.
u) IS-12269: 53 grade ordinary Portland cement.
v) IS-12894: Specification for fly ash lime bricks.
w) IS-13757: Burnt clay fly ash building bricks.

2.6.Doors, Windows and Ventilators

a) IS-399: Classification of commercial timbers and their zonal distribution.
b) IS-883: Code of practice for design of structural timber in building.
c) IS-1003: Timber panelled and glazed shutters (all parts).
d) IS-1038: Steel doors, windows and ventilators.
e) IS-1081: Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
f) IS-1361: Steel windows for industrial buildings.
g) IS-2835: Transparent sheet glass for glazing and framing purposes.
h) IS-1948: Aluminium doors windows and ventilators.
i) IS-1949: Aluminium windows for industrial building.
j) IS-2191: Wooden flush door shutters (Cellular and hollow core type).
k) IS-2202: Wooden flush door shutters (solid core type).
l) IS-3103: Code of practice for Industrial ventilation.
m) IS-3548: Code of practice for glazing in buildings.
n) IS-3614: Fire check doors.
o) IS-4021: Timber door, windows and ventilator frames.
p) IS-4351: Steel door frames.
q) IS-6248: Metal rolling shutters and rolling grills.
r) IS-208: Door Handles.
s) IS:281: Mild steel sliding door bolts for use with padlocks.
t) IS-362: Parliament Hinges.
u) IS-419: Putty, for use on window frames.
v) IS-451: Technical supply conditions for wood screws.
w) IS-733: Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes.
x) IS-1285: Wrought aluminium and aluminium alloy extruded round tube & hollow section (for general engineering purposes).
y) IS-1341: Steel butt hinges.

z) IS-1823: Floor door stoppers.
aa) IS-1868: Anodic coatings on Aluminium and its alloys.
bb) IS-2209: Mortice locks (vertical type)
cc) IS-2553: Safety glass.
dd) IS-3564: Door closers (Hydraulically regulated).
ee) IS-5187: Flush bolts.
ff) IS-5437: Figured, rolled and wired glass.
gg) IS-6315: Specification for floor springs (Hydraulically regulated) for heavy doors.
hh) IS-7196: Hold fast.
ii) IS-7452: Hot rolled steel sections for doors, windows and ventilators.
jj) IS-10019: Mild steel stays and fasteners.
kk) IS-10451: Steel sliding shutters (top hung type)
ll) IS-12823: Prelaminated particle boards.

2.7.Roof and Flooring

a) IS-2204: Code of practice for construction of reinforced concrete shell roof.
b) IS-3201: Criteria for the design and construction of precast concrete trusses.
c) IS-2210: Criteria for Design of R.C. shell structures and folded plates.
d) IS-809: Rubber flooring materials for general purposes.
e) IS-1195: Bitumen mastic for flooring.
f) IS-1196: Code of practice for laying bitumen mastic flooring.
g) IS-1198: Code of practice for laying, fixing and maintenance of linoleum floors.
h) IS-1237: Cement concrete flooring tiles.
i) IS-1443: Code of practice for laying and finishing of cement concrete flooring tiles.
j) IS-2114: Code of practice for laying in situ terrazzo floor finish.
k) IS-2571: Code of practice for laying in situ cement concrete flooring.
l) IS-5491: Code of practice for laying in situ granolithic concrete floor topping.
m) IS-5766: Code of practice for laying burnt clay brick flooring.
n) IS-1197: Code of practice for laying of rubber floors.
o) IS-2441: Code of practice for fixing ceiling coverings.

2.8.Waterproofing

a) IS-1322: Bitumen felts for waterproofing and damp proofing.
b) IS-1346: Code of practice for waterproofing of roofs with bitumen felts.
c) IS-1609: Code of practice for laying damp proof treatment using bituminous felts.
d) IS-3036: Code of practice for laying lime concrete for a waterproofed roof finish.
e) IS-3037: Bitumen mastic for use in waterproofing of roofs.
f) IS-3067: Code of practice for general design, details and preparatory work for damp proofing and water proofing of buildings.
g) IS-3384: Bitumen primer for use in water proofing and damp proofing.
h) IS-4365: Code of practice for application of bitumen mastic for waterproofing of roofs.
i) IS-5318: Code of practice for laying of flexible PVC sheet and tile flooring.
j) IS-8042: White Portland cement.
k) IS-13755: Dust pressed ceramic tiles with water absorption of 3%, E 6% (Group B11a).
l) IS-13801: Chequered cement concrete tiles.

2.9.Soil Engineering

a) IS-1498: Classification and identification of soils for general engineering purposes.
b) IS-1892: Code of practice for sub-surface investigation for foundations.

c) IS-2131: Method for standard penetration test for soils.
d) IS-2720: Methods of test for soils (all parts).

2.10. Water Supply, Drainage and Sewerage

a) IS-404: Lead pipes
b) IS-458: Concrete pipes
c) IS-651: Salt glazed stoneware pipes and fittings.
d) IS-771: Glazed fire-clay sanitary appliances (all parts).
e) IS-774: Flushing cisterns for water closets and urinals other than plastic cisterns.
f) IS-783: Code of practice for laying of concrete pipes.
g) IS-1172: Code of basic requirements for water supply, drainage and sanitation.
h) IS-1626: Asbestos cement building pipes, gutters and fittings (all parts).
i) IS-1742: Code of practice for building drainage.
j) IS-2064: Code of practice for selection, installation and maintenance of sanitary appliances.
k) IS-2065: Code of practice for water supply in buildings.
l) IS-2470: Code of practice for installation of septic tanks (all parts).
m) IS-3114: Code of practice for laying of Cast Iron pipes.
n) IS-4127: Code of practice for laying of glazed stoneware pipes.
o) IS-12251: Code of practice for Drainage of Building Basement.
p) IS-1200: Method of measurement: Laying of water and [Part- XVI] sewer lines including appurtenant items.
q) IS-1536: Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
r) IS-1537: Vertically cast iron pressure pipe for water, gas and sewage.
s) IS-3486: Cast iron spigot and socket drain pipes.
t) IS-5329: Code of practice for sanitary pipe work above ground for buildings.
u) IS-3076: Low density polyethylene pipes for potable water supplies.
v) IS-1538: Cast iron fittings for pressure pipes for water, gas and sewage.
w) IS-1230: Cast iron rainwater pipes and fittings.
x) IS-1729: Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
y) IS-784: Prestressed concrete pipes.
z) IS-1726: Cast iron manhole covers and frames.
aa) IS-5961: Cast iron grating for drainage purposes.
bb) IS-5219: (Part-I) "P" and "S" traps.
cc) IS-772: General requirements for enamelled cast iron sanitary appliances.
dd) IS-775: Cast iron brackets and supports for wash basins and sinks.
ee) IS-777: Glazed earthenware wall tiles.
ff) IS-2548: Plastic water closet seats and covers (all parts).
gg) IS-2527: Code of practice for fixing rainwater gutters and downpipes for roof drainage.
hh) IS-554: Pipe threads where pressure tight joints are made on the threads – dimensions, tolerances and designation.
ii) IS-778: Copper alloy gate, globe and check valves for water works purposes.
jj) IS-781: Cast copper alloy screw down bib taps & stop valves for water services.
kk) IS-782: Caulking lead.
ll) IS-1703: Copper alloy float valve for water supply fitting.
mm) IS-2326: Automatic flushing cisterns for urinals.
nn) IS-2556: Vitreous sanitary appliances (vitreous china).
oo) IS-3311: Waste plug and its accessories for sinks and wash basins.
pp) IS-3438: Silvered glass mirrors for general purposes.
qq) IS-3589: Steel pipe for water and sewage (168.3 to 2540mm outside diameter)
rr) IS-3989: Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.

ss) IS-4111: Code of practice for ancillary structure in sewerage system. (Part I to V)
tt) IS-4733: Methods of sampling and testing sewage effluents.
uu) IS-4764: Tolerance limits for sewage effluents discharged into inland surface waters.
vv) IS-1068: Electroplated coating of nickel plus chromium and copper plus nickel plus chromium.
ww) IS-5382: Rubber sealing rings for gas mains, water mains and sewer
xx) IS-5822: Code of practice for laying of electrically welded steel pipes for water supply.
yy) IS-7740: Code of practice for construction and maintenance of road gullies.
zz) IS-8931: Copper alloy fancy single taps combination tap assembly and stop valves for water services.
aaa) IS-9762: Polyethylene floats for float valves.
bbb) IS-10592: Industrial emergency showers, eye and face fountains and combination units.
ccc) IS-12592: Specification for precast concrete manhole covers and frames.
ddd) IS-12701: Rotational moulded polyethylene water storage tanks.
eee) IS-13983: Stainless steel sinks for domestic purposes.
fff) SP-35: Hand book on water supply and drainage with special emphasis on plumbing.

2.11. Paving and Road works

a) IS-73: Paving bitumen
b) IS-702: Industrial Bitumen
c) IS-1201: Method of testing tar and bituminous materials. thru' 1220
d) : Practice followed by Indian Road Congress (all parts).

2.12. Earthquake Resistant Design

a) IS-1893: Criteria for earthquake resistant design of structures.
b) IS-4326: Code of practice for earthquake resistant design and construction of buildings.

2.13. Chimney

a) IS-4998: Criteria for Design of R.C. Chimneys (all parts).
b) IS-6533: Code of practice for design and construction of steel chimneys
c) ACI-307: Specification for the design and construction of reinforced concrete chimneys
d) BS-4076: Specification for steel chimneys
e) CICIND: Model Code for concrete chimneys / Model code for steel chimneys

2.14. Cooling Tower

a) BS-4485: (Part 4) Structural design of cooling towers.

2.15. Structural Steelwork

a) IS-800: Code of practice for general construction in steel.
b) IS-802: Code of practice for use of structural steel in Overhead Transmission Line (All Parts).
c) IS-806: Code of practice for use of steel tubes in general building construction.
d) IS-808: Rolled steel beams, channels and angle sections.
e) IS-813: Scheme of symbols for welding.
f) IS-814: Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.
g) IS-816: Code of practice for use of metal arc welding for general construction in mild steel.

h) IS-817: Code of practice for training and testing of metal arc welders.
i) IS-818: Code of practice for safety and health requirements in electric and gas welding and cutting operation.
j) IS-819: Code of practice for Resistance spot welding for light assemblies in Mild Steel.
k) IS-919: Recommendations for limits and fits for engineering.
l) IS-1024: Code of practice for use of welding in Bridges and Structures subjected to Dynamic loading.
m) IS-1161: Steel tubes for structural purposes.
n) IS-1182: Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
o) IS-1200: (Part-VIII) Method of measurement of steelwork and ironwork.
p) IS-1239: Mild steel tubes, tubulars and other wrought steel fittings (all parts).
q) IS-1363: Black hexagonal bolts, nuts and locknuts (Dia. 6 to 39 mm) and black hexagon screws (Dia.6 to 24 mm). [all parts]
r) IS-1364: Precision and semi-precision hexagon bolts, screws, nuts and locknuts (Dia. range 6 to 39 mm). [all parts]
s) IS-1365: Slotted counter sunk head screws (Dia. range 1.6 to 20 mm).
t) IS-1367: Technical supply conditions for threaded steel fasteners. (Part 1 to 18)
u) IS-1443: Code of practice for laying and finishing of cement concrete flooring tiles.
v) IS-1608: Method for tensile testing of steel products.
w) IS-1730: Dimensions for steel plate, sheet and strip for structural and general engineering purpose.
x) IS-1731: Dimensions for steel flats for structural and general engineering purposes.
y) IS-1852: Rolling and cutting tolerances for hot rolled steel products.
z) IS-1977: Structural steel (Ordinary quality)
aa) IS-2016: Plain Washers
bb) IS-2062: Steel for General structural purposes.
cc) IS-2074: Ready mixed paint, air drying, red oxide zinc-chrome, priming.
dd) IS-2633: Methods of testing uniformity of coating of zinc coated articles.
ee) IS-3613: Acceptance tests for wire-flux combinations for submerged-arc welding of structural steels.
ff) IS-3664: Code of practice for Ultrasonic Pulse echo testing by contact and immersions methods.
gg) IS-3757: High strength structural bolts.
hh) IS-4000: High strength bolts in steel structures.
ii) IS-4759: Hot dip zinc coatings on structural steel and other allied products.
jj) IS-5334: Code of practice for Magnetic Particle Flaw detection of welds.
kk) IS-7215: Tolerances for fabrication of steel structures.
ll) IS-7280: Base-wire electrodes for sub-merged arc welding of structural steels.
mm) IS-7318: (Part-I) Approval test for welders when welding procedure approval is not required.
nn) IS-8500: Structural steel - micro alloyed (medium and high strength qualities).
oo) IS-9595: Recommendation for metal arc welding of carbon and carbon manganese steels.
pp) AWS D.1.1 Structural Welding Code.
qq) IS-8640: Recommendations for dimensional parameters for industrial building.
rr) IS-9178: Criteria for design of steel bins for storage of bulk material (all parts).
ss) IS-12843: Tolerances for erection of steel structures.
tt) IS-1181: Qualifying tests for Metal Arc welders (engaged in welding structures other than pipes).
uu) IS-2595: Code of practice for Radiographic testing
vv) IS-2629: Hot dip galvanising of iron and steel

ww) IS-3502: Steel chequered plate.
xx) IS-3658: Code of practice for liquid penetrant flaw detection.
yy) IS-4353: Sub merged arc welding of mild steel and low alloy steel Recommendation.
zz) IS-5369: General requirements for plain washers and lock washer.
aaa) IS-6623: High strength structural nuts.
bbb) IS-6649: Hardened and tampered washers for high strength structural bolts & nuts.
ccc) IS-6911: Stainless steel plate, sheet and strip.
ddd) IS-7205: Safety code for erection of structural steel.
eee) IS-7307: Approved test for welding procedures
(Part I) Fusion welding of Steel
fff) IS-7310: Approval test for welders working to approval welding procedure.
(Part I) Fusion welding of Steel
ggg) SP-6: IS Handbook for structural engineers.

2.16. Painting

a) IS-348: Specification for French Polish.
b) IS-427: Specification for Distemper, dry colour as required.
c) IS-428: Specification for Distemper, oil emulsion, colour as required.
d) IS-1477: Code of practice for painting of ferrous metal in buildings.
(Part I & II)
e) IS-2338: Code of practice for finishing of wood and wood based materials.
(Part I & II)
f) IS-2339: Specification for Aluminium Paints for general purposes in dual containers.
g) IS-2395: Code of practice for painting concrete, masonry and plaster surface.
h) IS-2932: Specification for enamel, synthetic, exterior - a) undercoating, b) finishing.
i) IS-2933: Specification for enamel, exterior - a) undercoating, b) finishing.
j) IS-5410: Specification for cement paint.
k) IS-162: Ready mixed paint, brushing fire resisting, silicate type for use on wood, colour as required.
l) IS-1650: Specification for colours for building and decorative materials.
m) IS-2395: Code of practice for painting concrete, masonry and plaster surfaces.
(Part I) Operations and Workmanship.
(Part II) Schedule.
n) IS-2524: Code of practice for painting of nonferrous metals in buildings.
(Part I) Pre-treatment.
(Part II) Painting.
o) IS-15489: Plastic emulsion paint.
p) IS-6278: Code of practice for white washing and Colour washing.
q) IS-10403: Glossary of term related to building finish.
r) IS-12027: Silicone based water repellent.
s) IS-13238: Epoxy based zinc phosphate primer (2 pack).
t) IS-13239: Epoxy surface (2 pack).
u) IS-13467: Chlorinated rubber for paints
v) IS-14209: Epoxy enamel, two component glossy.
w) BS-5493: Code of practice for protective coating of iron and steel structures against corrosion.

2.17. Sheeting

a) IS-277: Galvanised steel sheets (Plan & corrugated).
b) IS-513: Cold-rolled low carbon steel sheets & strips.
c) IS-730: Hook bolts for corrugated sheet roofing.

d) IS-801: Code of practice for use of cold formed light gauge steel structural members in general building construction.
e) IS-7178: Technical supply condition for tapping screw.
f) IS-8183: Bonded mineral wool.
g) IS-8869: Washers for corrugated sheet roofing.
h) IS-12093: Code of practice for laying and fixing of sloped roof covering using plain and corrugated galvanized steel sheets.
i) IS-12436: Preformed rigid Polyurethane (PUR) and Polyisocyanurate (PIR) foams for thermal insulation.
j) IS-12866: Plastic translucent sheets made from thermosetting polyester resin (glass fiber reinforced).
k) IS-14246: Continuously pre-painted galvanized steel sheets and coils.
l) BS-5950 (Part VI): Code of practice for design of light gauge profiled steel sheeting

2.18. Plastering

a) IS-1661: Code of practice for application of cement and cement lime plaster finishes.
b) IS-2402: Code of practice for external rendered finishes.
c) IS-2547: Gypsum building plaster.

2.19. Acid / Alkali Resistant Tiling

a) IS-158: Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali & heat resisting.
b) IS-412: Expanded metal steel sheets for general purpose.
c) IS-4443: Code of practice for use of resin type chemical resistant mortars.
d) IS-4456 (Part I & II): Method of Test for chemical resistant tiles.
e) IS-4457: Ceramic unglazed vitreous acid resisting tiles.
f) IS-4832: Specification for chemical resistant mortars.
(Part I) Silicon Type
(Part II) Resin Type
(Part III) Sulphur Type
g) IS-9510: Bitumastic acid resisting grade.

2.20. Safety

a) IS-1641: Code of practice for fire safety of buildings - General principles of fire grading and classification.
b) IS-1642: Code of practice for fire safety of buildings - Details of construction.
c) IS-3696 (Part I & II): Safety code for scaffolds and ladders.
d) IS-4081: Safety code for blasting and related drilling operations.
e) IS-4130: Demolition of buildings - code of safety.
f) IS-5121: Safety code for piling and other deep foundations.
g) IS-5916: Safety code for construction involving use of hot bituminous materials.
h) IS-7205: Safety code for erection of structural steel work.
i) IS-7969: Safety code for handling and storage of building materials.

2.21. Architectural Design of Buildings

a) SP-7: National Building Code of India.
b) SP-41: Hand book on functional requirements of buildings (other than industrial buildings).
c) ECBC: Energy Conservation Building Code
d) GRIHA: Green Rating for Integrated Habitat Assessment.

2.22. Other

a) Indian Road Congress (IRC) Bridge Codes
b) Indian Railway Standard Bridge Rules

3. GENERAL

All the quality standards, tolerances, welding standards and other technical requirements shall be strictly adhered to. The Bidder shall fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, soil conditions, local conditions and site specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications. In case of any conflict between stipulations in various portions of the specification, most stringent stipulation would be applicable for implementation by the Bidder without any extra cost to the Employer.

4. LAYOUT

Before starting the work, the Contractor shall carry out the setting out of foundation and structures and provide levels, with reference to general existing grid and bench mark. **If the Contractor uses the grid, bench mark and reference pillar made by other Contractors, he shall coordinate with the Contractor and shall satisfy himself of the accuracy of the reference marks.** If he is required to set out the foundation afresh, he shall do so independently with reference to the one existing grid and bench
mark which has been followed by other agency at the instruction of the Engineer. In case any discrepancy is found, it shall be immediately brought to the notice of the Engineer for any rectification/modification necessary. No complaint shall be entertained at a later stage. The Contractor shall accurately set out the position for holding down bolts and inserts.

If required, in the opinion of the Engineer, he shall construct and maintain pillars for grid, references and bench marks and maintain them till the completion of the construction. He shall also help the Engineer with instruments, materials and labours for checking the detailed layouts and levels. The Contractor shall be solely responsible for the correctness of the layout and levels, and Engineer's approval shall not be deemed to imply any warranty in carrying out the works correctly. The Tenderer’s shall take into account the cost of these in quoting their price.

5. WORKMANSHIP

Workmanship shall be of the best possible quality and all work shall be carried out by skilled workmen except for those which normally require unskilled persons. Welding shall be done by experienced and certified welders in proper sequence using necessary jigs and fixtures. Fabrication shall be done in shops having proper equipment for accurate edge and shaping and dimensioning of anchor bolt assembly, inserts and other misc. items. In addition to the requirement specified above, if the bye laws

of the local Govt., Municipal or other authorities require the employment of licensed or registered workmen for various trades, the Contractor shall arrange to have the work done by such registered or licensed personnel. In case of manufactured materials, the Contractor shall have, with no additional cost to the Owner, the services of the supervisors of the manufacturers to ensure that the work is being done according to the manufacturer's specifications.

6. TEMPORARY WORK

All scaffoldings, staging, temporary bracing and other necessary temporary work required for proper execution of the Contract shall be provided by the Contractor at his own cost and inclusive of all materials, labour, supervision and other facilities.

The layout and details of such Temporary work shall have the prior approval of the Engineer, but the Contractor shall be responsible for proper strength and safety of the same. All Temporary work shall be so constructed as not to interfere with any permanent work or with the work by other agencies. If it is necessary to remove any of the temporary work at any time to facilitate execution of the work or with the work of other agencies, such removal and re erection, if required, shall be carried out by the Contractor at the direction of the Engineer without any delay and any extra cost on this account shall be borne by the Contractor.

7. INTERFACE WITH STRUCTURES UNDER OTHER'S SCOPE

Modification in layout of foundation/structure during detail engineering stage may be necessary to avoid fouling with those under other's scope. Necessary changes on this account will be made without any extra cost to Owner.

8. SEQUENCE OF WORK AND PROGRESS REPORT

The sequence in which the works are to be carried out shall be as approved by the Engineer in accordance with the construction method accepted by the Engineer and to be followed by the Contractor. A programme of work is to be submitted for the Engineer's review and approval and this has to be periodically updated and modified as per actual progress to enable timely completion.

The Contractor shall regularly submit to the Engineer progress reports for periods of working as specified by the Engineer showing up to date progress on all important items of work.

9. CONSTRUCTION METHODOLOGY

Construction and erection activities shall be fully mechanized from the start of the work. All excavation and backfilling work shall be done using excavators, loaders, dumpers, dozers, porcelains, excavator mounted rock breakers, rollers, sprinklers, water tankers, etc. Manual excavation can be done only on isolated places with specific approval of engineer.

Dewatering shall be done using the combination of electrical and standby diesel pumps.

For concreting, weigh batching plants, transit mixers, concrete pumps, hoists, etc. shall be used.

All handling of materials shall be with cranes.

Heavy trailers shall be used for transportation.

Mechanized modular units of scaffolding and shuttering shall be used.

Grouting shall be carried out using hydraulically controlled grouting equipment.

All finishing items shall be installed using appropriate modern mechanical tools. Manual punching etc. shall not be permitted.

Heavy duty hoists for lifting of construction materials shall be deployed.

Compressors for cleaning of foundations and other surfaces shall be used.

Field laboratory shall be provided with all modern equipment for survey, testing of soil, aggregates, concrete, welding, etc.

All persons working at site shall be provided with necessary safety equipment and all safety aspects shall be duly considered for each construction/ erection activity. Moreover, only the persons who are trained in the respective trade shall be employed for executing that particular work.

PART-II

SPECIFIC TECHNICAL REQUIREMENT

Tamil Nadu Generation and Distribution Corporation Ltd.

Flue Gas Desulphurisation System & Auxiliaries for North Chennai TPP - Stage-III - 1x800 MW Supercritical Thermal Power Station Project

TENDER ENQUIRY DOCUMENT
FOR
EPC CONTRACT

[TENDER SPECIFICATION No. SE/E/PROJ-II/OT.NO.2/2018-2019]

VOLUME II

TECHNICAL

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India

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Tamil Nadu Generation and Distribution Corporation Ltd.

Flue Gas Desulphurisation System & Auxiliaries for North Chennai TPP - Stage-III - 1x800 MW Supercritical Thermal Power Station Project

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VOLUME II

SECTION 1

GENERAL TECHNICAL SPECIFICATION

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India

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VOLUME II

SECTION 1

GENERAL TECHNICAL SPECIFICATION

1.0 INTENT OF SPECIFICATION

1.1. The specification is intended to cover the design, engineering, manufacture, assembly / reassembly, constructional features, test at manufacturer's works, forwarding (duly packed for transportation), transportation (delivery to site), unloading, handling, storage and in plant transportation at site, complete execution of necessary and allied Civil / Mechanical /Process works, Electrical, Instrumentation works, complete services of erection, testing at site, successful commissioning, operation handing over the Flue Gas Desulphurization (FGD) system for the 1 x 800 MW North Chennai Thermal Power Project Stage III (NCTPS) in flawless operating condition to the Owner.

1.2. Construction, supplies and services shall be rendered in conformity with proven design principles, taking into account the current technology. The requirements of the contract must be fulfilled in its entirety. The supplies and services shall be rendered inclusive of all appliances and interconnecting arrangements with other supplies, necessary for installation of all accessories, needed for proper and reliable continuous operation and for satisfactory maintenance and repair.

1.3. In so far as data on the execution of supplies and services as contained in drawings, but none in specification and vice versa, such data shall be deemed to be contained in both. Contradictions, if any, between drawings and specifications and within various sections of the specification shall be brought to the attention of the Owner (Employer) / Consultant by the Bidder and the correct requirement shall be obtained before submission of the bid.

1.4. All materials & equipment supplied under this contract shall be new and unused.

2.0 DESCRIPTION OF SYSTEM

Tamil Nadu Generation and Distribution Corporation Limited (TANGECO) is presently executing the 1 x 800 MW plant on an EPC basis for BTG and BOP and it is scheduled to be completed by December 2019. In order to meet the MOEF & CC gazette notification, as an environmental improvement measure TANGEDCO have decided to install FGD for treating 100 % flue gas generated from the plant.

The FGD shall deploy a wet limestone based technology which is proven. The flue gas from the common discharge duct of ID Fans shall be diverted to the proposed FGD plant by installing a by-pass damper. The treated flue gas from the FGD shall be led to the chimney. The FGD system for the Unit shall therefore include untreated flue gas duct, booster fan, Gas heat exchanger, FGD scrubber and the treated flue gas duct complete with dampers, accessories, electrical, instrumentation & controls and necessary civil works. A common Lime unloading, storage and conveying system, Wet ball mills and slurry preparation and pumping system, absorption system and Gypsum recovery system is proposed.

The absorber/scrubber along with the slurry tank, Booster fans, Gas to gas heat exchangers shall be located near the Chimney area identified in the tender drawings.

The limestone handling storage area shall be located in the common area identified in the tender drawings.

The utilities such as power, water and steam shall be provided from the main power plant at terminal points as described in this specification.

The analysis of the flue gas from the power plant is attached as Annex -1.2.

The Service Water analysis is attached as Annex-1.3.

The analysis of the limestone is attached as Annex 1.4.

3.0 SCOPE OF WORK AND SERVICES

3.1 GENERAL

The equipment and works to be provided under this specification shall be as detailed below Scope of works includes, obtaining necessary approvals/ Statutory clearances, materials, execution as per codes, specification, best engineering practices and to the satisfaction of the Owner for all Civil / Structural, Mechanical, Electrical, Control & Instrumentation works and training of the O&M personnel.

a) Basic Engineering of the plant including preparation of Plant Definition Manuals;

b) Detailed design of all the equipment and system(s) including civil, structure steel works included in bidder's scope.

c) Providing engineering drawings, equipment sizing & performance data, instruction manuals, as built drawings and other information;

d) Compliance with statutory requirements and obtaining clearances from statutory authorities, wherever required;

e) Complete manufacturing including shop testing/type testing;

f) Complete Civil, Structural and Architectural works, including survey, providing construction offices, field laboratory and construction equipment;

g) Packing and transportation from the manufacturer’s works to the site including customs clearance & port clearance, port charges, if any.

h) Receipt, storage, preservation, handling and conservation of equipment at the site;

i) Fabrication, pre-assembly, if any, erection, testing, commissioning and completion of facilities including putting into satisfactory operation all the equipment including successful completion of initial operation;

j) Reliability tests, performance and guarantee tests after successful completion of facilities;

k) Furnishing of mandatory, and recommended spares;

l) Reconciliation with customs authorities, as required.

m) Satisfactory conclusion of the contract.

n) Insurance and other requirements for the complete FGD package in accordance with the provisions of general conditions of contract.

o) Complete scope of Dismantling/ Demolition or modification of existing facility if required for the project implementation. Bidder to identify such requirement during pre-bid stage and consult with Owner.

Required site survey for accessing the tie-ins, topography and layout shall be mandatory.

The scope shall include detailed design of the system, complete manufacture including testing, providing engineering drawings, data, operation manual etc. for the Owner/ Consultant's approval, packing and transportation from the manufacturers works to the site, receipt storage preservation and conservation of equipment at the site, erection, testing and commissioning of all the equipment, reliability tests, performance acceptance tests on completion of commissioning all the equipment & furnishing spares.

System shall be complete in all respects with all mechanical, civil, structural, electrical, control and instrumentation works.

The requirements, conditions, appendices etc. given in Technical Specifications shall apply to and shall be considered as a part of this volume as completely as if bound here with. The work to be carried out as per the above scope shall be all in accordance with the requirements, conditions, appendices, etc., stated in GCC, which shall be considered as a part of the Technical Specification as completely as if bound herewith. The Contractor shall be responsible for providing all material, equipment and service, which are required to fulfill the intent of ensuring operability, maintainability, reliability and complete safety of the complete work covered under this specification, irrespective of whether it has been specifically listed herein or not. It is not the intent to specify completely herein, all aspects of design and construction of equipment, nevertheless, the equipment shall conform in all aspects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation, in a manner acceptable to the Owner, who will interpret the meaning of the specification, drawings and shall have a right to reject or accept any work or material which in his assessment is not complete to meet the requirements of this specification and/or applicable international standards mentioned elsewhere in the specification.

Bidders are requested to carefully examine and understand the specifications and seek clarifications, if required, to ensure that they have understood the specification. The Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. In the event of conflict between the Technical Specifications and the Conditions of Contract, the requirements as indicated in the technical specification shall govern, unless confirmed otherwise by the Owner in writing before the award of this contract, based on a written request from the Bidder for such a clarification. However, if the Bidder feels that, in his opinion, certain features brought out in his offer are superior to what has been specified, these may be highlighted separately. The Bidder may also make alternate offers provided, such offers are superior in his opinion, to the requirements of these specifications in which case, adequate technical information, operating feedback, etc., are to be enclosed with the offer, to enable the Owner to assess the superiority and reliability of the alternatives offered. In case of each alternative offer, its implications on the performance, guaranteed efficiency, auxiliary power consumption etc., shall be clearly brought out for the Owner to make an overall assessment. In any case, the base offer shall necessarily be in line with the specifications. Under no circumstances the specified equipment and services shall be brought out as an alternative offer.

In case, all the above requirements are not complied with, the offer may be considered as incomplete and would become liable for rejection.

3.2 SCOPE OF WORK

3.2.1 Mechanical

The scope shall include design, engineering, supply, installation, testing and commissioning, performance testing and handing over of, but not limited to, the following:

a) Tapping of new ducts from main ducts (from the terminal points), expansion joints, dampers (including the bypass damper), etc.

b) Two Nos. (2x50% configuration) Booster Fans each sized for 60% BMCR flue gas flow, with all associated redundant lube oil pumps, coolers, valves and instruments.

c) Wet Limestone based Scrubbers /Absorbers complete with slurry holding tank, corrosion resistant lining, spray headers, and nozzles.

d) Gas to Gas heat Exchangers and its auxiliaries.

e) Return connection of new ducts to main ducts from Gas to Gas heat Exchangers, expansion joints, dampers, etc. including modification of existing duct.

f) Slurry recirculation pumps, strainers, valves, piping, spray headers, nozzles etc. including expansion joints.

g) Oxidation Air blowers/Compressors and its piping/injection system.

h) Mist Washing System for scrubber.

i) Ducting and its Supports etc.

j) Raw limestone covered storage shed (for 7 days storage), Limestone Crushers each with associated screens, Crushed limestone silo for 7 days storage, Mills, Limestone silo capable to handle one day consumption along with dust extraction system

k) Complete Lime unloading system Underground Hoppers, Vibrating feeders, electromagnetic separator, conveyors, Bucket elevators, feeders, etc.,.

l) Wet ball mills, Hydro cyclones and vacuum filters.

m) Limestone Slurry Preparation tanks, Limestone Slurry transfer pumps, Slurry circulation pumps, Bleed pumps, sump pumps etc.

n) Gypsum handling system with shed (for 15 days storage)

o) Process water tank and pumps.

p) Tapping of Steam piping from the existing auxiliary steam header including modification of existing auxiliary steam header and further piping inside FGD area.

q) Complete Air conditioning and ventilation for the buildings related to FGD and its auxiliaries.

r) Tapping of Service water piping from the existing header including modification of existing header and further piping inside FGD area (refer terminal point).

s) Tapping of potable water piping from the existing header including modification of existing header and further piping inside FGD area including necessary potable water tanks.

t) Tapping of Fire hydrant/spray piping from the existing headers including modification of existing header and further piping inside FGD area.

u) Waste water treatment & recycling system for the FGD effluent (Clarifier, neutralization system, dosing, sludge dewatering etc.) along with necessary handling facilities.

v) Complete fire protection system consisting of Fire Hydrant system, Detection alarm system, Fire extinguishers all necessary warning instructions and warning plates etc as required for the system as per TAC/NFPA guide lines.

w) Bidder shall provide buildings for and Milling System, Gypsum Dewatering system, FGD MCC/control room & Analyser room, Recirculation pump & Oxidation blower building . The buildings must be complete in all respect specially facilitating the smooth operation and maintenance of associated equipment of above systems by providing adequate maintenance space, handling facilities, walkways, staircase etc.

x) Supply, erection, commissioning, testing of Necessary material handling system including Unloading Hopper, Vibrating screens, Grizzlies, Bucket Elevators, conveyors, overhead concrete pillar, beams along with trolleys, chain pulley blocks, tools/tackles for various auxiliaries lifting/moving maintenance/dismantling purpose work in FGD and Auxiliary Area shall be included in bidders scope.

y) One number Elevator each for servicing FGD Absorber, Limestone building and Gypsum building, any other building as required

z) One (1) No. Pay loader & One (1) No. Crawler type Dozer for Limestone storage shed

aa) One (1) No. Pay loader & One (1) Wheel type Dozer for Gypsum storage shed

bb) Crane and hoist as required.

cc) Required vibration isolation system for all the rotating equipment as required, and further detailed in Civil specification

dd) Instrument air & service air compressors, Dryer, receivers and piping as required.

ee) Necessary modifications, interconnections at the owners Terminal points.

ff) Isolation valves, insulation, cladding for all utilities at the Owners terminal point.

gg) Interconnecting platforms between elevator and FGD at various levels of the scrubber.

hh) Pipe trestle, duct supports, complete pipe rack for piping in Bidder's scope etc.

ii) Necessary interface and completed piping from the existing facility to the FGD facilities for firefighting, Aux. Cooling water, DM water, Service/potable water, steam, waste water etc.

For the detailed system requirement Refer Vol. II, Section 2 for Detailed Technical Specification for Mechanical System.

3.2.2 Civil

The Scope shall include design, engineering, construction of all related civil, structural, architectural works complete in all respect. The major buildings / structures envisaged for this contract are as listed below:

a) Absorber Tower Foundation

b) Process Water Pump House

c) Electrical & Control Building

d) Bulk Limestone Silo and Day Limestone Silo

e) Limestone Slurry Preparation Building

f) Fan/GGH/ Equipment Foundation

g) Limestone Unloading Shed and unloading hopper

h) Dozer shed

i) Limestone Crusher House

j) Junction tower

k) Gypsum Storage Shed

l) Gypsum Dewatering Building

m) Waste Water Building

n) Tanks

o) Pipe Supports

p) Trestle for Duct Support , conveyors, Foundation, etc.,

q) Foundation for Pumps, Booster fans, Blowers, gas to gas heat exchangers, tanks and other miscellaneous equipment's etc.

r) Drains, paving, trenches, duct banks, collection pit, etc. in FGD area

s) Access Roads with storm water drains to various building/structures from existing Plant road

t) All foundation works in FGD area based on the geo technical report attached with this specification.

u) Each building shall be provided with 2 PVC tanks – one for service water tank of 1000 litres capacity and another for potable water tank of 500 litres capacity.

v) Plinth protection all around the buildings in FGD area

w) Micro leveling of the FGD area as required

x) Dressing up site upon completion of work

y) Borosilicate Glass Block (or) Titanium or C 276 lining inside the chimney flue can

For detailed Technical Specification, refer Volume II, Section 5 for Detailed Technical Specification for Civil

The work also includes:

a) Design and preparation of working drawings (Architectural, Civil and Structural), fabrication drawings, excavation drawings, shuttering drawings, bar bending schedule drawing and construction of all structures.

b) Preparation and submission of As built drawings of all structures and facilities to reflect as built status of construction in AutoCAD latest version in CD / DVD and hard copies

c) Plumbing & sanitary works

d) Painting of all Architectural, Civil and Structural works

e) Anti-weed treatment in all areas / buildings of FGD area.

f) Anti-termite treatment for all buildings of FGD area.

g) Handing over of complete FGD area facilities to the satisfaction of Owner.

h) All temporary roads, approach for main entry and approach roads inside the graded FGD area necessary for construction purpose and for conveying plant equipment with adequate parking area for heavy vehicles and all permanent roads for plant area, cross roads with necessary culverts wherever necessary.

i) Supply & fixing of inserts, bolts and other embedments specifically for equipment foundations, tanks, structures, etc. as required.

j) Rain Water Harvesting for all buildings in FGD area. All roof tops shall have RWH with filter arrangement.

k) All statutory clearances / NOC required for implementation of the project from various departments/agencies shall be obtained by the Bidder.

l) The Bidder shall fill or excavate the areas to the required formation levels as indicated in the plot plan and dispose the excavated materials as directed by the Owner. If excavation requires blasting, necessary statutory clearance from the concerned body shall be obtained by the Bidder.

m) All civil works related to arrangement for lifting equipment.

n) Clearing and removing the buried items if any in the whole proposed plant area and the same is to be deposited to the existing stores.

o) All underground structures (as applicable) such as basement, sump etc. and water retaining structures shall be water proofed as per specification.

p) All the buildings shall have one dining room as per Owner's requirement.

q) All offices, rooms, bays shall be provided with furniture like almirah, tables, chairs, etc. wherever necessary.

r) Fencing along with gates (main gates and wicket gates as applicable) of suitable size shall be provided wherever necessary due to security / safety / statutory requirements.

r) Paving for open store yard and silo areas.

s) An Eye and Face fountain (Combined unit with receptacle) conforming to IS: 10592 shall be provided in Battery room.

t) Roof parapet wall of 750 mm height is to be provided for all buildings. Concrete staircase may be provided for access to roof for all concrete buildings.

u) One operator and maintenance room shall be provided in all floors of each building (Min. size of 5m x 5m).

It is not the intent to specify herein all the works in the scope of this contract. All other buildings, structures and works that are necessary which are not specifically mentioned here but required for construction, operation and maintenance of the FGD plant or mentioned elsewhere in the specification are deemed to be included in the scope of the Bidder.

In the event of conflict between requirement of any two clauses of this specification or different codes/standards, the more stringent requirement as per the interpretation of Owner is to be followed by Bidder.

General Requirements

All buildings / structures / areas for the FGD area shall be provided with the following as applicable:

Plastering, painting, plumbing, sanitation, water supply, electrification, lighting, air conditioning, firefighting, anti-termite treatment, plinth protection, damp proof course, garland drains, septic tanks, all modular furniture, doors, windows, rolling shutters, ventilators, approach roads, colour and white washing, sunshades, false ceiling, false flooring, flooring, under deck insulation, water proofing, roof treatment, rain water down take pipes, stair case, lift/elevators, cranes and monorails, porch, potable water tanks, fans, etc.

All Finishing works for buildings covered in FGD area shall be as per finishing schedule mentioned in this specification.

Floor level of all buildings shall be 500mm above FGL.

Protection of existing utilities and services

During construction, the Bidder shall provide all protection for existing utilities and services as may be required by his construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Owner.

In addition to the requirements as specified, herein the Bidder shall comply with the following requirements:-

a) Use all necessary precautionary and protective measures required to maintain existing utilities, services and appurtenances that must be kept in operation. In particular, the Bidder shall take adequate measures to prevent undermining of utilities and services presently in services.

b) Protect existing or new utilities and services where required by the Bidder's operations and/or as directed by the Owner. The Bidder shall be responsible for bracing and supporting utilities and services to prevent settlement, displacement or damage.

c) If any existing structure such as pipe line, road drain, culvert, towers, light posts, underground structures, buildings, tanks, rail line, etc. is damaged during execution of project, same shall be reconstructed by Bidder at his own cost at locations wherever approved by owner.

Instruction to bidders

I. Data to be furnished by Bidder at the time of Bid

a) Detail general arrangements/architectural drawings of all buildings and structures showing dimensions, levels, plans, sections, elevations, loadings, materials proposed, types of framings, wall / cladding, floors, roofs, types of finishes etc.

b) Detail design criteria proposed to be adopted for each building, structures, foundations, facilities, etc.

c) Organisation chart with no. of Engineers to be furnished by Bidder.

d) Details of thermal insulation for ceiling and detail of false ceiling assumed with manufactures catalogue and areas where they propose.

e) List of equipment to be deployed and rates of labour assumed by the bidder and by their sub-contractors to be furnished.

f) List of software proposed to be used against various areas for analysis, design, drafting and project monitoring along with their source and validation report for the software.

g) The list of documents indicated elsewhere of this section to be submitted by the Bidder to the Owner for his approval and manner in which the same need to be submitted. No construction shall commence at site without obtaining approval from the Owner on these documents. Therefore, it is necessary that bar charts for buildings/ structures / area wise shall be submitted for design / drawing activity indicating.

i. Level-1 pert chart showing the starting and completion date of all civil construction activities.
ii. Level-2 pert chart showing the time required for preparation of design criteria, for approval of design criteria by Owner, time required for detailed design and drawing preparation and time required for approval of design and drawing by Owner. This part shall be taken into account the construction schedule (Level -1 part).
iii. Level-3 pert chart for all civil works shall be submitted to Owner for monitoring of progress of works at site.

h) A detail note on quality plan both for design and construction activity proposed to be adopted for obtaining quality works.

i) List of all sub-Bidders/Consultants/Architects that the bidder proposes to employ, in case the contract is awarded to him, indicating their addresses with telephone number, experience on similar jobs, name, qualification and experience of persons who shall be involved in the job on behalf of the Bidder etc. shall be submitted to Owner. Only the sub-Bidder approved by Owner shall be engaged by the Bidder on the job.

j) Write-up on proposed storm water drainage system furnishing layout of the drains, types of drains.

k) A write-up on dewatering system proposed at the time of construction where deep construction is to be executed.

l) Tentative plot plan showing location of all buildings, structures, roads, site office, storage etc. with plan dimensions of facilities.

II. Inspection of the site by bidder

a) Bidder shall inspect the site, examine and obtain all information required and satisfy himself regarding matters and things such as access to site, communications, transport, right of way, the type and number of equipment and facilities required for the work, availability of local labour, materials and their rates, local working conditions, weather, sub-soil conditions, natural drainage etc. Ignorance of the site conditions shall not be accepted by the Owner as basis for any claim for compensation or extension of time.

b) The submission of a bid by the Bidder will be considered as evidence that such an examination was made and any later claims / disputes in regards to rates quoted shall not be entertained or considered by the Owner.

c) The Bidder shall organize his own arrangement to transport his equipment, men and materials so as to match the construction schedule.

III. Construction tools and Materials Supplied by Bidder

a) Bidder shall provide and maintain at the site necessary number and type of machinery and equipment in good working condition for proper setting out and timely completion of the various works cover under this specification. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expenses. No claim shall be entertained for mobilizing additional equipment and/or personnel to complete the work within the stipulated time.

b) Bidder shall provide all fuels and lubricants required for the operation and maintenance of construction machinery and equipment as well as his transport vehicles at his own cost.

c) The Bidder shall ensure that the work shall proceed uninterrupted even in the event of power failure. As such, adequate number of diesel operated equipment shall be provided by the Bidder at his own cost as an alternative arrangement, in case electrically operated equipment is proposed to be brought to site.

d) The Bidder shall maintain sufficient stock of material so that there is no interruption of works at any point of time during the contract period & extended period if any.

e) All materials supplied by the Bidder shall be original, new and of the best quality and shall conform to the given specifications. Approval in writing shall be obtained from the Owner before any alternative or equivalent material is used other than what is specifically mentioned in the drawings.

f) Bidder shall furnish manufacturer's test certificate for all the manufactured items supplied by him. Representative specimens of the material shall also be submitted to the Owner and shall be tested at a recognized testing laboratory at Bidder's cost in case Owner so desire.

g) The Owner reserves the right to test any construction material supplied by the Bidder in an established testing laboratory at Bidder's cost and to instruct the Bidder to remove all materials, which do not meet the specification requirements.

h) Bidder to arrange third party quality inspection & audit of all construction material at site.

i) Bidder has to set-up a testing laboratory equipped with the following minimum apparatus, materials and competent trained staff required for carrying out field tests:

i. Slump cone apparatus to measure slump.
ii. Concrete cube testing machine with adequate number of moulds of (15cm x 15cm x 15cm) to measure compressive strength of concrete.
iii. Vicat apparatus to find initial and final setting time of cement.
iv. IS sieve with vibrating machine to determine fineness modulus of coarse and fine aggregate.
v. Abrasion & impact testing equipment for testing coarse aggregate and apparatus to determine flakiness index of aggregates.
vi. Complete apparatus for the test of air content of concrete by pressure method as per IS: 1199.
vii. Density bottle to determine sand bulkage.
viii. Hydrometer for testing pH value of water
ix. Thermometer for checking temperature
x. Apparatus for measuring proctor density, water content of compacted soil determining CBR values.
xi. All apparatus for determining dry density and water content of sand/soil and aggregates. Any other equipment felt appropriate by the Owner for measurement of paint thickness, testing of structural members, welding. Etc. The testing machines shall be recalibrated periodically and as directed by Owner to detect errors. The moulds for cubes shall be checked frequently and made to conform to specifications contained in IS: 516.

IV. Work Execution and Supervision

a) Bidder shall have at the site accredited and qualified engineers and foremen /supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the work.
b) Bidder's Engineer-in-charge of the work at site shall be capable of interpreting the specification and drawings and make adequate site decisions as and when required. He shall also take instructions from the Owner and be responsible for carrying out the instructions.
c) Bidder shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner, with fully understanding of the importance of work for a project of this magnitude.
d) In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accidents. He shall also report such accidents to all the competent authorities wherever such reports are required by them.
e) All temporary electrical installation shall be supervised by a qualified electrical supervisor of the Bidder.

f) Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner, is not in accordance with the specification.
g) During inclement weather, rains etc. Bidder shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at Bidder's cost and any damage to works shall be made good by the Bidder at his own expense.
h) Should the work be suspended by reasons of strikes / riots by Bidder's own employees or any other causes whatsoever save and except the force majeure condition, Bidder shall take all precautions necessary for the protection of works and make good, at his own expenses, any damage arising from any of these causes.
i) During the course of Bidder's works, other works either by the Owner or by the Bidders or by both simultaneously will be in progress within the project area. Bidder shall make his best effort to work in harmony with others in the best overall interest of the project and towards its speedy completion.
j) The Bidder shall be responsible for maintaining cleanliness of the site. The site shall be free of unwanted rubbish or filth, which is hazardous & detrimental to health, and affect safety of the work place. Proper watering to be done for dust suppression.
k) All material supplied shall conform to the specification. Entry of unwanted material also shall be prohibited.

V. List of drawings & documents to be supplied by EPC Bidder after award of contract

a) The Bidder shall begin further works like preparation of design criteria only after obtaining approval of the report.
b) General layout drawing with coordinates of roads, boundary wall and facilities, piping/cable corridors, pipe and cable trestles, provision of landscaping and green belt development, diversion roads and drains, equipment laydown area, etc.
c) Drawing showing underground facilities with coordinates like buried pipes, buried cables, trenches, ducts, sewer, drains, sump pits, culverts, foundation, etc.
d) Drawing showing loading data at various levels for all buildings and structures
e) Detailed design calculations / drawings shall be commenced by Bidder only after approval is obtained from the Owner on the basic design criteria for building / structure/ areas to be submitted by the Bidder. No later deviation from the approved design criteria shall be permitted unless specifically approved by the Owner in writing, prior to its adoption.
f) Civil assignment drawings showing all details such as equipment loads, live loads, erection and maintenance loads, cut-outs, crane capacity and wheel loads and wheel spacing, point loads due to piping / pipe hangers, ventilation duct, cable trays etc. shall be submitted for information. Vertical bracing, brick wall location, etc. shall be based on approved general arrangement (GA) drawings of the equipment, piping / cable tray / ventilation duct layout drawings and shall be submitted by the Bidder for Owner's approval. Interferences shall be indicated in civil GA drawings, Civil GA drawings submitted without prior approval of relevant GA drawings for equipment piping / cable tray / ventilation duct layout shall not be considered for review and approval.
g) Design calculations and drawings and other documents for all facilities shall be submitted sequentially after obtaining approval in a phased manner as per approved L2 schedule. Bidder shall ensure that design calculations / drawings for several structures are not submitted at one time. For this purpose, design / drawing submission schedule furnished during bidding stage and agreed upon by Owner shall be followed.
Owner will review and furnish comments / approval, if any, to the designs and drawings. The Bidder shall resubmit the design documents and drawings within a maximum period of three weeks thereafter. Timely submission of designs / drawings to the Owner for review / approval is the sole responsibility of the Bidder and postal or other delays as reasons for late / non-submission shall not be entertained by the Owner.
h) Site Grading and storm water drainage study furnishing levels of various terraces arrangement and details of drains, culverts etc. for storm water drainage system.

i) Details of corrosion protection measures for all structures.
k) Construction, fabrication and erection procedure for all major structures and other machine foundations.
l) Should there be a requirement for preparation of separate drawings to show enlarged details to facilitate construction / erection, then such drawings shall also be prepared by the Bidder at no extra cost.
m) Design drawings shall indicate structural arrangements, member sizes, member forces, splice location, details of base plate, anchor bolts details of moment connection, construction joints, water stops, loadings etc., so that the drawings indicate clearly all the necessary information brought out in relevant design calculations. Proposed bracing patterns shall be subject to approval by Owner. Design drawings showing typical connection details conforming to design assumptions shall be submitted for approval before starting fabrication drawings.
n) Preparation and review of structural steel fabrication drawings is entirely of the responsibility of the Bidder and will not be approved by the Owner. However, all fabrication drawings shall be submitted by the Bidder for Owners reference and records prior to commencement of fabrication.
o) Bar bending schedule for all concrete / structural steel works shall be prepared by the Bidder and submitted to the Owner for his reference.
p) All architectural features of buildings shall be detailed by the Bidder's qualified architect.
q) Detailed drawings along with schedule of doors / windows etc. floor / wall finishes including colour scheme shall be submitted for obtaining approval from the Owner.
r) All construction drawings shall include total quantity of concrete (grade wise), reinforcement (diameter-wise) and structural (section wise).
s) The designs shall clearly spell out the erection scheme for various structures envisaged by the Bidder and resulting additional loadings, if any, shall be duly accounted for. Before taking up actual erection work, detailed erection scheme proposed to be followed by the Bidder shall be submitted for Owner's approval.
t) Approval / comments conveyed by the Owner neither relieves the Bidder of his contractual obligations and his total responsibility for correctness of dimensions, materials of construction loadings, quantities, design details assembly fits, performance particulars, safety and stability of the structures including foundation / appurtenances and conformity of supplies with the statutory laws as may be applicable, nor does it limit the Owners right under this contract. No change in the approved designs / drawings shall be permitted without prior written approval of the Owner.
u) Owner or his representative has every right to go to Bidder's design office to check the quality control being implemented at their design office to ensure that the documents being prepared are of approved quality. The Bidder shall provide all assistance required by Owner for carrying out the audit.
v) Checking for any interference is the sole responsibility of the Bidder.
w) Erection scheme for all major equipments shall be submitted to Owner for his approval before taking up detail design works.
x) All design calculations and drawings shall be in English and shall be in SI units.
y) Designs drawings and other documents submitted by the Bidder shall be thoroughly checked and approved by the authorized Bidder's engineers. Any unchecked / unsigned documents will not be reviewed by the Owner. Also design calculations not accompanied by supporting engineering drawings, incomplete or shabbily done design calculations, design calculations without adequate reference or backup data and documents where previous comments have not been incorporated will not be reviewed by the Owner. No claim from the Bidder for extension of time or extra cost on this account shall be entertained by the Owner under any circumstances.
z) No check will be specifically carried out by the Owner to verify arithmetical / numerical accuracy of the calculations, input data, compatibility of dimensions among various drawings or between drawings and design calculations. These shall remain entirely the Bidder's responsibility.
aa) Bidder shall submit Hard & soft copies of designs / drawings prepared by him in accordance with the distribution schedule for approval.

bb) All modification suggested by the Owner to meet specification requirements and sound engineering practice shall be incorporated by the Bidder at no extra cost to the Owner. In this respect, the decision of the Owner shall be binding on the Bidder. Owner will accord his approval only after the Bidder has incorporated in the design and drawings all modifications required by the Owner.
cc) Hard copies & soft copies of all design calculation and drawings shall be submitted for records after approval of the Owner.
dd) All structural analysis may be done adopting STAAD pro / SAP wherever finite element analysis is needed. The complete input (soft copy with editable format & hard copy) and output data (soft copy & hard copy) is to be submitted for Owner's review and approval. The software's mentioned above are not exhaustive.
ee) Bidder shall submit hard copy (to Owner) of all revised drawings/ documents, as and when the revisions are made at every stage.
ff) Payment will not be made for defective works and other works completed without approved design and drawings.
gg) Final completion report shall be furnished by the Bidder including narrative report with as-built drawing in consultation with Owner.
hh) Write up on various statutory requirements and their compliance for various buildings and facilities.
ii) Quality assurance and Quality Control procedures. Third party quality audit is required.
jj) Copies of all reports on investigation and studies carried out by the BIDDER as per the scope.
kk) EPC Bidder to ensure that photograph of progress of work at site with required album is being submitted to owner once in every month in soft & hard copy.
ll) EPC Bidder to ensure that Bill of quantities has been furnished in various construction drawings.
mm) All drawings are approval category except fabrication drawings which are information category.
nn) Study note on disposal of sewage and other effluent from the plant to satisfy the statutory requirement.
oo) All other designs, details / drawings or any other submissions as indicated elsewhere in this specification and as required by the Owner.
pp) Preparation & Review of structural steel fabrication drawings is entirely of the responsibility of contractor & will not be approved by the owner. However, all fabrication drawings shall be submitted by the contractor for owner's reference & records prior to the commencement of fabrication.

3.2.3 Electrical

The Scope shall include complete design, engineering, procurement, manufacturing, assembly, inspection, testing at manufacturer's works, packing, forwarding, transporting and insurance, including mandatory spares at site, erection, testing, commissioning, Trial/ Reliability Run, conducting performance guarantee tests and final acceptance of the following electrical equipment complete with all accessories:

a) 11 KV Switchgear and 6.6KV Switchgear for FGD

b) Auxiliary power transformer (11KV/6.9KV)

c) Neutral grounding resistor for auxiliary power transformers

d) Service transformers (11KV/0.433KV)

e) 1x100% Emergency DG set of minimum 300KVA or as per sizing calculation (whichever is highest) along with AMF panel.

f) 415V Power Control Centers, Motor Control Centers, Distribution Boards, Local starters and Local Push Button Stations.

g) 6.6KV Segregated Phase bus ducts, for interconnecting secondary of 11/6.9KV transformer and 6.6KV switchgear incomers

h) 415V Non Segregated Phase Bus ducts for interconnecting 11KV/0.433KV LT Service transformer and 415V PCC Incomers

i) 11KV & 6.6KV Motors and LT Motors

j) Electrical actuators

k) 1x100%, 220V DC system of minimum 200AH battery & 150A Charger or as per sizing calculation (whichever is highest), including battery, charger and Distribution board

l) 2x100%, 230V AC UPS of minimum 30KVA or as per sizing calculation (whichever is highest), with 1X100% Battery & ACDB

m) Elevator

n) 11KV, 6.6KV & LT Power cables and control cables for all the equipment supplied by the Vendor, including incoming 11KV cables & electrical / process interlock control cables from Owner's 11KV Station switchgears at power house building

o) Telephone system

p) Public Address system.

q) Cabling system complete with cable trays, supports, conduits, glands, lugs etc. for all the cables covered in the Bidder's scope.

r) Illumination system (Indoor & outdoor) complete with lighting distribution boards, lighting panels, lighting fixtures, lighting poles, winch operated lighting mast, receptacles, fans, conduits, wires, switch boxes etc.

s) Fire sealing system for cable penetrations in the walls/floors.

t) Complete earthing system including buried earth mat, equipment earthing and earth.

u) Electronic earthing system with earth pits

v) Lightning protection system for all the buildings, structures and equipment.

w) Safety equipment such as Rubber mats, First aid box, Danger plate, Sand buckets etc.

x) Engineering of complete Electrical system including preparation of required sizing calculations, fault calculations, layouts, scheme diagrams, cable schedules, Interconnection schedules, relay setting calculation etc.

y) Construction power supply

z) Mandatory spares for three years.

aa) Recommended spares for three (3) years of operation and maintenance

bb) Any other electrical equipment and accessories required to complete the system

3.2.4 Control and Instrumentation

The FGD System shall be provided with all necessary instruments / equipment for the safe operation, control and monitoring from the FGD Control Room. Bidder Scope of supply and work as mentioned

The primary operations including control & monitoring of the FGD System shall be carried out from the programmable logic control system (PLC) /DDCMIS shall have hot redundant standby processors, redundant power supply modules, redundant communication bus and redundant I/O modules. Minimum **three sets (6 nos) of redundant processors** shall be

considered for the PLC / DDCMIS system. Backup panel system shall be provided as mentioned in the specification.

a) Two no. Operator station (24"), one no. Operator cum Engineering station(24"), another one no. 80" HD LED screen Operator work station, one no. A3 colour laser printer & one no.of A3 B/W Laser jet printer shall be provided in the FGD control room and one no. operation station (24") along with A4 Color laser printer shall be provided in the Central control room (Refer tender drawing).. This Microprocessor based PLC/ DDCMIS system shall include the total functional requirements of measurement system, control system, protection & interlock, annunciation system, operating system & communication system.

b) The PLC system shall be interfaced with main plant DDCMIS through redundant bidirectional MODBUS TCP-IP /OPC/ RS 485 link for monitoring and also shall be time synchronised with redundant Plant Master Clock system through via NTP / IRIGB protocol. Supply & Laying of all communication cables shall be considered. In addition to that all necessary hardwiring of I/Os shall also be considered with plant DDCMIS for control , interlock and protection signals. Local Fire alarm panel shall be interfaced with Main Plant Main Fire Alarm Panel for necessary Alarm.

c) CCTV system shall be provided with 1 no Operating station 48" LED (wall hanging) at FGD control room for CCTV monitoring. FGD CCTV shall be interfaced with existing plant CCTV system located in the existing CCR.

d) One No. Lap top with necessary master software loaded for PLC / any other control System shall be supplied along with software in CD/DVD Form.

e) Bidder to note that Vibration Monitoring System shall be envisaged for all the HT driven equipment & HT Motors of FGD plant. However FGD VMS system supplied by bidder shall be hooked-up with the Main plant VMAS system. , The FGD bidder to provide required signals & raw buffered outputs, cables and other accessories and terminal point will be VMAS panel located in main plant building.

f) Industrial grade 2 x 100 % Parallel redundant UPS with heavy duty battery and Floor mounted ACDB shall be provided for powering PLC, Operator / Engineering work station, Analysers, SOVs and Field instruments, CCTV etc

g) All field instruments and sensors for remote measurement viz. Flow meters, Smart Transmitters, RTD, Process Switches, and Temperature Transmitters with all accessories shall be supplied as per attached PIDs and detailed specification for the completeness of the system.

h) All final control elements like solenoid valve, on-off valves and actuators as required.

i) Instrumentation cables & control cables & any other special cables as required for the system. Bidder shall supply all necessary cable, cable trays, conduits, accessories, between PLC to field / MCC.

   Bidder to consider following Cables in their scope.

   Supply, laying, glanding and termination of all cables between:

   i. Power, Control, Instrumentation & Core cables: Where any one end equipment/ instruments/ items are in their scope.

   ii. All C&I Cables including OFC shall be Armoured type only. Bidder to suitably select the size (cross Section area) of Instrumentation Cable keeping in mind of Voltage drop due to large distance.

iii. All necessary cable between Field instruments, limit switches and any other equipment to JB/LCP and from JB/LCP/MCC/SWGR to the PLC panels cabling shall be done by bidder.

iv. Complete supply, installation and laying of all cables between FGD system PLC and UPS by the bidder.

v. All necessary cables between Local Fire Alarm system to existing plant Main Fire alarm system in control room.

vi. All necessary cables for Fire systems, VMAS, CCTV systems.

vii. All necessary OFC, hardwired cable & any other cable upto mainplant DCS shall be Bidder only.

viii. Same as any other requirement for FGD PLC/DDCMIS from main plant DDCMIS by bidder only.

j) Instrument erection hardware which includes all junction boxes, cable trays, cable glands, lugs, cable ties, support, local panels, pneumatic and process hook up hardware, Impulse piping & fittings and other erection materials and accessories required for the system shall be bidder scope of supply.

k) Industrial grade Control Desk / Furniture in local control rooms and central control room.

l) Necessary calibrated instruments, valves and accessories for carrying out performance tests of FGD System.

m) Erection, testing& commissioning of the entire PLC / DDCMIS, control panels, field instruments / final control elements and all other I&C equipments supplied by the bidder.

n) Earthing of all I&C equipments, control panels, Instruments, Junction boxes and cable trays including above ground panel / below ground / redundant electronic earthing. Bidder shall note that all electronic earthing shall be redundant.

o) Mandatory, recommended, erection & commissioning spares.

p) Formats for all engineering documents shall be strictly as per Purchaser's requirement only. Bidder's standard formats shall not be acceptable. All other I&C items, works and services detailed elsewhere in this specification.

q) Training of Purchasers engineering personnel for PLC / DDCMIS programming, trouble shooting, graphic and logic development

r) All Panels, junction boxes shall be of exterior color RAL 7035 and interior color of glossy white only. Bidder shall note that the Analog and digital signals shall be wired to different junction boxes.

s) Drive control philosophy will be submitted during pre-bid engineering stage, However I/O's Be approved during detail engineering.

t) Bidder shall refer to **FGD PLC SYSTEM CONFIGURATION and other Annexures** for further details in the Volume II, Section -6, Tender Drawings.

u) All necessary logic work shall be in SAMA Format and all the format of document bidder shall strictly follow the format of Owner only without any commercial implication.

v) All necessary protection system & remote annunciation system as per latest technology & state of art shall be provided as a safe guard against failure opening of doors at the landing platforms or any other type of emergency, if any.

w) Required CEMS analyser shall be considered and supplied as per process & technical specification requirement.

x) All other I&C items, works and services detailed elsewhere in this specification.

y) Bidder to submit FGD complete detail operation in the 3D animation in English for training purpose.

z) Station LAN cabling for FGD building by Bidder from Common switch which will be located near the FGD building.

3.2.5 Consumables

a) Supply of all consumables required for erection, commissioning, trial operation and performance test is included in the basic scope and same shall be supplied by successful Bidder. List of such item shall be identified & furnished with bid & finally included in the bill of material document. The complete list shall be furnished by the Bidder in his offer.

b) Grouting materials for all equipment, structures, etc.

3.2.6 Maintenance tools and tackles

One (1) set of special tools and tackle required for operation, maintenance, dismantling, erection, inspection and repair shall be supplied in neatly packed-in steel boxes complete with operating instructions for the equipment as necessary. These shall not be used for erection/commissioning purposes by the Bidder and shall be in unused and new condition, when they are handed over to the Owner. The complete list shall be furnished by the Bidder in his offer.

3.2.7 Common Supplies

a) All necessary painting and corrosion protection. The painting and corrosion protection for the equipment and structures is included in bidder's scope. The painting scheme and the finish color for all the equipment shall be as specified by the Owner after award of contract. Necessary finish paints including touch up paints, if not applied at shop, should be supplied by the Contractor, in sealed containers for site application.

b) Complete lot of base plates, foundation bolts, inserts, embedment, clamps, nuts, washers etc. as required for the system.

3.3 GENERAL SCOPE OF SUPPLY AND SERVICES

The scope of supply and services covered by this EPC enquiry document shall be complete from site clearing to FGD project take over by the Owner including all supplies and services. The Bidder's scope of supply and services listed below are to be included and shall not be limited to the following:

1. Design, Engineering, Procurement, Testing at Manufacturer's Works, painting, Packing, Forwarding and Supply of all equipment, plants and facilities within the limits of supply and for connection at the boundary limits, as specified in the relevant detailed technical specification for the completion of the FGD on an EPC basis including Special Tools & Tackles, startup/Commissioning spares, Mandatory Spares etc.,

2. Intermediate site storage, transport to erection area, Receipt of material at site including unloading from carriers at site, handling, storage & preservation at site and intra site transport.

3. Inspection, testing, cleaning, painting, marking, etc. at the EPC contractors and/or sub-contractors workshops, delivery and transportation to the site, including insurance, unloading, etc.

4 Overall Project management, project control, quality assurance, site management and coordination for all technical matters, interconnections, connection to off-site facilities, scheduling, contractual matters and obligations, etc. with suppliers, sub-suppliers, subcontractors, vendors, the Owner, authorities as required on a EPC basis for the implementation, construction and putting into commercial operation of the whole project under the overall and sole responsibility of the EPC contractor.

5. Complete civil engineering including design, Geo technical investigation and carrying out all necessary civil and construction works at site as specified.

6. Supply of all information, documents, calculations, drawings, reports, etc. which are required for Owner's approval and to obtain all necessary permits, clearances, from the Government authority.

7. Apply for all permits and get the authorities approval for all actions, which require approval or permit from local government and statutory authorities. The contractor shall obtain and pay for necessary permits as required including license fees for installation and inspection of the equipment, also make such tests as called for by the regulations in the presence of authorized representatives of such authorities as well as in the present of the Owner's representative. The contractor shall be responsible to obtain license, certificate for operating at site.

8 Supply of all consumable materials required for civil construction, erection, testing and commissioning, reliability run, performance guarantee test, taking over of the plant. However Limestone and water required for these trial / test of the plant will be provided by the Owner at specified terminal point, but shall be under no obligation to do so for any re-run of such tests due to contractor.

9. Provision of all labour, necessary erection equipment, temporary site facilities, temporary connections to power supply, water supply, etc. for erection and commissioning required for the fulfillment of the Contractor's duties in connection with the works and for completion of the entire project in time.

10. Provision of all accommodation, transport, canteen facility, social facilities, etc. for the Contractor's personnel employed at site.

11. Co-ordination with other agencies including with the Owner at the plant interconnections (interfaces). The project in under execution with a separate contract for BTG and BOP on an EPC basis, the FGD contractor need to co-ordinate with both the contractor during the time of execution .

12. Cleaning and application of corrosion protection during erection as required by the Owner and apply final & touch up painting in accordance with the specification.

13. Carry out commissioning, testing, trial operation, reliability run and performance guarantee test of the systems / equipment / plant including civil, structural & architectural works specified and handing over of the plant to the Owner requirements and approval and in compliance with the requirements of this specification.

14. Installation and removal of temporary piping and equipment for carrying out flushing or any other operation.

15. Removal of surplus materials, scraps out of fabrication yard, temporary infrastructures, subsequent cleaning up and handing over of plant to the owner.

16. Provision of supply of all documents required and specified including AS BUILT drawings.

17. Training services for the Owner's operation and maintenance personnel.

18. Supply and Installation of proven and latest air quality monitoring system at the strategic locations of the plant to monitor and comply with norms of various statutory bodies.

19. Conducting Hazop Study with the involvement of the "Company" and furnishing the report.

20. The specification has described the scope of work/supply and endeavored to cover all the major equipment and related activities and work necessary for satisfactory completion of the FGD Project. However any other minor item/service, which has not been specifically mentioned but is required for the completeness of the work shall also be supplied by the contractor without any additional cost to Owner. The bidder is therefore advised to visit the site and acquaint himself with the condition of the plant and equipment to enable him to make assessment of the complete job of FGD Package system for 1 x 800 MW TPS

21. The Contractor shall accept full responsibility for the completeness and for the faultless working of equipment and the plant as a whole. These shall be executed on the basis of proven design principles and in accordance with the state of-the-art in such a manner that the purpose to be served by the plant is fulfilled in every respect and a maximum of operational dependability and efficiency are assured. Standardization of equipment, materials etc. as well as of buildings shall be employed in the design. Care shall be taken to ensure safe operation as well as simplicity of assembling and dismantling of all parts of the plant.

22. Satisfactory conclusion of the Contract:-

    By accepting the Contract, the Contractor shall be deemed to accept the obligation of supplying everything necessary for the purpose mentioned above, regardless of any omission in the specification or on the drawings.

    More detailed scope of supply and service is described under this section and the relevant chapter of the detailed technical specification.

23. Scope of Engineering Services:-

    The engineering services of the Contract refer to the complete basic and detail engineering of all equipment and equipment systems, Providing engineering drawings, data, instruction manuals, as built drawings and other information for the Owner's review, approval and records.

    The Contractor shall be responsible for all licensing applications, however Owner will extend all co-operation required by the contractor.

    All services shall be performed by the Contractor to obtain the required permits to commence the works and operate the Plant, including but not limited to:

- Clarifications with authorities
- Participation in all clarification meetings
- All other services as required.

3.4 COMMON EQUIPMENT AND SERVICES

The following supplies and services are to be included in the Bidder's scope

- Plant Hand Book contains the design and performance data of equipment, systems, covering complete supply package including single line diagram.

- All necessary co-ordination with other contractors on site for erection, testing and commissioning of equipment and accessories.
- Making available of all testing and commissioning equipment.
- All necessary pipelines, warm up system, vents, drains, valves, actuators, required for commissioning, operation and preservation in standstill.
- All temporary installations required for tie-in measures including post weld heat treatment complete, inner cleaning, etc.
- All temporary pipe work as required during connection measures
- All support structures, hangers, supports etc.
- All base frames, mounting plates, grouted in parts, rag bolts, covers, etc.
- All required steel parts embedded in concrete
- All couplings and coupling guards for electric motors and other drives
- All lifting equipment required for maintenance
- Required safety equipment, pressure relief valves, etc.
- All thermal (Hot and Cold) and noise insulation including cladding as well as any other noise attenuation measures
- Stairways, ladders, platforms, galleries and walkways to all plant components, including escape routes as necessary, pipe cross overs,
- All necessary steel structures, stairs, ladders and platforms including weather protection
- All required ventilation and / or air conditioning equipment as specified and as required for safe operation of mechanical and electrical equipment, to be supplied
- All necessary corrosion protection measures for plant components and equipment stored or mounted on site up to the time of ”Handing Over”.
- Complete primer and top coatings conforming to color code, to be agreed with the Owner/Owner’s Engineer
- Noise abatements measures to comply with noise pollution control requirement
- Complete labeling of all plant components according to the Owners system in English and also in local language for notices etc.
- All fire protection measures
- Initial lubricant filling and sufficient lubricants for commissioning and reliability test run, minimization of lubricant types by screening and co-ordination with the Owner,
- Provision of all connections and temporary pipe work for steam blowing of the steam pipelines
- Flushing of all other pipelines including disposal of the effluents; protection with wood and/or plastic at all instrumentation and appendages to be installed during construction
- Chemical cleaning
- All standard accessories and auxiliary equipment which normally form part of the scope of supplies
- All tests, inspections and works acceptances as well as all certificates and reports of these
- Cleaning of all filters/strainers before ”Handing Over” of the relevant Unit
- Valve trims for purging and subsequent exchange
- Removal of any unused material from site
- Micro leveling of the area
- Earthworks, drainage, excavation and refilling works
- Roads and pavement (to be connected with the existing roads)
- Concrete and reinforced concrete works, masonry and earthing
- Water proofing works for pressing and non-pressing water
- Roofing (non asbestos)
- Plumbing
- Facade works/glazing works; non asbestos
- Non-load bearing walls/installation partitions/dry construction works
- Metalwork and blacksmith work/raised flooring/doors and gates/sheet metalwork
- Flooring work

- Corrosion protection for underground/ over ground RCC and steel structures, equipments and piping
- Crane way works
- Potable water, service water and waste water, sewage water, storm water (permanent and during construction), etc.
- Housekeeping during construction (at least once a week total)
- Transport of all dumping material to dump locations (at least once a week)

4.0 TERMINAL POINTS

4.1 MECHANICAL WORKS

a) Untreated Flue gas duct: At the existing ID fan duct. Material Carbon steel. Size – 6500 mm x 7700 mm Design pressure shall be decided based on Booster fan head. (Please refer to the existing ID fan duct layout)

b) Treated Flue gas duct: At the existing ID fan common duct. Material- Carbon steel. Size- 6500 mm x 7700 mm. Design pressure shall be decided based on Booster fan head. (Please refer to the existing ID fan duct layout)

c) Service water pipe terminal. Shall be tapped from the existing header inside the Filtered water pump house (refer terminal point drawing).

d) Potable water pipe terminal. Tapped from the existing header on Pipe Rack (refer terminal point drawing).

e) Auxiliary Steam pipe terminal. Tapped from the existing Auxiliary Steam header on Pipe Rack (refer terminal point drawing)

f) FGD effluent water (treated clarifier water) pipe terminal- At the inlet of Guard pond.

g) Limestone: At the Limestone stockyard

h) Gypsum: At the silo outlet .

i) Fire water pipe terminal- Tapped from the existing Fire hydrant network. Size to be confirmed during detailed engineering.

j) Instrument Air and Service- Contractor has to consider the necessary compressor package to meet the requirement and hence terminal point is “Not applicable”. .

k) Cooling Water : Auxiliary Cooling water before the inlet of Self-cleaning strainer of ACW header which will be the inlet and the outlet secondary cooling water line shall be terminated at the CW forebay

l) DM water : At the terminal point in the existing pipe rack

All necessary interconnections /Modifications at the interface points is in the Bidder scope. Necessary isolation valves with counter flanges and hardware at the terminal point are in Bidder scope. Bidder shall visit the plant to identify the listed interface/ terminal points at bid stage for physical identification of interface points, and for planning the pipe/cable /duct layout during execution. Bidder shall consider a tolerance of $\pm$50 m while considering the interface terminal point location from the specified location.

The existing , ID fan , Flue gas duct layout between ID fan & Chimney is furnished as reference drawing 1 & 2 in the specification.

The list of terminal points with co-ordinates are identified in the Terminal Point drawing.

The available utility parameters at the terminal points are listed below.

Terminal Point Number (TP No.)	Utility	Available Process Parameters at T.P
TP 1	Service Water	100 m3/hr (max)
TP 2	Potable water	1 m3/hr (max) at 2 Kg/cm^2 (g)
TP3	Auxiliary Steam	6 TPH (max) at 12 Kg/cm^2 (g)/ 210 deg C
TP 4	FGD effluent water outlet (treated clarifier water)	To Guard pond
TP 5	DM water	0.5 m3/hr at 1.0 kg/cm2 (g)
TP 6	Auxiliary cooling water (supply)	200 m3/hr (max) at 3.0 kg/cm2 (g) normal and max 7.0 kg/cm2 (g)
TP 7	Auxiliary cooling water (return)	At required pressure at terminal point
TP 8	Firefighting water	From the existing hydrant network.

The terminal point details needs to be validated during the detail engineering

4.2 CIVIL WORKS

a) Road network from FGD facilities to upto nearest plant road as per General Layout attached.

b) Strom water Drain in FGD facilities area upto nearest existing road side drain.

4.3 ELECTRICAL WORKS

HT Power Supply : HT power supply envisaged at 11 KV station switchgear- OBA-panel no.4 and OBB-panel no.5 located at HV Switchgear room of Power house building. Complete cabling and termination from this point of source including its supply is in bidder's scope.

Earthing : 2 nos. Test link pits shall be installed by bidder near Chimney by shall connect the same with the existing earth grid near Chimney.

Telephone System : Existing IP based EPABX system for main plant is located in service building. Bidder shall extend minimum 50 nos extensions from the same to the FGD control building through necessary cablings, terminations and shall terminate in new JB, to be supplied by the bidder, in FGD control building, from which the telephone communication network will be done by telephone cables laid in existing cable racks/trays, drawn through conduits, laid directly buried underground as applicable, in respective zones of FGD area.

PA System : From the existing main plant central control exchange MDF, bidder to lay 100 pair telephone cable to FGD control room building and terminate at a new SDF, to be supplied by bidder. All further distribution and instruments shall be carried out by the bidder.

EDMS & IEMS : Integrating the FGD system electrical with EDMS & IEMS of existing main plant (CCR TG building). All necessary cabling and any modification in the existing system for this integration shall also be in bidder's scope.

Cable tray	:	Bidder shall use the existing cable tray, only if the tray with same voltage grade of cable is available with adequate free space for additional cables. If not available, bidder shall install new tray in the route.

4.4 CONTROL AND INSTRUMENTATION

Cable, cable tray and accessories including supply, laying and termination	:	No Terminal Point. All cables where one end / both end equipment is supplied by bidder. i) Complete supply, installation and laying by bidder between bidder supplied equipments. ii) Complete supply, installation and laying between Field instruments / Valves / local control Panels and FGD PLC / DDCMIS by the bidder. iii) Complete supply, installation and laying between Switchgear / MCC&FGD PLC system by the bidder. iv) Complete supply, installation and laying between Respective UPS terminal and FGD PLC / LCP by the bidder
MODBUS /OPC DDCMIS interface	:	Terminal Point at Plant DDCMIS end (in CCR)
GPS master clock Time Synchronization	:	Terminal point at Master Clock end(in CCR)
CCTV	:	Terminal point at Plant CCTV(in CCR)
Fire system	:	Terminal point at Plant Main Fire Panel (in CCR)
VMAS	:	VMS shall be supplied by FGD vendor for all HT drives under his scope. However VMAS shall be supplied by main plant contractor, Required signals & raw buffered output, cables and other accessories shall be supplied by FGD vendor and terminal point will be VMAS panel located in main plant building. Including termination and modification both (Hardwired and software) required in VMAS
CEMS and other Analyzers	:	Complete supply and installation by Bidder, Terminal point at DDCMIS in CCR.
Field Instruments / Final Control elements / Erection hardware	:	No terminal point. Complete supply and installation by the bidder within his battery limits.
Earthing	:	No terminal points. Complete requirement by bidder within his battery limits
UPS/Auxiliary Power Supply System	:	No terminal points. Complete requirement by bidder within his battery limits

5.0 PROVISIONS BY THE OWNER

Following are the provisions / supplies by the Owner:

- Graded land within the property line limits as indicated in the General Layout for FGD.
- Geotechnical investigation report
- Limestone and water for startup, testing and commissioning. However, Bidder shall indicate in the offer the quantity required in his offer exceeding which the supply by Owner will be on chargeable basis
- All utilities/services up to the terminal points as specified in the specification.
- Permits specifically identified as to be obtained by the Owner. Bidder shall specify the same in the offer submitted.

6.0 QUALIFYING REQUIREMENTS FOR EQUIPMENTS / SYSTEMS

The sub-vendors being engaged by the EPC contractor for the various packages in the scope of works shall have successfully executed similar such works in the last ten years. The credentials of such sub vendors shall be furnished to Owner/ Consultant for review and approval. Sub-vendors who are approved by Owner/Consultants shall only be engaged by the EPC contractor for the various packages under the scope of works.

7.0 SITE CONDITIONS

7.1 GENERAL

The Project Information is enclosed as Annexure 1

7.2 GEOLOGICAL CONDITIONS

7.2.1 Soil Profile

Geotechnical investigation is furnished in **Attachment 1** of this Technical Specification.

7.3 DESIGN REQUIREMENTS RELATED TO SITE CONDITIONS

7.3.1 Design Ambient Data

- **Design ambient conditions for FGD and auxiliaries**

  Design ambient temperature : 30℃
  Design ambient air relative humidity : 75%

*Basic conditions as per Schedule of Guaranteed shall also be applicable).

- **Design ambient Conditions for Electrical equipment sizing**
  - For electrical equipment : 50 °C
  - Relative Humidity Mean Maximum : 90%
  - Relative Humidity Mean Minimum : 36%

7.3.2 Wind data

Wind loads to be considered for design of structures shall be based on the design wind speeds arrived at based on IS : 875 (Part -3) – Latest Edition

7.3.3 Seismic Data

Seismic loads to be considered for design of structures shall be as per as per IS: 1893.

8.0 SITE WORK AND ERECTION REQUIREMENTS

8.1 CONSTRUCTION POWER

The construction power supply system by its design and nature shall be temporary system and not a part of permanent supply system. The Purchaser shall be providing 415V 3 Ph, 3 Wire and 50 Hz construction power supply at two (2) points. However bidder shall mention the construction power requirement at various phases of construction, in the bid document. Construction power supply shall be given on chargeable basis at the prevailing rates of Tamil Nadu TRANSCO.

The contractor shall provide metering equipment, comprising of CT, PT units, trivector meters of suitable accuracy and shall be responsible for periodic payment of bills for the energy consumed. Necessary protections for the construction power shall be provided to protect the Client's source from any fault in his system.

Bidder/Contractor may specify in the tender conditions itself, if there is any change in the construction power supply system maximum demand requirement. Bidder shall indicate 6 monthly maximum demand requirements.

Operation and maintenance of all construction power supply equipment is in the scope of Bidder.

Bidder/ Contractor shall maintain a power factor of 0.95 or better for the construction power used.

Distribution of 415V supply shall be done using underground cables. All cables being used for construction power shall be armoured only. For the areas like roads, nearer to buildings and areas where there are frequent vehicle movement the cable shall be routed in hume pipes or GI conduits. Buried cable shall be suitably identified by the route markers.

In any case, non-availability of power, its interruption and variation in supply voltage will not constitute a condition for claim for extra costs and time on part of the contractor. The contractor will be responsible for making all necessary arrangements to ensure that the uninterrupted construction power supply is available during critical erection and commissioning activities. For this purpose, required DG sets has to be arranged by contractor.

The Electrical installation shall be generally be carried out as per Indian Electricity Rules & Acts for road crossing, protective guarding shall be provided. The clearance for the lowest conductor from ground shall be decided keeping in view the vertical clearance required for movement of vehicle /crane, etc.

Adequate safety equipment shall be provided to all the workers, like hand gloves, head gear, etc. Meggers & Testers shall be provided in sufficient quantity. Earthing and Lightning protection system shall be provided as per IS and CEIG requirements.

All the working areas shall be adequately illuminated for safe working with proper fittings/fixtures. The wire shall be laid with proper fixing without any hindrances to personnel or vehicle movement.

After the completion of the job, the contractor shall remove the entire installation and make available the area to the owner.

8.2 CONSTRUCTION WATER

Construction water shall be provided by the Owner to the Contractor at chargeable basis. Bidder shall mention the construction water requirement at various phases of construction, in the bid document.

8.3 CONSTRUCTION COMMUNICATIONS

Any communication system which the Contractor might need is within the scope of the Contractor's supply.

8.4 ACCESS TO CONSTRUCTION SITE

Most transportation will have to be via sea or road. Heavy equipment if transported by rail have to unloaded at the nearest railway station (facility shall be checked by the contractor) and transported to site by other means. Any road transportation to the site will have to be through the existing plant access road and high ways.

8.5 SITE SAFETY & SECURITY

It's Contractor's duty to organize and constitute a safety system for providing protection to installation work, contracting material storage, warehouse, field office, accommodation etc., within the contractor's scope of supply and services.

Guards shall be provided by contractor for safety and security.

The Contractor is responsible for the storage of material and the upkeep of equipment at the working site. There shall be fencing for temporary storage and material storing yard with special duty personnel on duty day and night.

Temporary safe railings shall have safe lighting equipment to send out indications such as material warehouse, field or site office and accommodation.

The duty of the Contractor includes the site management and safety of the engineers.

8.6 FIELD SAFETY AND HEALTH ORGANIZATION

According to both, local safety and health regulations, field safety organization shall provide necessary tools, documentation and other measures especially with respect to handling of dangerous goods and fire risks and medical service.

Contractor shall be in charge of examining field safety under the control of a field safety engineers.

8.7 CLEANING ON SITE

Contractor shall be responsible to keep the construction site clean and remove any waste material or hazardous waste to an appropriated waste disposal site approved by authorities in a safe and orderly way.

8.8 LAYDOWN AND CONSTRUCTION

Space available within the site shall be utilized for Contractor's laydown and construction.

9.0 SPARE PARTS, WEAR AND TEAR PARTS

Spares for the FGD plant shall be divided into two categories namely:

(a) Start-up and Commissioning Spares

(b) Operation & Maintenance (O & M) Spares

Start-up and Commissioning Spares

Start-up and Commissioning spares are those which would be required during plant or equipment testing, start-up and commissioning. All spares used until the plant is finally handed over by the Contractor to the Owner come under this category. All start-up and commissioning spares as required shall be provided by the Contractor without any additional cost to the Owner. The list and details of start-up and commissioning spares shall be furnished by Contractor prior to award of Contract.

Contractor shall be responsible for the ready and timely availability for all the start-up and commissioning spares as required during various stages of testing, cleaning and commissioning upto handing over of each system of the plant.

O & M Spares

The spares required for 3 years trouble free operation of the plant shall be identified and listed by the bidder in his offer. Owner will review the list of spares specified and finalise the same including any additional spares that will be necessary for three (3) years trouble free operation to meet the plant O & M requirements. The spares for the plant shall be furnished by the Contractor and delivered during the commissioning of the FGD plant.

The spare parts must be able to replace the original part completely and have the same technical specifications in quality, material, inspection and mechanical aspects.

Contractors shall supply all measurement testing data of any spare part supplied, if applicable.

All spare parts supplied shall be packed and stored for a 5 years reservation based on the local climatic conditions. Small spare parts shall be packed and sealed by transparent plastic bags and drying agents will be used if necessary. Every spare parts shall have operation instructions and design marks of the factory when it is supplied.

When multiple spare parts are packed in one packing box or container, the general indication to the spare parts outside the packing boxes or containers shall include a detailed list. All packing boxes, containers, and other such tanks shall be marked properly and numbered clearly. All electrical equipment including switches, fuse connection easy melting and other similar apparatus shall be protected and insulated.

The identification of all spare parts shall be in the English language.

Spare parts shall be supplied 6 months before start of acceptance test .

Wear and tear parts, to be replaced by the Owner at his own cost, shall be marked separately.

Contractor's recommended/required spare part list shall be confirmed during detail design.

Contractor shall identify in the spare parts list, the items having a delivery time of more than 3 months

10.0 TRAINING REQUIREMENTS

10.1 GENERAL

The Contractor shall be responsible for the instruction and training of the Owner's operation and maintenance personnel and his O & M contractor in all aspects of plant design, construction, erection, commissioning, etc. and in such a way that operation, maintenance and if necessary repairs of all the power plant equipment and facilities specified can be handled competently by said personnel.

Such training of the Owner's personnel shall be performed

- In Contractor's and/or sub supplier's/manufacturer's home office and/or workshops.
- In similar capacity FGD operated power plant and such power plants which are under erection and commissioning as well as at the proposed similar Power Plant by using the training simulator.
- On the job site by the Contractor's and/or his sub-suppliers, supervisors and/or instructors deputed to the site for supervision of erection, commissioning, testing and trial operation and/or by specialized training instructors;
- At the FGD Plant by the supervisors deputed to the Plant during the Warranty Period;

In compliance with the provisions of the Contract and the requirements of this specification.

The personnel required for the safe and efficient plant commercial operation and maintenance of the various types of equipment installed shall be provided by the Owner in accordance with the recommendation to be made by the Contractor.

The training will be performed in English. Translators/interpreters shall be provided by the Contractor.

The Contractor's instructors shall use modern training techniques, procedures and aids and make available to the trainees all required notes, manuals, drawings, etc., to supplement the Operation and Maintenance Instruction Manuals.

The Contractor shall provide a detailed description about the recommended training services, including

- Number, category, seniority, required experience, profile required, etc. of the trainees

- Preliminary training program, showing

  - Training facilities, training aids places of training etc.
  - Training schedule
  - Specialty and details of lectures and training
  - Duration of training courses

for all kind of training activities, abroad, classroom, on the job site, at the proposed FGD Plant, etc.

The recommended training program should be based on the organizational and staff structures of coal fired power plants already in operation in India and should take into consideration not only the training for operation and maintenance staff, such as operators, skilled workers, foremen and technicians etc, but also for senior staff and key personnel employed for the management and organizational duties of the various power plant decisions,

such as for operation, maintenance, instrumentation and control, chemistry, administration, security, spare parts handling, scheduling and engineering, etc.

10.2 CONTRACTOR'S OBLIGATIONS AND TASKS

10.2.1 The Contractor shall make every effort to train the Owner's personnel and his authorized O & M contractors so that they can be qualified for the management, operation and maintenance of the Contract Plant.

10.2.2 The Contractor shall nominate a person in charge of organization and co-ordination activities for training.

10.2.3 The Contractor shall select instructors with proper experience and skillfulness and English speaking capability to train the Owner's personnel.

10.2.4 The training program will be carried out according to the requirements of each specialty. It will consist mainly of but not limited to the following:

a) Systematic explanation in a classroom of specific subjects, such as the equipment performance, construction, main systems, auxiliary systems etc.

b) Visit to power plants with FGD;

c) Practical training in similar power plants which are under erection and commissioning.

d) Practical training on simulators and control rooms of FGD in similar power plants.

e) Supply of all necessary training documentation (such as books, manuals, drawings), equipment, tools and instruments etc. The Contractor will make best effort to achieve above item (c) and (d) with utility authority.

10.2.5 The Contractor will make available free of charge to the Owner's personnel working cloths, safety helmets, stationery etc. as needed by the training program.

10.2.6 The Contractor shall allow the Owner's personnel to carry back all the technical documents supplied during the training.

10.2.7 The Contractor shall make at the end of the training period an evaluation of the results obtained by each trainee. These results will be confidentially notified to the Owner.

10.2.8 The Contractor shall assist the Owner's personnel in arranging their entry visas and all the formalities staying in foreign countries for training. The Contractor shall also take all the necessary measures to ensure the safety of the Owner's personnel during their stay in the foreign country.

10.2.9 The Contractor shall appoint a person in charge of logistic coordination. This person shall take care for booking of rooms according to the requirements of the Owner and arranging for transportation (free of charge) from their living place to the training site.

10.2.10 The Contractor shall provide free medical services to the Owner's personnel, but excluding dentistry, buying glasses and tonic medicines.

10.3 OWNER'S RESPONSIBILITIES

10.3.1 The Owner shall appoint a person as official representative of the Owner's trainees.

10.3.2 The trainees shall understand the English language and shall follow the training courses with due diligence. During their stay abroad the Owner's personnel shall observe the Laws of that country and the rules/regulations of the factories/plants where the training will be conducted.

The official holidays or national holidays, Saturdays and Sundays shall be the holidays of the Owner's personnel.

10.3.3 For the successful completion of the training program, unless mutually agreed by the parties, the program cannot be interrupted for vacation leave.

10.3.4 The Owner shall take care, at his own cost, for:

a. buying round trip air ticket between India and the place of training

b. arranging lodging and boarding for the Owner's personnel from their arrival abroad to the date of their departure.

10.4 TRAINING SCHEDULE AND PROGRAM

10.4.1 The Training program for the Owner's personnel will be defined during the liaison meeting.

10.4.2 Two (2) months before the arrival of the first group of the Owner's personnel in training site, the Owner shall inform the Contractor of the date when the Owner's personnel are expected to be sent to training site

10.4.3 Within 2 (two) weeks after receipt of the Owner's information mentioned above, the Contractor shall confirm its agreement or indicate difficulties , if any, for the staying of the personnel. Thirty (30) days before the arrival of the Owner's personnel in the training site the Owner shall inform the Contractor of the brief career of the personnel including names, date of birth , nationality, specialty, experience, qualification, position and knowledge of foreign languages, passport details etc., so that the Contractor can assist in arranging their entry visas.

10.4.4 The Contractor shall not charge the Owner with the costs for the training activities in the respective training sites.

10.4.5 In case the Owner fails to send his personnel to attend the above training, the Contractor shall reimburse the relevant amount to the Owner.

11.0 TAGGING

Components whose identity is important for operation and maintenance of the plant viz., all apparatus, signal tapping points, instruments and control equipment, cubicles, as well as the terminal boards, etc., installed in the latter shall be provided with permanently attached tag bearing the Owner's coding together with relevant text clearly inscribed. The inscription shall be approved by the Owner/Consultant. The tag shall be of engraved plate of sufficient rigidity and figures and letters embossed and painted. Such nameplates or labels shall be of white non hygroscopic material with engraved black lettering. The language of inscription shall be English. The method of implementation and labeling shall be informed for all components after award of contract. For equipment identification and tagging KKS numbering system shall be adopted.

12.0 PAINTING AND CORROSION PROTECTION

The painting specification for all the equipment shall be as specified in various sections of this specification Annexure 1.6. The detailed painting specification and colour scheme shall be firmed up by the Purchaser after award of contract. Necessary finish paints including touch up paints, if not applied at shop, should be supplied by the Bidder, in sealed containers for site application.

13.0 PROTECTIVE GUARDS

Suitable guards shall be provided for protection of personnel on all exposed rotating and/or moving machine parts. All such guards with necessary spares and accessories shall be designed for easy installation and removal for maintenance purposes.

14.0 QUALITY ASSURANCE

14.1 GENERAL

Contractor shall provide effective quality assurance according to ISO 9001 standard or other equivalent quality standard. The preliminary quality assurance program is part of the contract agreement. The program gives the description to all the management and regulations about the necessary quality assurance activities in relation to the execution of the contract.

Quality achievements shall be ensured by combined factors such as the application of quality system regulations, technical specifications (including acceptance regulation of quality control requirements), the examination of quality achievement, precautionary methods and the control of corresponding data.

All manufacturing, processing, testing and inspection operations affecting the equipment or material shall be subject to surveillance by Owner or Owner's Representative. These will be identified by customer Hold Point.

14.2 QUALITY ASSURANCE SYSTEM

The quality assurance system of the Contractor shall illustrate its organization process, duty and obligation, quality supervision and standards and subject to reexamination by the Owner.

The implementation of the system shall be ensured by the following:

the guidance and training of all staff by management council in application of the quality assurance program and the ordinary supervision through reexamination and management of the quality assurance program.

If an international joint venture is established, the responsibilities shall be specified so as to let the quality assurance group perform its duty, communicate with the Owner formally, and be responsible for the development of the quality assurance program. An agent should be involved to prepare a report book and introduce it to the quality assurance management staff. The report book illustrates the responsibilities to be fulfilled in management and supervision of the quality assurance program and examine the implementation of the quality assurance guarantee program by the staff of the international joint venture enterprise.

14.3 BASIC FILES

The basic working files influencing quality implementation and examination will be developed and kept updated in an orderly manner. The copies of these files should also be supplied to the construction site to be available for the Owner’s representative to take examination.

14.4 PROJECT GUIDANCE AND MANUFACTURE DRAWINGS

Design shall be based as close as possible on the approved design. Some modifications can also be made in order to make major improvements in the manufacture and building technologies and to meet the special needs of the Owner.

Any improvements on the former design shall be checked and examined individually. Those results that have been discussed carefully shall be reflected in project directions and order files of Owner. The plan about the output and input of design, independent design check and evaluation and design changes shall be controlled and quality acceptance standards shall be established.

Quality assurance plan/ overhaul and test plan

The quality assurance plan to ensure necessary quality shall be included in the quality assurance system of the Contractor. This document shall outline overhaul and test principles and record the procedures and steps of the inspection and the requirements for authorizing the inspection as stipulated in the Contract.

The supply of the main elements of equipment to the Owner shall be included in the quality assurance plan and be submitted to the Owner for reexamination.

The Owner can challenge the inspection point and the required quality assurance records illustrated in the combined plan of inspection and test procedures that have been agreed upon. These and other inspection and test procedures used in the manufacturing period shall be illustrated in detail in a separate document for adjusting and formulating the plan.

The Contractor shall give Owner adequate notice 30 working days prior to each test. The confirmation of the inspection and test data shall be delivered to the Owner in less than 30 days.

Instruction manuals on operation procedures shall be supplied to the Owner.

The content of the instruction manuals ensures that special operation procedures are carried out in a controlled way. All the documents in relationship to the quality assurance plan shall be supplied to working site for the convenience of reexamination.

The detailed Quality Assurance plan for the project is enclosed as Annexure 1.7.

14.5 WORKING GUIDANCE

Working guidance shall control quality and production activities mainly and should be supplied to the working site for reexamination.

14.6 NONCONFORMITY POINT

Nonconformity terms shall be reexamined to make it acceptable or modified or renewed with the final goal of attaining the approved standards. The documents for correct operation shall be provided to manufacturing or construction site for inspection.

14.7 QUALITY GUARANTEE RECORD

Contractor shall keep the records for quality guarantee.

These records should prove that the system and equipment has satisfied the requirements of the contract; all staff, operation programs and equipment are qualified in special operation procedure, and that the supervision to the Subcontractor is in accordance with the contract requirements.

The specified quality assurance record that is as approved in the combination plan of inspection and test shall be provided to the Owner.

14.8 SUPERVISION

Contractor shall supervise Subcontractor's implementation of combining quality and production.

14.9 MATERIAL PURCHASE

Material shall be purchased according to project specification and stated standards. The related control data, such as, chemical analysis, mechanical performance, non-destructive tests shall be illustrated in these standards in detail.

Supervision activities shall be performed in Subcontractor's office in connection with the Contractor's orders and quality plan and standards.

Before the delivery of all goods, the goods shall conform to the random examination and parameter rightness examination and pass the check and acceptance of the records of documents of the Subcontractor to ensure that goods are up to standards.

14.10 STANDARD EQUIPMENT AND PARTS

Standard equipment and parts shall be manufactured by a company that has passed quality assurance inspection.

All parts must be manufactured by the standard criteria and quality assurance standards.

14.11 PRODUCTION CONTROL

Working guidance shall illustrate in detail about the program procedure, control files and the field procedures.

Inspections and acceptance tests shall be performed and recorded.

The corresponding type of quality management (IS0 9001, 9002 9003 or equivalent standards) shall be illustrated in Contractor's order in such detail that it corresponds to the type and scope of the equipment supply. The standard industrial products that are purchased with no reference to list or manufacturer's directions need not be illustrated.

In the procedure of planning inspection, adjustment, evaluating adjustment and the corresponding quality examination and confirmation, the production control of the Subcontractor should be supervised.

15.0 EQUIPMENT ERECTION, SITE TESTING, COMMISSIONING

This clause generally covers the standards, scope of works, documentation, scope of installation, testing and commissioning of various requirements to be adhered to during the execution of the mechanical, Civil , electrical works and Instrumentation & Control works.

Works shall be performed in accordance with this technical specification and various other drawings and schedules submitted and approved by the Owner during the execution and the instructions from Engineer-in-charge or his authorized representatives during the progress of the work. All consumables required for the job shall be ensured by the contractor .All necessary equipment & instruments required to carry out the works, recalibration of the instruments required during loop checking and commissioning shall be done by the contractor.

Field quality plans shall be submitted and shall detail out for all the equipment, the quality practices and procedure etc. to be followed by the Contractor's site quality control organization during various stages of site activities including receipt of materials/equipment at site, preservation and storage, pre-assembly, erection, pre-commissioning and commissioning. The Contractor shall provide all necessary means for execution of inspection and testing, according to the requirements.

16.0 SPECIAL TOOLS AND TACKLES

The Bidder shall supply a complete set of unused special tools and tackles, including tool box, as required for erection, maintenance, overhaul or complete replacement of the equipment and components under this Specification. The cost of this shall be included in the base price.

17.0 LANGUAGE TO BE USED

English shall be used as the general Contract language English translations shall be provided for any code and standards not in English language.

Name plates of equipment and instrument scale, etc. shall be marked in English as required for start-up, testing and training etc.

Documents for training shall be provided in English.

18.0 DOCUMENTATION

a. Drawings, Data / Documents to be submitted along with BID

The bid document shall have complete information for the FGD plant offered clearly identifying and describing the plant design, implementation and operation concept.

All documentation, diagrams and drawings necessary for presentation of the desired results and for comprehension and clarification of the related technical and commercial matters shall be included in the technical offer and shall contain the following documents as a minimum requirement

1 Time schedule for engineering, manufacturing erections/installations, commissioning and Reliability Test Run
2 Construction approach, phases of construction, commissioning and operation
3 General arrangement of the various sections showing disposition of FGD unit, Limestone and gypsum storage silos, Sizing calculations, etc
4 Description of main features of the design concept
5 Description of major equipment, systems, civil works, including site development, Scrubber tank, Ball mill, Ducting, All pumps, blowers, Booster fan, Rotary drum filters, Hydro cyclones, Service water piping, Slurry piping, Effluent piping, agitators, tanks, Silos, Compressors, Air receivers, Service air Piping, Instrument air piping, etc
6 General information and technical documentation of process and auxiliary systems
7 Information on conditions of operation
8 Descriptive Data sheets, performance curves, catalogues for all pumps, fans, blowers, Compressors, AC and ventilation system Heat load calculations, Ducting layout, data sheets.
9 Documents on the quality assurance system of the bidder
10 Training program and schedule for the Corporation's personnel
11 Details of operation, maintenance and training
12 Standards, codes and regulations: listing of major standards, codes and regulations (local, international, supplier's own country) which will be applied for the design and construction of plant equipment and facilities, for civil works and for testing of equipment
13 Completely Filled in Technical Data sheets as per schedule(Part-II Section-7).
14 Sub –vendor list
15 Spare lists
16 Control System Configuration
17 Bill of Quantity for I&C items
18 Basic operational and control philosophy of the system offered
19 Drive control philosophy

b. Drawings, Data / Documents to be furnished by the successful Bidder

The Bidder shall submit the following data / information / documents/ drawings to the OWNER/CONSULTANT, who in turn shall review and furnish comments on only important drawings/ documents. Bidder shall furnish a list of data / drawings / documents which shall be submitted to the Owner/Consultant with due dates of submission

immediately after award of Contract. The Bidder on fortnightly basis shall update the list. All drawings shall be generated in AUTO CAD.

- Detailed design and drawings for FGD unit, lime and Gypsum storage silos, Electrical and Control room etc.
- Final version of all documents drawings submitted along with the offer.
- Detailed design documents for scrubbers, pipe & detailed Cross Section drawings including support arrangement details & anchoring arrangements details etc.
- Bidder to submit and obtain Owner's Engineer's approval of all drawings / documents design, detail engineering and construction before proceeding with construction and execution. A list of such drawings will be finalised at the time of Award and which will get updated as the detail engineering progresses. The below mentioned list is Preliminary which shall be finalized after award of contract.

Document	Category A – Approval I – Information
General	
• Complete list of documents with proposed submission deadlines	I
• Progress reports	I
• Erection and installation progress reports	I
• Quality assurance procedure and program	I
• List of subcontractors/ manufacturers	A
• Proposed inspection and testing programs	A
• Detailed program for commissioning	A
• Detailed program of Reliability Test Run	A
• Testing documents/Report of results of all tests	A
• As-built-documentation including drawings of all equipment	I
• Spare part lists	I
• Performance guarantee / test procedure	A
• Quality Assurance Plans	A
• Process presentation of FGD plant	I
Mechanical Engineering	
• Layout of FGD and Auxiliaries	A
• GA and Cross sectional drawing of Absrober/ Scrubber, Storage Silos	A
• GA Drawings and Data sheets for All Pumps, Booster fans, Ball mills, GGH, Hydro Cyclones, Rotary drum filter, blowers, Compressors, Crushers, Conveyors, Dampers, valves, etc	A
• Sizing calculations for Absorber, GGH, Limestone requirement, and Gypsum generation.	A
• Slurry balance diagram	A
• P&ID for FGD system and auxiliaries	A

Document	Category A – Approval I – Information
• PFD/P&ID for Lime Stone unloading, crushing & storage system	A
• PFD/P&ID for gypsum handling and storage system, waste water system.	A
• Data sheet for Drain/ Submersible pumps	I
• Data sheet for Electrical hoist/ Cranes, Bucket Elevators, Conveyors, etc	I
• Sectional and detail drawings of all components	I
• Heat load calculations, ducting layout, Data sheet for HVAC	A
• GA drawing for bucket elevators, hopper, conveyor, feeder, crane, hoist, etc	I
• GA drawing for compressor building layout, compressor, air receiver, air dryer etc	A
• Data sheets for Dampers, Valves, Expansion joints	A
• Valve & piping Schedule/ Damper Schedule	I
• Data sheet for Bucket Elevators, Conveyors, feeder, hoist, Cranes, etc	I
• Data sheet for compressor, dryer, filters etc	I
• Drive selection calculation for bucket elevators, conveyor, feeder, hoist, crane, etc	I
• Drive selection calculation for compressor and dryer.	I
• Sizing calculation for hopper & silo	A
• Sizing calculation for pumps, tanks	I
• Piping Layout of Hydrant/ Spray system	I
• P&ID indicating Instruments and the interlocks for Hydrant and Spray (MVWS) system	A
• Hydraulic calculation for Hydrant system, automatic High and Medium velocity spray system.	I
• Layout for Fire Detection and Alarm system	A
• Interface wiring diagram from DV LCP to existing fire alarm panel	A
• Schematic Drawing for fire detection and Alarm system	I
• Data sheet and GA drawings for Hydrants, Detectors, Fire alarm Panel, cabling, Extinguishers etc.	I
• Layout for Make-up water/ Service Water/ Potable/ Auxiliary Steam piping with Cross section and details.	A
• P&ID, data sheet Ducting layout, Wiring drawing of HVAC system	I
• Layout for Effluent Water piping with Cross section and details.	I
• Characteristic correction curves for Booster fans	I
• Gas flow rate Vs SO_2 removal Efficiency	I
• Inlet SO_2 concentration Vs SO_2 removal Efficiency	I

Document	Category A – Approval I – Information
• Inlet Dust concentration Vs dust removal Efficiency	I
• Inlet gas temperature Vs Stack Temperature	I
• Gas flow rate Vs Pressure Drop	I
• Gas flow rate Vs Water Consumption	I
• Characteristic curves for all Pumps, Blowers, Cyclones etc	I
• CFD modeling procedure and reports	A
Electrical engineering	
• Main single line diagram	A
• Design basis report for electrical system	A
• Sizing Calculation for equipment like Transformers, Switchgear, NSPBD, Cables, UPS System, Battery , Earthing, lightning protection, Illumination, etc.	A
• Technical data sheet for all the electrical equipment	A
• General arrangement drawing for all the electrical equipment	A
• Schematic diagram / wiring for all the electrical equipment	I
• Characteristic curves for all the motors	I
• Electrical switchgear room layout, Battery room layout etc.	A
• Cable tray layout for all the area	I
• Earthing layout for all the area	I
• Lightning protection layout for all the area	I
• Lighting layout for all the area	I
• Cable schedule	I
• Interconnection diagram	I
• Catalogues	I
• Relay setting calculation for complete system	A
• List of make or vendors	A
• Spares list	I
• List of Special tools	I
• Quality plan	A
• Test reports	A
Control & Instrumentation Engineering	
• Master Drawing List – Instrumentation	A
• System Description and Configuration for FGD plant, VMAS, Fire Fighting system for FGD plant, HVAC for FGD plant (P&ID wise)	A
• Operation and Control philosophy – Description of closed loop and open loop control schemes along with control schemes/logics	A
• Vendor Data sheets for all the I&C items– Field instruments / analyzers / Detectors / local control panels / Flow elements / Control valves / Final control elements / Cables etc	A
• Vendor Data sheets for all the I&C items of VMAS , Fire detection and protection system, HVAC system	A

Document	Category A – Approval I – Information
• Control Room layout	A
• GA & IA drawings – Pump instrumentation, Local control panels, Junction Box, LIE / LIR	A
• Instrument Hook-up diagrams	A
• Drive Control philosophy	A
• Drive List	A
• Cable tray layouts	A
• Instrument Schedule	A
• Cable Schedule	I
• Cable Interconnection	I
• IO list (hardwire + Soft Link)	I
• Control valve / Flow element sizing calculations	A
• I&C power distribution and earthing scheme	A
• Quality Assurance Procedure (MQP) / Test certificates	A
• Performance guarantee / test procedure	A
• Bill of Quantity for instrumentation items	I
• Spare list (mandatory, recommended, commissioning, consumables)	I
PLC vendor drawings	
• PLC Hardware and Software design specification	A
• System Architecture	A
• Bill of Quantity for PLC	A
• Data sheets for PLC items	A
• GA & IA of cabinets, consoles	A
• FAT & SAT procedure	A
• IO assignment and Panel layout details	A
• Power Distribution and Earthing scheme	A
• Power Consumption Calculations	A
• UPS sizing calculations	A
• HMI displays and Graphics	A
• Closed loop control schemes – SAMA drawings	A
• Open loop control schemes – ISA format	A
• List of software and licenses	A
Other Instrumentation drawings / documents	
• O&M manuals	I
• As-built drawings	I

Document	Category A – Approval I – Information
Civil Drawings	
• Detailed civil arrangement drawings of all buildings and RCC/steel structures, with Design Basis Report and foundation system	A
Detailed drawings and documents	
• Foundation for Absorber Tower. • Lime Silos • Gypsum Silos • Building for Lime slurry preparation (Enclosing Ball mill, mill separator tank, Lime Slurry tank etc) • Building for Gypsum Recovery system, compressors, • Pipe trestle for supporting flue gas duct, and other piping • Foundation for Pumps, Booster fans, Blowers, tanks and other miscellaneous equipments etc. • Drains and trenches, collection pit • Electrical Switch gear room, Battery room, cable trenches etc. • PLC Control room • AHU room • Access Roads with storm water drains to various building/ structures from Plant road	A
Other documentation	
• Quality assurance manuals	I
• Manual of Codes and Standards	I
Operating manual • Operating procedures and instructions of the Plant with description of all systems, processes and functional groups • As built documentation • General and individual control concept description	I
Service and maintenance manual • Maintenance procedures and instructions with description of all equipment and facilities	I

Purpose: A: for Approval
I: for Information

c. General Documents to be furnished by the successful Bidder

a) Contract network schedule

b) Flow diagram for all systems indicating equipment, piping valves, specialties and instrumentation including performance test scheme, technical write-ups

c) Details of painting specification.

d) Final technical data sheets for all equipment

e) Installation drawings and manuals for all equipment/systems

f) Integrated operation and maintenance manuals for the complete plant as well as for all individual equipment.

g) Test certificates for type/routine and standard acceptance tests

h) Detailed interface schedule for all terminal points identifying terminal point no., size, material, type of connection, design flow, pressure and temperature at the terminal points

i) Detailed schedule of LOA to commissioning shall be furnished in the Bar chart.

j) Lubricants list (with quantities for initial fill and make-up).

k) Erection procedure.

l) As-built drawings for all equipment/systems supplied under this contract and all structures / works executed under this contract incorporating all changes/ modifications upto the time of commissioning / handling over to the Owner/ consultant.

m) Detailed write-up on all pre-commissioning and commissioning activities.

n) Storage instructions for all equipment

o) Drawings/data to be required /submitted to statutory authorities

All documents, data sheets, drawing, schedules, lists, etc., to be submitted by the Bidder against this Contract shall be submitted in soft copies on CD/DVDs in addition to the required number of prints/reproducible. Required number of copies for all revisions shall be arranged by BIDDER, the number of copies and the methodology shall be covered elsewhere in the specification.

d. Engineering Information Submission Schedule

Prior to the award of Contract, a Detailed Engineering Information Submission Schedule shall be tied up with the Bidder. For this, the bidder shall furnish a detailed list of engineering information along with the proposed submission schedule. The list would be a comprehensive one including all engineering data / drawings / information for all bought out items and manufactured items. The information shall be categorized into the following parts.

i) Information that shall be submitted for the approval to the Consultant. /Owner before proceeding further and

ii) Information that would be submitted for Consultant. /Owner's information only.

The Engineering Information Schedule shall be prepared month wise.

The schedule should allow adequate time for proper review and incorporation of changes / modifications, if any, to meet the contract without affecting the equipment delivery schedule. The early submission of drawings and data is as important as the manufacture and delivery of equipment and hardware and this shall be duly considered while determining the overall performance and progress.

18.1 TIME SCHEDULING, BASED ON CPM

- Overall time schedule for design, manufacture, supply, assembly and commissioning broken down for the principal plant components and all construction works, stating dates for completion of any preparatory work from others which may be necessary.
- Detailed erection, installation and commissioning schedule.
- The Project is scheduled to be commissioned in 20 months from the date of award of EPC contract.

The Contractor shall ensure that the final draft of all schedules, lists or data sheets / equipment are produced to a uniform format irrespective of whether the source of the above schedules, lists and data sheets is in the main Contractor or a Sub-contractor of the main Contractor. All documents shall carry a uniform numbering system.

All Contractor's drawings which are found to be incorrect during the construction period or which require changes owing to site constraints, shall be corrected by the Contractor to an "as built" condition to reflect any necessary changes.

The stipulations and requirements specified elsewhere in the specification shall also be followed with respect to preparation and submission of drawings.

Apart from those documents named in the various sections of the Specification, the Contractor has to submit as minimum requirement the drawings summarized in the above clause to the Owner or his representatives within the periods specified in months, starting from the "Commencement Date" according to the Definitions of the Contract. The delivery time as far as not specified, shall be proposed by the Bidder in his Tender in accordance with his overall implementation schedule and will be defined finally during Contract negotiations.

18.2 LIAISON MEETINGS

The liaison meetings shall be organised by the contractor (once a month during design period and once in 15 days during construction period) in accordance with stipulations specified elsewhere in the specification.

Contractor shall supply all documents required in the appropriated number as requested by the Owner.

18.3 DISTRIBUTION OF DOCUMENTS

The source, distribution, no. of copies etc shall be as per the following document distribution schedule.

Document Distribution Schedule - After Placement of Order

Sl.No.	Document	Total Copies	Distribution		
			Owner		Consultant
			HQ	SITE	
1.	PERT Network, work schedules, Bar charts, Layout drawings	12	4	4	4
2.	Data, drawings, documents, write-ups, calculation				
	- Preliminary	12	4	4	4
	- Revised	12	4	4	4
3.	Approved drawings, documents etc.	12	4	4	4
4.	Instruction manuals for erection and O&M	12	4	6	2
5.	As built drawings including O &M manual				
	- Hard Copy	12	5	5	2
	- Soft Copy	4	3	-	1

18.4 MANUALS

18.4.1 General

The Contractor shall provide the manuals in a timely manner to enable the Owner / Engineer to review and comments and request changes as necessary.

Payments will be withheld for non-compliance or for late delivery of the drawings, procedures and manuals. In particular the Contractor shall be held responsible for consequential damage to the plant where such damage is due to late delivery of the O&M manual resulting in non-familiarity of the operating technique.

The Contractor shall also note that while all documents, procedures and manuals shall be in the English language including that of the sub vender of the contractor, it is particularly important that the O&M manuals be in clear concise English.

All manuals shall be divided by systems or sections and cross-indexed as necessary.

18.4.2 Certification Manual

This manual shall contain the approved works certification documentation for FGD plant equipment and services as specified in the relevant codes and standards and in this specification and the Contractors Quality Manual. This manual shall also include all material tests certificates. Certificates and test procedures shall be specific to the plant supplied.

18.4.3 Design Manual

This manual shall contain all the design calculations and all equipment and system data sheets and design criteria required under the Contract.

18.4.4 Construction Manual

This shall include a comprehensive record of as built site construction tests and records. Again the manual(s) shall be compiled in separate parts to reflect the plant and services supplied.

18.4.5 Commissioning Manual

This manual shall include all the records, certificates and test results arising from the agreed pre-commissioning and commissioning procedures carried out on site. The performance tests and guarantee test results shall also be included. There is a particular requirement that all commissioned equipment values be recorded in this manual and subsequently incorporated into the O&M manuals.

18.4.6 Operating and Maintenance (O&M) Manuals

The Contractor shall provide the O&M Manual properly bound, within the time specified, to enable the Owner's staff to become fully acquainted with the operation, adjustment and maintenance of the FGD plant. The manuals shall contain full and explicit instructions in respect of the operation of the FGD plant under all operating conditions and the maintenance routines and requirements to be established to maintain the FGD plant in optimum performance. These instructions shall be in the English language and be as comprehensive as possible and the form in which they are to be set out shall be agreed with the Owner / Engineer. The instructions may be divided as appropriate into in individual sections and sub-sections as necessary. All section and sub-sections shall be clearly indexed and cross-referenced as required for clarity.

The instructions shall be tailored to suit the specific requirements of the Operations and Maintenance functions and personnel, taking into account the staffing philosophy for the thermal power plants.

The instructions for the related parts shall be accurate and easy to understand and shall contain the necessary sequence of individual activities. The diagram and drawings associated with the instruction shall be clear and unambiguous.

It is an essential requirement that all information and plant data contained in the manual must be project specific and derived from the design, manufacturers / suppliers and commissioning data of the as-built FGD plant. Where the Contractor includes standard brochures the installed item of equipment shall be clearly identified. All sections shall contain an introductory description of the particular item/system including its function and operating criteria and any special features. On the basis of the commissioning and running experience of the FGD Plant, the instructions shall be amended to a final form within three months of the end of commissioning and, for this purpose, the Contractor shall supply the required number of printed copies of all approved amendments for insertion in the bound set of instructions.

The entire O&M manuals including that of the sub venders shall all adopt the same format paper size etc. The Bidder shall prepare manuals integrating all equipments supplied by the sub venders.

19.0 GENERAL REQUIREMENTS

19.1 GENERAL

19.1.1 General design requirements

The equipment of the entire supply, the main parts as well as auxiliary parts and accessories, must be designed in such a way as to ensure its proper operation, easy control, regulation, erection and maintenance under every working condition.

In the design, particular importance shall be assigned to simplicity, accessibility and solidity of the machinery and its parts. It is of particular interest to achieve simple assembly, easy access for maintenance and repair and simple and safe operation.

The equipment must operate without vibrations that may affect its operation, that of other machinery or of civil works under every condition.

The works shall be designed to facilitate inspection, cleaning, maintenance and repair. Continuity of supply is of prime concern. The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the operation and maintenance of the works. The plant shall be designed to operate satisfactorily under all variations of load, pressure, and temperature, as may be met in normal usage under the variation in climatic conditions.

Corresponding parts throughout shall be made to gauge and be interchangeable wherever possible. In case required, the supplier shall provide the necessary references for all kinds of equipment.

All equipment performing similar duties shall be of the same type and manufacture in order to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed.

In selecting materials and in manufacturing, it is necessary to take into consideration the anticipated operating conditions of components and the environmental state of the plant site. The selection of materials shall also ensure the effective service life of each of the components used in the FGD plant.

The selection of materials shall conform to the requirement of International Standards Organization. Where there is no sufficient information issued by ISO, it is permissible that the material supplying standards of the manufacturing factory of Contractor are adopted. For all the materials and equipment required by the plant, only new ones or those which have not been used before shall be supplied. This requirement means that the raw material of the equipment and that part of new materials may not be derived from recycled material.

19.1.2 Standards and Codes of Practice

The work must be performed according to the most recent relevant codes, and standards, accident prevention regulations and legal regulations.

All material and equipment supplied and all work carried out as well as calculation sheets, drawings, quality and class of equipment, methods of inspection, constructional peculiarities of equipment and parts and acceptances of partial plants, as far as these are beyond the special requirements of the specifications, shall comply in every respect with the technical codes of the International Organization for Standardization (ISO). IEC/IS recommendations apply to the electrical equipment.

Equipment and special guarantees not covered in the scope of ISO and IEC/IS, shall conform to internationally approved standards.

The Contractor is not only responsible for each piece of equipment being correct but also the completed plant must meet design operating condition and performance requirements.

Where there are no standards or regulations, or the standard is not sufficient to meet the need of design and supply, for such items relating to the power plant, the Contractor shall carry out the design, manufacture, supply and installation on the basis of good engineering practice with Owner's approval.

During the period of Contract execution, if any standards change, the Contractor shall be responsible to notify the Owner and provide the basis for the prospect that it would not cause the lowering of quality, performance and service life of the power plant due to alteration of the standard. Upon mutual agreement, the amended standard can then be followed.

Further requirements about applicable standards and codes are specified in the detailed technical specifications.

19.1.3 Vibration

Vibration shall be reduced to the minimum as far as possible where there is vibration. Amplitude and frequency limitation in the design and supporting structure shall be considered.

Special care shall be taken to avoid operating equipment making resonance with foundations, packing, duct, platform, piping or other components.

Unless otherwise stated or agreed by the Owner each rotating machine has to comply with the requirements for designation as 'good' stipulated by VDI (Verein Deutscher Ingenieure) Specification 2056 for the respective group of machinery. If the vibration is higher than stipulated as 'satisfactory' the Owner has the right to reject the corresponding equipment, subject to the conditions specified elsewhere.

19.1.4 Noise levels

The plant shall be designed and constructed to reduce the operating noise level as much as possible and when the plant is operating at all loads, the noise pressure levels specified “Environmental Requirements”-must not be exceeded.

19.1.5 Units of Measurement

For all the technical tables and diagrams, calculation results, drawings, test data and scales adopted in the design and provided for the FGD plant, the standard international unit system (SI) as per International Standardization Organization (ISO) shall be uniformly employed.

SI system shall be employed for all the first-class plant layout and arrangement drawings of equipment made especially for the project. In spite of the employment of British Standard in the layout or drawings and single item standard drawings made with other measuring units, the principal dimensions and demarcation points on these drawings shall also be converted into SI system to be directly marked onto them.

In all correspondence, technical schedules, drawings and instrument scales, the following units shall be used:

Quantity	Name of Unit	Symbol
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
	Minute	min
	Hour	h
Temperature	Degree Celsius	℃
	Kelvin	K
Electric Current	Ampere	A
Luminous Intensity	Candela	cd
Area	Square metre	m^2
Volume	Cubic metre	m^3
	Litre	l
Force	Newton	N
Pressure (gauge or absolute)	Bar	bar
	Kilopascal	kPa
	Millimeter of water column	mmwc
	Kilo gram per square centimeter	Kg/Cm^2
Stress	Newton per square millimetre	N/mm^2
Velocity	Metre per second	m/s
Rotational speed	Revolutions per minute	rpm
Flow	Cubic metre per hr	m^3 /h
	Tons per hour	t /h
	Kilogram per second	kg /s
	Litre per second	l/s

Quantity	Name of Unit	Symbol
Density	Kilogram per cubic metre	kg /m³
Torque, moment of force	Newton metre	Nm
Moment of inertia (mr²)	Kilogram square metre	Kgm²
Work, energy or heat	Joule	J
Heat capacity, Entropy	Joule per kelvin	J/K
Calorific value	kilo calorie per kilo gram	kcal/kg
Power, radiatn flux	Watt	W
Heat release rate	Watt per square metre	W/m²
Thermal conductivity	Watt per metre kelvin	W/mK
Dynamic viscosity	Newton second per square metre	Ns/m²
Kinematic viscosity	Metre squared per second	m² / s
Surface tension	Newton per metre	N/m
Concentration	Parts per million	ppm
Electrical conductivity	Microsiemens per metre at 25℃	µ s/m
Frequency	Hertz	Hz
Electric charge	Coulomb	C
Electric potential	Volt	V
Electric field strength	Volt per metre	V/m
Electric capacitance	Farad	F
Electric resistance	Ohm	
Conductance	Siemens	S
Magnetic flux	Weber	Wb
Magnetic flux density	Tesla	T
Magnetic field strength	Ampere per metre	A/m
Inductance	Henry	H
Luminous flux	Lumen	lm
Illuminance	Lux	lx
Thermal resistivity	Kelvin metre per watt	Km / W

19.1.6 Safety

Special importance shall be assigned to all aspects related with the safety of personnel operating, assembling and maintaining the equipment, including other persons who may come in contact with same.

The possibilities of human failure must be foreseen. Provisions shall be taken to avoid damage caused by human error or to ensure that such damage both to persons as well as to the equipment is the least possible.

Rotating or any other moving part of the machinery, hot parts or any part that may cause accident to the staff, must be adequately protected, in accordance with the safest method known.

All components with surface temperatures exceeding 60°C shall be fitted with insulation to protect personnel. The surface temperature shall not exceed 60°C in the condition of the ambient temperature is 40°C.

When it is required to limit the medium temperature drop due to the medium conveying in order to meet the requirements of anti-block, anti-dew and other process, it must be insulated from the point of view to control the medium temperature.

Bright paints will be used to be agreed upon with the Owner to protect personnel, so that anything representing a potential danger will stand out: such as elements in movement, suspended hot, with electric tension, etc.

Likewise, appropriate colors shall be selected for the equipment for the purpose of diminishing weariness of workers.

It should be possible to carry out frequent maintenance operations required by the equipment without interrupting its operation and without danger to the personnel.

The equipment shall be provided with the necessary elements to keep possible failure of the main, auxiliary or control elements from causing serious consequences. For this purpose, protections shall be installed such as: stops in case of failure of shafts auxiliary suspensions that will keep parts from falling or coming loose because of centrifugal forces or others; stops to limit movement in case of failure of normal limiting devices, etc. Protections that will decrease or deviate liquid or gas escapes shall also be provided for the same purpose.

Brakes, gears, clutch and similar devices will be located preferable in the last stage of the transmission, so that they will remain operational even in case of failure in other stages.

Access stairs to the equipment must be safe, with anti-skid rungs and handrail. Normal circulation areas of the equipment shall be protected to keep personnel from falling or shall be surrounded by strong guardrails, platforms should have kicking plates to keep loose objects placed on the floor from dropping off, entrances and large openings in the equipment shall be provided with lids or doors affixed in such a way as to open them also from the inside.

The equipment should be adequately protected against environmental elements, such as humidity, dust etc., and the influences that other equipment may have, such as heat radiation, induced vibrations, etc. The supply shall include protective cabinets for parts exposed to the open air or sensitive parts requiring such protection.

Lubricated parts and parts containing lubricants should be protected against oil leakages, as well as against contamination with extraneous material, with oil seals, packings and similar devices.

Every equipment or parts of equipment that must operate under certain conditions of maximum pressure, temperature, speed, position etc., should have devices to keep such

limits from being exceeded and, if necessary, to stop the operation of the machine (Safety valves, limit switches, thermal switches, etc.,)

The operational certainty of these devices should be in relation with the importance and operational need to maintain the established limits. Resetting of these devices, either automatic or manual shall be agreed upon with the buyer in each case. These elements shall be installed in such a way as to make it easy to detect the device that caused the machinery to stop.

For protection against the possible failure of the above devices, additional safety elements shall be provided such as stroke limiting stops, diaphragms, bolts, etc. and/or links or other dimensioned rupture elements so that in case of failure, when exceeding extreme operating conditions, additional safety is provided to the equipment.

Ladders have to be installed for inspection of dampers, venturies, etc.

In designing an area where combustible gases are likely to accumulate, due consideration shall be given to providing safety measures to allow the gas to continuously diffuse or leak off to prevent explosion. The electric equipment in those areas shall be of the fireproof and explosion proof type. Suitable grounding shall be provided on the casing of electrical apparatus which might be energized.

The design of FGD plant shall include a complete set of composite fire monitoring, protection, and fighting system to identify, isolate, and distinguish fires as well as minimizing potential fire hazards.

A warning alarm for the FGD plant and alarm for evacuation shall be provided. The alarm is to be audible in the normal working areas of personnel. The selection of the alarming device shall be such that it is audible about the normal background noise of the plant. Visual alarm shall be provided in addition to audio alarms in high noise areas.

Draining of water and venting of gas shall be performed with respect to the safe mode of discharge, and is not allowed to be carried out at or near the places where people exit and at the exit of the plant.

19.1.7 Fire Protection and Precautions

The Contractor shall adopt necessary methods to minimize fire hazards.

The fire protection system shall in general follow the recommendation of Tariff Advisory Committee of India and the system and equipment shall met with their approval.

The basic guiding ideology is to adopt two methods: fire prevention and fire control. The following design philosophy will apply:

- Ensure the safety of personnel;
- Ensure the safety of the important and main equipment of the FGD plant;
- Prevent fire from spreading;
- Limit the damage to equipment.

Fire precaution shall comply with the following principle:

To improve conditions in designing and layout and to reduce potential fire danger, and the spreading of fire by adopting the method of observation.

The following methods shall be adopted to prevent fire from occurring:

- Using as far as possible fire proof or fire resistant materials

- Ensuring that, isolating combustible material is not used or stored in possible fire source area of the FGD plant.
- Reducing the area where cleaning and examination are difficult in FGD plant arrangement.

The following methods shall be taken into account to control the spread of fire:

- Use of fire proof material
- use of fire detection sensors and/or fire proof construction materials;
- providing a set of effective fire extinguishing system;
- providing a set of effective fire detecting equipment;
- providing the fire detection device in civil construction;

The fire detection system should detect a fire quickly and reliably at the beginning of the fire and activate a special alarm device operation.

The designing of detection system shall prevent against erroneous operation.

The supplied fire detection system will be a combination system involving an automated and manual hydrant, water hose, take up reel and special fire extinguisher.

The end connection type of hydrant shall fit in with local fire brigade requirements to ensure the manual device in FGD plant to be compatible with the fire control device of local fire brigade.

During the construction phase of FGD plant, the Contractor adopts advanced and safe working practices and a set of guidelines to keep the site in a clean condition to reduce the possibility of fire.

19.1.8 Markings, Labels

All elements should be properly marked at the workshop, in order to make assembly and maintenance work as easy as possible. Whenever necessary, markings should be indicated in the corresponding drawings and/or special drawings for markings. Marks should be unmistakable and as far as possible follow a logical system that will make it easy to find the marked element. Marks should be indelible and clearly visible. Marks made only with paint will not be accepted. Parts that are the same but are not interchangeable shall be marked so as to differentiate them. Wherever necessary the position of a part within the whole shall be marked.

19.1.9 Signs

General

Safety colors, safety symbols and safety signs must comply in construction, geometrical form, color and meaning with the ISO Recommendation 507 of the ISO committee TC 8O 'Safety Colors'. All signs should give the identification number. All signs shall be in the English language.

The signs should be of a material which is weather-resistant and of sufficient durability of 25 years for the conditions prevailing on site. Indian Regulations and codes are to be considered.

The positions for the signs must be chosen so that they are within the field of vision of the persons to whom they apply. The signs should be permanently attached. Temporarily dangerous areas (e.g. construction sites, assembly areas) may also be marked by movable signs. The safety signs must be mounted or installed in such a manner that there is no possibility of misunderstanding.

Information signs

Information signs should supply the necessary information to acquaint personnel with the physical arrangement and structure of site, buildings and equipment, e.g. floor numbers, load-carrying capacities including marking of floor areas, working loads of cranes, lifting gear and lifts, room identification etc.

In the choice of information signs in situations not covered by ISO Recommendation 5O7 the possibility of using pictograms should be considered. Pictograms are particularly suitable for the identification of rooms, areas and buildings in the non-technical areas of the plant, sanitary and amenities buildings, etc.,

Emergency signs

In the event of accidents, all necessary information should be available immediately to those affected. Thus, a sufficient number of signs of appropriate size should be installed, e.g. escape routes (including marking of floor areas), emergency exits, fire alarms, fire extinguishers, instructions for special fire-extinguishing agents, warnings against fire-extinguishing agents (CO_2), first aid equipment, first aid points, accident reporting points, telephones etc.,

Mandatory signs

Signs indicating obligatory actions must be provided and installed wherever certain action is necessary e.g. do not obstruct the entrance; keep right etc.

Signs should also indicate when the wearing of protective clothing and equipment is necessary and obligatory, e.g., protective goggles, protective clothing, helmets, head guards, breathing equipment, ear muffs etc.

Warning signs

Warning signs should refer to the existence or possible existence of danger, e.g. flammable substances, explosive substances, corrosive or noxious substances, suspended loads, general danger, width/height restriction, steps, risk of trapping, slipping, falling, etc. In addition to warning signs, appropriate black-yellow strip markings should also be used where necessary.

Local indicators

Easily visible indicators have to be arranged for: All dampers, valves, level indicators and flow indicators, dampers, mill classifier, etc.

19.1.10 Package, Storage and Store House

The Contractor should provide all the specifications and instructions for the self purchased and fabricated equipment during the planning period of the Contract. These specifications should include the cleanliness and maintenance requirements of materials during fabrication and the protection measures for the equipment from damage during transportation. Loss of materials during storage should be avoided before installation. The instruction should be worked out especially to suit the particular work site program.

Packing

All equipment and instruments should be fully packed and protected from damage during transportation and field storage. The equipment instruments should be provided with through protecting measures before packing. All machine surfaces should be protected with planks or similar materials and reinforced with metal strips or plates from the outside.

Under actual conditions, all equipment such as motor, switch, Control device, instrument and component should be sealed at the joint with polyethylene insulation board and a corresponding drying agent should be provided.

For all piping ends as well as pipes and tanks, the openings should be protected from damage and sealed to avoid the invasion of ash, moisture and air. These protection measures should be kept intact before the start of installation or moving for periodic inspection. The cost spent for the moving, modification and replacement of the packing and protection device should be paid by the Contractor.

A waterproof enclosed packing list should be provided in each planks or packing case.

The name of articles in the packing case should be marked clearly on the packing list so as to be identified easily.

The articles in the case should be supported by wooden bars in order to be fixed safely and it should not be wedged individually with wooden pad. The marks outside the case should be printed with climate proof materials or paints so as to be protected from being removed during transportation.

All materials and equipment should be packaged according to the typical environmental conditions during storage. In case of severe conditions, these materials and equipment should be packaged carefully by taking a full and appropriate preventive measure to protect from any damage or wear.

The marks should be painted or printed clearly and durably with characters of 40 mm height at minimum on both ends of the packing case. The labels should be well protected to prevent loss.

A mark indicating the correct lifting position should be shown in arrow on the packing case.

Field Storage and Cleaning.

The arrangement requirements of storehouse should be developed during the program contracting period to suit the field conditions and possible storage facilities. Equipment components should be packed and maintained to suit the needs of transportation and field storage. The detailed rules should be worked out in the contract to suit the general requirements and any special requirement of storehouse as well as the inspection requirements for special components.

The Contractor and his appointed Subcontractor for installation should guarantee jointly that a good supplementary storage will be carried out within the equipment site controlled by them.

Classes for Storehouse:

Three classes for storehouse are described as follows:

- Storehouse class A: Special measures are taken to protect the stored goods and the temperature, humidity, ash are controlled within a specified range.
- Storehouse class B: Goods are stored with temperature uncontrolled.
  Storehouse class C: It is an outdoor storage with a drainage system on the ground.

No matter what class of storehouse is used, the following basic requirements shall be satisfied.

For storehouses of class A and B they should be fireproof, heat resisting, waterproof and well ventilated. They should not be wet and should be provided with good drainage system and preferably with a brick laying or concrete ground. For storehouses of class C, they should not be wet and should be well drained, preferably with a brick laying or crushed stone ground.

Component surfaces should not be contacted directly with the ground or ground laying material. There should be a layer of oil cloth or wax or other similar materials between the machine surface and ground surface.

After the store house/field are accepted, all components should be inspected as to whether the paint, seal and packing are mechanically damaged. All these damages should be repaired if these components will not be installed immediately.

The components stored in storehouse class C should be protected from rainfall, salt corrosion, ash and other adverse conditions with a temporary cover or tent if possible. A drainage device should be provided for this temporary cover or tent.

Inspection during Storage:

All components shall be inspected for their painting, storing, sealing etc. and any damage or wear should be repaired during acceptance and storage periodically. The inspection interval is determined by the component function, applied protection measure and storehouse class.

Unpacking or inspection for outdoor package (class C) shall not be carried out during rainfall or big wind (salt corrosion is possible).

Many components are provided with a drying agent or sealed in a coverage (polyethylene or insulating cover) containing drying agent. The drying condition shall be inspected during storage after 4 weeks and 8 weeks from acceptance, and then in an interval of every 12 weeks. If it is necessary to replace the drying agent during any inspection, a full inspection every 4 weeks shall be carried out until a successful inspection result is obtained and in the meantime, the conventional inspection shall be carried out continuously.

19.1.11 Painting, Insulation and Anti-dewing

Anti corrosive coatings and painting should be carried out as a pre-treatment to all equipment and parts. The paint system used should coordinate with the painted objects and surrounding conditions of project.

In multi-layer painting system, different painting layers should be selected to make the painting coordinate. If multi-layer painting system is used, various painting layers should have different colors so that the later layer can be distinguished from the former one.

After the equipment or apparatus finished preliminary or full painting, it can be supplied to field. After the installation is finished, ground coat must be painted.

Entire painting procedure should be supplied in order to repair the injures of painting coat after the equipment is delivered to field.

Color strip indication system should be used for pipes.

These strips should be painted on the joint of pipes, entrance, valves of pipe. This pipe without outside protection layer should be marked by some color in whole length.

The principle color of field equipment should be determined by Owner and Contractor in contracting stage.

Further requirements with regard to painting, insulation, and anti-dewing are specified in the relevant sections in the detailed technical specifications. The specified requirements shall be applied to the whole equipment and facilities of the FGD Plant Contract.

19.1.12 Language to be used

English shall be used as the general Contract language English translations shall be provided for any code and standards not in English language.

Name plates of equipment and instrument scale, etc. shall be marked in English as required for start-up, testing and training etc.,

Documents for training shall be provided in English.

19.2 DISCREPANCIES IN THIS TECHNICAL SPECIFICATION

Any contradiction between Various parts/ sections of this Technical Specification, between text and drawings, the document giving the more extended scope or requirement shall be considered to be within the Contractor's scope of supply.

20.0 FUNCTIONAL GUARANTEES, PENALTIES FOR SHORTFALL IN PERFORMANCE AND PERFORMANCE GUARANTEE TESTS

GENERAL

The term "Performance Guarantees" wherever appears in the Technical Specifications shall have the same meaning and shall be synonymous to "Functional Guarantees". Similarly the term "Performance Tests" wherever appears in the Technical Specifications shall have the same meaning and shall be synonymous to "Guarantee Test(s)".

20.1 PERFORMANCE GUARANTEES / PERFORMANCE TESTS

20.1.1 General Requirements

The Contractor shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment covered in these specifications.

The guaranteed performance parameters furnished by the Bidder in his offer, shall be without any tolerance values whatsoever. All margins required for instrument inaccuracies and other uncertainties shall be deemed to have been included in the guaranteed figures. No tolerance or allowance on the test result will be permitted for instrument errors or inaccuracy, the method of testing or any other causes.

The Contractor shall conduct performance test and demonstrate all the guarantees covered herein. The various tests which are to be carried out during performance guarantee tests are listed in this Sub-section. The guarantee tests shall be conducted by the Contractor at site in presence of Owner on each unit individually.

All costs associated with the tests including cost associated with the supply, calibration, installation and removal of the test instrumentation shall be included in the contract price.

The performance tests shall be performed using only the normal number of Owner supplied operating staff. Contractor, vendor or other subcontractor personnel shall be used only for instructional purposes or data collection. At all times during the Performance Tests the emissions and effluents from the Plant shall not exceed the Guaranteed Emission and Effluent Limits.

It shall be responsibility of the Contractor to make the plant ready for the performance guarantee tests.

20.1.2 Test Instrumentation, Flow Measurement and their Calibration

All instruments required for performance testing shall be of the type and accuracy required by the code and prior to the test, the Contractor shall get these instruments calibrated in an independent test Institute approved by the Owner and submit the same to Owner prior to commencement of test. All test instrumentation required for performance tests shall be supplied by the Contractor and shall be retained by him upon satisfactory completion of all such tests at site. All calibration procedures and standards shall be subject to the approval of the Owner prior to commencement of test. The protecting tubes, pressure connections and other test connections required for conducting guarantee test shall conform to the relevant codes.

Tools and tackles, thermowells (both screwed and welded) instruments/devices including flow devices, matching flanges, impulse piping & valves etc. and any special equipment, required for the successful completion of the tests, shall be provided by the Contractor free of cost.

The Performance test shall be carried out as per the agreed procedure. The detailed PG test procedure shall be submitted within 90 days of the date of Notification of Award and finalization of the PG test procedure shall be done within 180 days from the date of Notification of Award.

The P&G test procedures shall be submitted for equipment/system & subsystem under Contractor's scope for all Guarantees as mentioned below, as per latest International codes / standard including correction curves, meeting the specification requirements along with sample calculations & detailed activity plan of preparation (including test instrumentation), conductance and evaluation of Guarantees.

The Contractor shall submit for Owner’s approval the detailed Performance Test procedure containing the following:

(a) Object of the test.
(b) Various guaranteed parameters & tests as per contract.
(c) Method of conductance of test and test code.
(d) Duration of test, frequency of readings & number of test runs.
(e) Method of calculation.
(f) Correction calculations & curves.
(g) Instrument list consisting of range, accuracy, least count, and location of instruments.
(h) Scheme showing measurement points.
(i) Sample calculation.
(j) Acceptance criteria.
(k) Any other information required for conducting the test.

20.1.2.1 Test Reports

After the conductance of Performance test, the Contractor shall submit the test evaluation report of Performance test results to Owner promptly but not later than one month from the date of conductance of Performance test. Preliminary test reports shall be submitted to the Owner after completing each test run. Four (4) hard copies and two (2) soft copies on CD-ROM of each test report of final conducted test on each equipment/plant/system shall be submitted to Owner for approval.

Performance Guarantee Tests on the equipment/systems not covered in this Sub- section shall be carried out as per the procedure/test codes specified in respective detailed specifications.

20.1.3 Acceptance of Guarantee Test Results

(i) For Category-I Guarantees

In case during performance guarantee test(s) it is found that the equipment/system has failed to meet the guarantees, the Contractor shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Employer and re-conduct the performance guarantee test(s) with Employer's consent. In case the specified performance guarantee(s) are still not met but are achieved within the Acceptable Shortfall Limit as specified in Cl.20.1.4, of this sub-section &Vol I SCC Employer will accept the equipment/system/plant after levying Penalties as per Vol.I SCC. However, if, the demonstrated performance guarantee(s) continue to be beyond the stipulated Acceptable Shortfall Limit, even after the above modifications/replacements within ninety (90) days or a reasonable period allowed by the Employer, after the tests have been completed, the Employer will have the right to either of the following:

Reject the equipment / system / plant and recover from the Contractor the payments already made

OR

Accept the equipment /system/ plant after levying Penalties. The Penalties for shortfall in performance indicated in Vol.I SCC shall be levied separately for each unit. The rates indicated in Vol.I SCC per unit basis. The Penalties shall be pro-rated for the fractional parts of the deficiencies.

(ii) For Category-II Guarantees

In case during performance guarantee test(s) it is found that the equipment/ system has failed to meet the guarantees, the Contractor shall carry out all necessary modifications and/or replacements to make the equipment/system comply with the guaranteed requirements at no extra cost to the Employer and re-conduct the performance guarantee test(s) with Employer's consent. In case the specified performance guarantee(s) are still not met even after the above modifications/replacements with in ninety (90) days or a reasonable period allowed by the Employer, after the tests have been completed, the Employer will have the right to Reject the equipment /system / plant and recover from the Contractor the payments already made.

Conformance to the performance requirements under Category-II is mandatory as compliance of limiting the SO2 emission from the plant is a statutory requirement. If the stipulated guarantee is not met, the Purchaser at his discretion will reject the FGD Plant/ System and recover from the Contractor the payments made for the entire contract.

20.1.4 AMOUNT OF PENALTIES APPLICABLE FOR GUARANTEES

20.1.4.1 The rate of penalties and acceptable shortfall limits for different guarantees shall be as under and such penalties shall be deducted from the Contract Price.

Sl.No	Guarantee	Rate of Penalty	Acceptable Shortfall Limit with Penalty
i)	**SO_2 Removal Efficiency:** For shortfall in guaranteed SO_2 removal efficiency in percentage points under conditions stipulated in Cl. 20.2 of Vol.II Sec.1.	As specified in Vol.I SCC, AMOUNT OF PENALTIES APPLICABLE FOR GUARANTEES	(-)0.25% point from the guaranteed SO2 removal
ii)	**Auxiliary Power consumption of FGD and Auxiliaries:** For increase in the auxiliary power consumption in KW guaranteed as per the requirements of Cl.20.2 of Vol.II Sec.1	As specified in Vol.I SCC., AMOUNT OF PENALTIES APPLICABLE FOR GUARANTEES	(+) 5% of the guaranteed auxiliary power consumption
iii)	**Limestone Consumption:** For increase in the limestone consumption of FGD system in T/hr under conditions stipulated in Cl.20.2 of Vol.II Sec.1	As specified in Cl.3.0.0 AMOUNT OF PENALTIES APPLICABLE FOR GUARANTEES, Vol.I SCC.	(+)10% of the guaranteed limestone consumption.

NOTE :

(i) Each of the penalties specified above shall be independent and these penalties shall be levied concurrently as applicable.

(ii) Contractor's aggregate liability to pay penalty for failure to achieve the performance guarantee shall not exceed Contract price.

(iii) All these penalties for short fall in performance shall be deducted from the contract price.

(v) The guaranteed values shall be referred with documents/drawings enclosed with Contractor's proposal.

20.1.4.3 LD for Non-fulfilment of Time Schedule

As per LD defined in SCC

20.1.4.4 Penalties for Inferior Civil Works

Any Civil Work carried out by the Contractor not meeting the requirements of relevant Technical Specifications for Civil/Structural/Architectural works covered elsewhere in bid documents, relevant Indian Standard Codes and Contract stipulations, the same will be considered as Inferior quality Civil works by the Owner. The Contractor shall dismantle/demolish such inferior quality Civil works and reconstruct the same including supply of material, labour, etc. complete up to the satisfaction of the Owner/Company at no extra cost

to the Owner. No extension in the time will be granted by the Owner for any inferior quality Civil works and Penalties thereupon due delay of work, as stipulated in relevant sections of the bid documents, will be applicable.

For non-fulfillment of PG values the LD will be levied as indicated in above clause of this Section. The ceiling of LD for each unit shall be 10% of the contract value. The

20.1.5 GUARANTEES PARAMETERS

20.1.5.1 Guarantees Under Category-I

The Performance Guarantees which attract Penalties are as follows:

The following shall be guaranteed by the Bidder under guarantee point condition:

(i) SO_2 removal Efficiency

The Contractor shall guarantee their best SO_2 removal efficiency for inlet SO_2 concentration corresponding to worst coal and 100% (TMCR) unit load. The Contractor shall Guarantee that the SO_2 removal efficiency shall not be less than 95 % or the value specified under guarantee point conditions (as specified in table 20.2 of this section).

(ii) Limestone consumption of FGD system

The contractor shall guarantee the limestone consumption of FGD system in kg/h under guarantee point condition at 100 % (TMCR) unit load with worst coal firing, meeting an outlet guarantee of less than 100 mg/Nm^3 (6% O2, dry basis).

(iii) Auxiliary Power Consumption

The Contractor shall guarantee the total auxiliary power consumption for the FGD plant in normal operation at the guarantee point conditions (as specified in table 20.2 Section -1)

20.1.5.2 Guarantees under Category- II

SO_2 removal in treated flue gas: Maximum concentration of SO2 in treated flue gas at the exit of FGD for the unit shall not exceed the guaranteed values.

20.1.5.3 Guarantees Under Category-III

The parameters/capabilities shall be demonstrated for various systems/ equipment shall include but not limited to the following:-

a. Minimum SO2 removal efficiency of scrubber corresponding to the design conditions of the FGD plant.

b. Mist Outlet Droplet Content

The mist eliminator outlet droplet content shall be guaranteed to be < 20 mg/Nm3 at absorber outlet measured over a period of 24 hrs continuous operation.

Mist outlet-droplet content shall be measured as per applicable clauses in VDI Norm 3679 and the Contractor shall carry out the tests as per the test procedure approved by the Employer

c. Maximum pressure drop of flue gas across the FGD system, corresponding to the guarantee conditions of the FGD plant, mmwc (g)

d. Permissible range of plant load variation for design SO2 removal efficiency of the FGD plant (MW or % of unit MCR)

e. Permissible maximum SO2 concentration in the inlet flue gas for design SO2 removal efficiency of the FGD plant, mg/Nm3.

f. SO_2 removal efficiency with one spray level out of service corresponding to guarantee conditions of FGD plant*(for multi spray tower systems)

g. Gypsum purity.
The contractor shall demonstrate that the purity of the gypsum produced shall not be less than 90%, chloride content shall not be more than 100ppm and the moisture content shall not be more than 10% for the range of specified coal(s) and limestone.

h. Noise

All the plant, equipment and systems covered under this specification shall perform continuously without exceeding the noise level over the entire range of output and operating frequency specified in Vol.II, Section.2 of the technical specifications.

Noise level measurement shall be carried out using applicable and internationally acceptable standards. The measurement shall be carried out with a calibrated integrating sound level meter meeting the requirement of IEC 651 or BS 5969 or is 9779.

Sound pressure shall be measured all around the equipment at a distance of 1.0m horizontally from the nearest surface of any equipment/ machine and at a height of 1.5m above the floor level in elevation.

A minimum of 6 points around each equipment shall be covered for measurement. additional measurement points shall be considered based on the applicable standards and the size of the equipment. the measurement shall be done with slow response on the a - weighting scale. the average of a-weighted sound pressure level measurements expressed in decibels to a reference of 0.0002 micro bar shall not exceed the guaranteed value. corrections for background noise shall be considered in line with the applicable standards. all the necessary data for determining these corrections, in line with the applicable standards, shall be collected during the tests.

In addition to the above, the following parameters/capabilities shall also be demonstrated:-

(i) Wet ball Mill capacity at rated fineness

The contractor shall demonstrate the guaranteed capacity of each limestone pulverizer under the following conditions:

i) Limestone fineness : 90% or higher (as per the requirement of the absorber) through 325 mesh (for spray tower Process) OR 90% or higher (as per the requirement of the absorber) through 200 mesh (for jet bubbling process).
ii) Limestone Quality : All available quality from the specified range.

Contractor shall demonstrate the above capacity with the originally installed grinding elements in nearly worn-out condition as mutually agreed for the purpose of ascertaining wear life of any of the wear parts.

(ii) Wet ball Mill wear parts guarantee

Contractor shall demonstrate the life of wet ball Mill wear parts in line with requirements stipulated in section 2.0 of the Technical Specification. The establishment of the above guarantee shall be based on the operating records available at the Power station and will be computed for each pulverizer based on actual total hours of operation.

(iii) Wet ball Mill ball consumption

Contractor shall guarantee ball consumption per ton of limestone throughput in line with requirements stipulated in Vol.II, Sec-2.1 of the Technical Specification. Contractor shall furnish the minimum ball diameter below which the balls shall be replaced.

(iv) Vacuum Belt Filter Capacity

Contractor shall demonstrate the capacity of the Vacuum Belt Filters to dewater the quantity of gypsum with the specified purity and moisture content as specified in Vol.II, Sec-2.3 of the Technical Specification.

(v) Waste Water

The Contractor guarantees that the maximum purge flow rate to waste water treatment system for the complete plant shall be 10m3/hr averaged over a 24 hour period from the unit.

(vi) Performance characteristics of booster fans (capacity, head developed, etc.).

(vii) Margins in Booster Fan.

Booster Fans - As specified in Cl. 5.4.0, Sec 2.1, Vol II of Technical Specifications

(viii) GGH Leakage

The leakage through the GGH seals shall not exceed 1.5% of the hot gas inlet flow.

(ix) Passenger cum Goods Elevator for FGD absorber & Limestone Grinding Building: Over load tests, travel and hoist speed checks.

(x) Availability of FGD Plant

The Contractor shall guarantee the maximum availability of FGD Plant for the range of coal and limestone specified inline with the requirements stipulated in this Sub-Section

(xi) Air Conditioning System

A. Following shall be demonstrated at Shop

1) Capacity and static pressure of AHU fans at its rated duty point.

B. Following shall be demonstrated at Site

1) Capacity (TR) of water cooled condensing units (D-X type) for A/C system of FGD control room building.
2) Guaranteed room conditions during summer for all the Air conditioned areas.
3) Vibration and noise level of condensing units & centrifugal fans of AHUs.

(xii) Ventilation System

A. Following shall be demonstrated at Shop

1) Capacity and discharge pressure of pumps of UAF units at its rated duty point of Ventilation system.
2) Capacity and static pressure of UAF fans at its rated duty point of Ventilation system.

B. Following shall be demonstrated at Site

1) Vibration & Noise level of centrifugal fans & pumps of UAF units.

(xiii) Equipment Cooling Water System

i) Vibration, noise and parallel operation without hunting & abnormal noise and with flow sharing within 10% of each other at the rated duty point shall be demonstrated at site.

ii) Design heat load of plate type heat exchangers and Inlet & Outlet temperatures of the Plate type heat exchangers on the primary and secondary side to be demonstrated at site. Pressure drop across the Plate type heat exchanger on the primary & secondary water circuit to be demonstrated at site.

(xiv) Compressed Air System

A. Following shall be demonstrated at shop

i. Capacity & Discharge pressure of each air compressor.

B. Following shall be demonstrated at site:

i. Dew point of air at the outlet of air drying plants of air compressor.
ii. Pressure drop across air drying plant.
iii. Vibration and noise level of air compressors, blowers of air drying plant (if applicable).

(xv) Particulate matter in flue gas

Bidder's design shall ensure that the particulate emission at chimney inlet shall not be more than 30 mg/Nm3 or as per the values specified for all the specified operating conditions.

(xvi) Capacity of lime & gypsum handling equipment

The Bidder shall demonstrate the capacity of bucket elevators/steep angle conveyor, Belt Conveyor and Lime Crusher capacity of any one set as per Owners Choice and as specified elsewhere in the specification.

(xvii) Capacity of limestone handling system and Gypsum Handling System:

The contractor shall demonstrate the rated capacities of each belt conveyor for limestone and gypsum and the associated equipment.

20.1.5.4 AUXILIARY POWER CONSUMPTION (PA)

The unit auxiliary power consumption shall be calculated using the following relationship.

Pa = Pu + TL
Pa = Guaranteed Auxiliary Power Consumption.
Pu = Power consumed by the auxiliaries of the unit under test.
TL = Losses of the transformers supplied by bidder based on works test reports.

While guaranteeing the auxiliary power consumption the bidder shall necessarily include all continuously operating auxiliaries under this package.

Any other equipment required for continuous operation of the system shall also be considered for calculation of auxiliary power consumption. Power consumption of all equipments provided on unitized basis shall be included in the unit auxiliary power consumption. For common

station auxiliaries, the power consumption shall be assigned to each unit based on unit load for the purpose of calculating the unit auxiliary power consumption.

The auxiliaries to be considered shall include all the auxiliaries required to run the system on a continuous basis meeting the requirements of the technical specification but not be limited to the following:

i. Absorber Recirculation Pump(s)
ii. Absorber Oxidation Air Blower(s)
iii. Absorber Oxidation Tank Agitators
iv. Gypsum Bleed Pumps
v. Limestone Gravimetric feeder, Wet ball mill and their integral Auxiliaries
vi. Limestone Slurry Pump(s)
vii. Vacuum Belt Filter, Vacuum Pump and its integral auxiliaries
viii. Power consumption of Booster water pump
ix. Process water pump(s)
x. Mist Eliminator Wash Water pump(s)
xi. DM Cooling (normally working) Water pump one(1) to supply cooling water on the primary (DM) side of the plate type heat exchangers in the closed loop Equipment cooling water system.
xii. Auxiliary Cooling (normally working) water pump one(1) to supply cooling water on the secondary side of the plate type heat exchangers in the closed loop Equipment cooling (unit auxiliary) water system.
xiii. Booster Fans.
xiv. Power consumption of Limestone Slurry Tank Agitators
xv. Power consumption of Filtrate Pump(s)
xvi. Power consumption of Belt Filter Wash Water Pump
xvii. Power consumption of Hydro-cyclone Waste Water Sump Pump and Waste Water Pump
xviii. Power consumption of all other continuous running Agitators
xix. Air Conditioning System
Power consumption at motor input terminals of working units (i.e. excluding stand-by) at its rated duty point of compressor and condenser fans of air cooled condensing unit, Air handling unit (AHU) fans for the Air conditioning system of FGD Control Room Building
xx) Guaranteed power consumption of single stream conveyors and associated equipments (vibrating screen, crushers, belt feeders, paddle feeders) for limestone and gypsum handling at rated capacities.

The equipments listed above for calculating auxiliary power consumption are indicative. Any other equipment required for continuous operation of the system shall also be considered for calculation of auxiliary power consumption.

Note :

1. The bidder shall furnish a list of equipments to be covered under auxiliary power consumption, which shall be subject to Employer's approval.

2. The equipments listed above for calculating auxiliary power consumption are indicative. Any other equipment required for continuous operation of the system shall also be considered for calculation of auxiliary power consumption.

20.1.5.5 METHOD OF COMPUTING TEST EFFICIENCY OF FGD

The performance tests shall be carried out in accordance with ASME PTC 40 (1991) code. NO tolerance or allowance on the test result shall be permitted for instrument errors or inaccuracy, the method of testing or any other causes. The details of the test shall, however be mutually agreed upon between the employer and the contractor.

20.1.5.6 METHOD OF COMPUTING AVAILABILITY

FOR CATEGORY-III

The Contractor shall guarantee 98 % availability of FGD plant for a continuous period of 120 days. An availability guarantee test shall be conducted to assure this level of availability for a period of 240 days as per the procedure indicated below.
Availability 'A' in %:

$$A = \frac{Tc \times 100\%}{Tk}$$

Tc – recorded time of FGD operation, expressed in hours,

Tk – recorded time of boiler operation, expressed in hours,

However, it is required that:

(i) In order to calculate the FGD availability, operation hours will be counted except boiler start-ups when the operation hours counting will start on the moment of shut down of all oil burners,

(ii) FGD will be regarded as a FGD in operation, when by-pass damper is closed and total flow of flue gas from boiler goes via FGD, and SO2 content is below 100 mg/Nm3 (dry basis at 6% O2) in cleaned flue gas for the range of specified coals & loads.

(iii) If FGD is out of operation during the boiler operation time as a result of the Employer's decision, this time will not be counted as boiler operation time for calculating the FGD availability,

(iv) Boiler operation hours will be counted based on the recorded boiler operation hours and the recorded data will be made available to the Contractor by the Employer.

Mandatory spares have been identified in the Employer. Contractor can use the mandatory spares supplied under the contract during this period in agreement with the Employer. However, if other additional spares are required for demonstration of availability demonstration guarantee, Bidder to should clearly indicate along with their offer.

If the calculated availability after 120 days availability test is lower than the guaranteed value, the Contractor will undertake actions as per clause **19.1.5.4** of this Sub-Section to achieve the guaranteed availability.

Recovery of Penalties

The Owner may, without prejudice to any method of recovery, deduct the amount for such Penalties from any amount due or which becomes due to the Contractor either under this or any other Contract, including en-cashing of appropriate value of Contract Performance Bank Guarantee. Payment of Penalties shall in no way relieve the Contractor from its contractual obligations to complete the works or from any of the obligations under the contract. Any delay in the levy or recovery of penalty shall not constitute waiver of the right of the Owner under the contract towards levy and recovery of penalty.

Test Condition

The performance test on FGD will commence after a minimum period of Seven hundred Twenty (720) hours of operation after completion of initial operation. During the interval between the commencement of initial operation and the commencement of performance test only routine maintenance shall be carried out.

The performance tests shall be carried out in accordance with ASME PTC 40 (1991) code, as amended/ revised. The test efficiency shall be based on the overall performance of the FGD system over a mutually agreed period of operation under the conditions given elsewhere in this specification and allowing the normal operation of the power unit.

20.2 DESIGN AND GUARANTEE CONDITIONS

Design and Guarantee conditions shall be referred in Annex 1.2.

ANNEX - 1.1

PROJECT INFORMATION

1.0	**General**		
1.1	Project Title	:	1 x 800 MW North Chennai Coal Based Super Critical Thermal Power Project Stage III.
1.2	Plant capacity	:	800 MW
1.3	Type of project	:	Brown field
1.4	Owner	:	Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)
1.5	Plant site location	:	In the premises of North Chennai Thermal Power Station (NCTPS)
1.6	Location co-ordinates	:	80° 19' E to 80° 20' E Longitude 13° 13' N to 13° 18' N Latitude
1.7	Nearest Village	:	Ennore & Puzhudhivakkam Village
1.8	Nearest Town & City	:	Chennai (35 Km)
1.9	State Capital	:	Chennai (35 Km)
1.1	Nearest Railway Station	:	Athipattu Pudunagar (~ 5 Km) on Chennai – Vijayawada Line
1.11	Nearest Airport	:	Chennai (~ 60 Km)
1.12	Nearest Seaport	:	Ennore (~ 3 Km)
1.13	Nearest Road access	:	All weather road from Pattamandri on the Thiruvottiyur – Ponneri highway
2.0	**Meteorological Condition**		
2.1	Climate	:	Tropical, very dry and hot summer, dry and cold winter and good rain-fall in monsoon accompied with strong wind
2.2	Site Elevation	:	(+) 10.0 Meter above Mean Sea Level
2.3	Ambient Temperature		
a.	Annual Maximum Mean Temperature	:	45 ºC
b.	Annual Minimum Mean Temperature	:	15 ºC
c.	Design ambient temperature	:	30 ºC
2.4	Relative Humidity		
a.	Maximum	:	90%
b.	Minimum	:	36%
c.	Design	:	75%
2.5	Annual Rainfall		

	Maximum	:	2540 mm
	Average	:	1600 mm
	Minimum	:	1175 mm
2.6	Basic Design Wind Pressure	:	As per IS: 875 (Latest Edition)
2.7	Wind Speed	:	11.8 kmph (Avg), 50 m/s (max)
2.7	Seismic zone	:	Zone: III as defined in IS:1893-2002
2.8	Design ambient temperature for Electrical equipment	:	50 ℃

ANNEX - 1.2

FLUE GAS ANALYSIS

The Flue Gas Desulphurisation (FGD) System shall be designed to comply with the requirements stipulated under "Guarantee Case and Design Case" in the table below

SL. NO	DESCRIPTION		Unit	GUARANTEE CASE (Design Coal)	DESIGN CASE (Worst Coal)	DESIGN CASE (Design Coal)	DESIGN CASE (Best Coal)
1	Boiler Load		MW	100% TMCR	100% BMCR	100% BMCR	100% BMCR
2	Ambient air condition	DBT	^{o}C	30 deg c	30 deg c	30 deg c	30 deg c
		RH	%	75% RH	75 % RH	75 % RH	75 % RH
3	Total Gas Flow rate at FGD package Inlet – NTP condition		Nm^3/s	699.9	744.5	764.6	756
4	Gas Temperature		^{o}C	128	131	133	134
5	Total Volumetric Flow rate at FGD package Inlet		m^3/s	1028	1146	1137	1127
6	Flue Gas Composition at FGD system inlet						
6.1	O_2		(% V/V Wet)	4.635	4.513	4.596	4.579
6.2	CO_2		(% V/V Wet)	12.33	12.294	12.361	12.527
6.3	H_2O		(% V/V Wet)	11.205	11.764	11.225	10.672
6.4	SO_2		(% V/V Wet)	0.048	0.055	0.048	0.041
6.4	N_2		(% V/V Wet)	71.783	71.374	71.770	72.181
6.5	Dust		mg/Nm3	50	200	200	200
6.7	SO_2		mg/Nm3	1390	1570	1390	1200
7	Flue gas pressure at FGD inlet		mmWC	0	0	0	0
8	SO2 concentration in flue gas at FGD outlet		mg/Nm3 (6% O_2, dry basis)	<100	<100	<100	<100
9	Minimum SO_2 removal efficiency		95 %	95%	95%	95%	95%

SL. NO	DESCRIPTION	Unit	GUARANTEE CASE (Design Coal)	DESIGN CASE (Worst Coal)	DESIGN CASE (Design Coal)	DESIGN CASE (Best Coal)
10	Limestone purity	%	80	70	70	70
11	Gypsum purity	%	95	95	95	95

Note:
The flue gas volume in Nm^3/s shall be calculated at 101.325 kPa and 273.15 K

ANNEX- 1.3

SERVICE WATER ANALYSIS

The Service water (make-up water) water quality is mentioned below:

Sr. No.	Parameter	Unit	Result
1	Temperature	℃	35
2	pH	-	7.5 – 8.2
3	LSI		0 -0.2
4	Alkalinity		< 100 PPM of Ca CO3
5	Hardness		< 80 PPM
6	Chloride		< 350 PPM
7	Sodium		< 170 PPM

ANNEX- 1.4

DESIGN LIMESTONE ANALYSIS

Sl. No	Constituents	Unit	% by Weight	
			Analysis #1	Analysis #2
1.	Silica as SiO_2	%	7.5	4-6
2.	Iron as Fe_2O_3	%	8.0	1.5-2.2
3.	Aluminium as Al_2O_3	%	1.0	1.8-2.8
4.	$CaCO_3$	%	70.0	85-89
5.	$MgCO_3$	%	3.4	
6.	Acid Insoluble	%	7.0	Below 1%
7.	Others	%	2.42	-
8.	Inherent Moisture Content	%	Max 0.5	-
9.	Bond Work index	KWH/T	11.61	13

ANNEX - 1.5

LIST OF MANDATORY SPARES (FGD)

Bidders shall supply the Mandatory Spares for FGD & Auxiliaries after commissioning of the FGD system of the 800 MW unit.

Sl. No.	Description	Nos. / Sets
1.1.0	**Booster Fans**	
	1. Fan assembly (excluding fan body)	1 no.
	2. Booster fan motor	1 no.
	3. Fan bearings	1 set
	4. Booster fan motor bearings	1 set
	5. Spares for blade bearing Assembly	
	5.1 Bearings	2 sets
	5.2 'O' rings	2 sets
	5.3 Bushes	2 sets
	5.4 Metallic rings	2 sets
	5.5 Intermediate piece (if applicable)	1 set
	6. Lube Oil / Hydraulic Oil system	
	6.1 Pump assembly	1 no. of each type
	6.2 Pump motor	1 no. of each type & rating
	6.3 Pressure regulator	2 nos.
	6.4 Filters	2 nos.
	6.5 Coupling between oil pump & motor	1 nos.
	7. Fan Blades	1 set
	8. Coupling between Fan & Motor	1 set.
	9. Hydraulic servomotor	1 no.
	10. Booster fan impeller liner	1 set

Sl. No.	Description	Nos. / Sets
	11. Booster fan casing liner	1 set
1.2.0	**Gates in Flue Gas System**	
	1. Seals	1 set of each type (Set means complete replacement for one gate)
	2. Actuator	1 no. of each type & rating
	3. Expansion joint	1 number for each type and size
	4. Seals for guillotine gate(Both port side and bonnet side) (In case Gates are provided)	1 set for each gate
1.3.0	**Absorber**	
	1. Absorber Spray/Oxidation nozzles	10% of each type and size
	2. Absorber Mist Eliminator Washing Nozzles	10% of each type and size
	3. Absorber Mist Eliminator	5% of each type and size/configuration
1.4.0	**Oxidation Air Blower**	
	1. Impeller Assembly	1 no.
	2. Bearings	1 no. of each type
	3. Suction air filter	2 No
1.5.0	**Agitators** **(A)** (For Absorber Oxidation Tank & Aux. Absorbent/Emergency tank),	
	1. Impeller Assembly	1 no. of each type and size
	2. Bearing Assembly	1 no. of each type and size
	3. Motor	1 no. of each type and size
	4. Belt and Pulley (If applicable)	1 no. of each type and size

Sl. No.	Description	Nos. / Sets
	5. Gear Box Assembly (If Applicable)	1 no. of each type and size
	6. Agitator shaft assembly	1 no. of each type and size
	7. Shaft seal	1 no. of each type and size
	8. Complete Agitator assembly	1 no. of each type and size
	(B) AGITATORS For Mill Separator Tank, Limestone Slurry Preparation Tank, Secondary hydro-cyclone feed, Waste water, Filtrate tank and any other tank provided with agitators)	
	1. Impeller Assembly	1 no. of each type
	2. Bearing Assembly	1 no. of each type
	3. Motor	1 no. of each type
	4. Belt and Pulley (If applicable)	1 no. of each type
	5. Gear Box Assembly (If Applicable)	1 no. of each type
	6. Agitator shaft assembly	1 no. of each type and size
	7. Complete Agitator assembly	1 no. of each type and size
1.6.0	**Slurry Pumps** (Absorber Slurry Recirculation/Gas Cooling Pump/ Recycle Pump, Gypsum Bleed Pumps, Mill Circuit Pump, Limestone slurry supply Pumps and any other slurry pumps)	
	1. Impeller Assembly	4 no. of each type and size
	2. Complete Casing (For the Absorber Slurry Recirculation/Gas Cooling Pump/Recycle Pump Bidder shall supply complete casing)	1 no. of each type and size
	3. Casing Liners (where replaceable liners are provided)	1 set*
	4. Seals	4 set of each type and size
	5. Bearings	2 no. of each type and size

Sl. No.	Description	Nos. / Sets
	6. Motor	1 no. of each type and size
	7. Gear Box	1 No. for each type and size of pump.
	8. Motor-Pump Coupling	1 no. of each type
	9. V belt & Pulley if applicable (viz: Gypsum bleed p/p)	1 no. of each type and size
	10. Gypsum Bleed P/P T bends	1 no. of each type and size
1. 7.0	**Hydro-cyclones** (Mill , Gypsum Primary Dewatering, Secondary Waste Water and any other Hydro-cyclone)	
	1. Hydro-cyclone Isolation Valve	10% of each type OR 1 no. whichever is higher
	2. Hydro-Cyclone	10% of each type OR 1 no. whichever is higher
	3. Hydro-Cyclone rubber lining-Feed chamber and Overflow chamber	10% of each type OR 1 no. whichever is higher
	4. Vortex finder & Apex inserts	10% of each type OR 1 no. whichever is higher
1.8.0	**Feeders**	
	1. Belt	2 sets *
	2. Belt drive motor	1 nos.
	3. Belt drive reducer	1 nos.
	4. Speed Reducer Assembly	1 set*
	5. Weighing Instruments	1 set*
	6. Feeder weighing roll	1 no.
	7. Gravimetric feeder gate actuator assembly	1 no.
	8. Counter assembly of feeder complete	1 no.
	9. Feeder head pulley assembly	1 no.

Sl. No.	Description	Nos. / Sets
1.9.0	**Limestone Mills**	
	1. Mill Wear Parts (Liners) & Grinding element	1 set
	Note : One set of Mill Wear Parts (Liners) above is defined as under : 1 Set = (Grinding elements needed for complete replacement of one mill) X (8000 x 1) / GWL, rounded off to nearest higher whole number. Where : GWL = Guaranteed wear life of Mill Wear Parts as offered by the bidder.	
	2. Mill Motor	1 no.
	3. Auxiliary Motor	1 no.
	4. Gear box internals (including Bearings and Seals)	2 sets *
	5. Complete Gear Box	1 set *
	6. Mill motor Bearings	1 set *
	7. Lube Oil / Grease System	
	7.1 Pump assembly	1 no. of each type
	7.2 Motor	1 no. of each type
	7.3 Pressure regulator	1 no. of each type
	7.4 Filters	2 nos. of each type
	7.5 Pump & Motor coupling	1 no. of each type
	7.6 Lub Oil and Grease skid	1 set
	8 Control Valve Grinding and Dilution water	1 no each type.
	10. Mill recycle P/P VFD (if any)	1 set
1.10.00	**Slurry Valves**	4 nos. of each type and size
1.11.00	**Slurry Line Bends**	4 nos. of each type and size

Sl. No.	Description	Nos. / Sets
1.12.00	**Vacuum Belt Filter**	
	1. Filter Cloth	4 sets
	2. Belt	1 sets
	3. Vacuum Box Seals	2 sets
	4. Drive Motor	1 no.
1.13.0	**Vacuum Pumps**	
	1. Pump Impeller Assembly	1 no.
	2. Pump Bearing	1 set
	3. Seals	1 set
	4. Motor	1 no.
	5. V belt	1 no
1.14.0	**Vacuum Breaker Valves**	
	1. Valve Assembly	1 no.
	2. Actuator	1 no.
1.15.0	**Sump Pumps**	
	1. Complete Impeller Assembly	1 no. of each type
	2. Casing Liners	1 set* of each type
	3. Bearing	3 set*
	4. Motor	4 no. of each type
	5. Pump discharge valve assembly	1 no. of each type
	6. V belt	1 set
1.16.0	**Horizontal Centrifugal Pumps**	
	1. Complete Impeller Assembly	1 no. of each type
	2. Casing Liners	1 set* of each type

Sl. No.	Description	Nos. / Sets
	3. Bearing	2 set*
	4. Motor	1 no. of each type
	5. Pump discharge valve assembly	1 no. of each type
	6. V belt	2 set
1.17.0	**Goods cum Passenger Elevator**	
	1. Friction block	2 nos.
	2. Guide roller of each type	20% of total population or 3 nos. of type whichever is higher
	3. Contactors of each type	2 nos.
	4 Control Transformer	1 no. of each type
	5. Time device	2 nos. of each type
	6. Rectifiers	4 nos. of each type
	7. Overcurrent relay	2 nos. of each type
	8. Auxiliary relay	3 nos. of each type
	9. Resistor	3 nos. of each type
	10. Fuses of each rating	20% of the total population
	11. Limit switches of each type	3 nos.
	12. Push button	3 nos. of each type
	13. Contact device (if applicable)	3 nos. of each type
	14. Brake motor	2 nos. of each type
	15. Transmitters	2 nos. of each type
	16. Switches of each type	3 nos.
	17. Receiver	2 nos. of each type
	18. Bearings of each type & size	2 nos.
	19. Roller of each type	3 nos.
	20. Worm gear spares	
	'0' rings	3 sets *
	Sealing ring of each type	3 sets *
	21. Spares for brake	

Sl. No.	Description	Nos. / Sets
	Fan	2 nos. of each type
	Magnetic coil	3 nos. of each type
	Brake disc	2 sets *
	Brake pad	2 sets *
	22. Bushing (for door front)	2 sets *
	23. Pinion	2 nos. of each type
	24. Elevator Motor with VWF drive	1 no of each type
	Note: 1. Any change in size, material, design etc, which obviates one to one replacement of the part shall be considered a different type. * Unless otherwise stated, a set shall mean complete replacement for one equipment. Also, indicate the list of recommended spares for the above mentioned systems in their offers which is required for satisfactory operation & maintenance. The commissioning spares shall be considered in Contractor scope of main supply.	
1.18.0	**Equipment Cooling Water System**	
A-1)	**Spares for horizontal pumps for ECW system (for each type & size)**	
1	Impeller with nuts & other accessories	1 set
2	Wearing rings (Impeller & Casing ; as applicable)	2 set
3	Shaft	1 set
4	Shaft Sleeves	2 set
5	Pump & Drive Coupling, bushes, pins with all fasteners	1 set
6	Pump bearings	1 set
7	Mechanical Seal (if applicable)	1 set
	Note : One(1) set consists of quantity required for complete replacement for one(1) Pump of each type/size	
A-2)	**Spares for Electrically operated hoist for FGD system for ECW system (for each type & size)**	
1	Bearings	1 set
2	Rope guide	1 set
3	Brake lining	1 set

Sl. No.	Description	Nos. / Sets
4	Wire rope	1 set
	Note : One(1) set consists of quantity required for complete replacement for one(1) hoist of each type & capacity	
A- 3)	**Spares for Plate type heat exchangers for ECW system (for each type & size)**	
1	Gaskets	Lot. comprising 30% of total requirement
2	Fasteners	Lot. comprising 10% each type
3	Plates	Lot. comprising 20% of each type
	Note : One(1) set consists of quantity required for complete replacement for one(1) heat exchanger of each type & capacity	
1.19.0	**Miscellaneous Equipments (Applicable for all the systems)**	
1.19.1	**E.OT Crane**	
1	Bearing for wheels	1 Set
2	Brake liners for all the brakes	1 Set
3	Hydraulic thrusters for brakes	1 Set
4	Wire rope for crane	1 Length
5	Electrical items of Crane	
a)	Carbon brushes and brush holders for motors	1 Set
b)	Solenoid coils for all brakes	1 Set
c)	Overhead relays for motors	1 Set
d)	Set of fuses	1 Set
e)	Limit switches for main hoist, long travel & cross travel	1 Set
	Note : one set consists of quantity required for complete replacement for one crane of each type & capacity	
1.19.2	**Electrically operated hoists**	
	Bearings	1 Set
	Rope guide	1 Set
	Brake lining	1 Set
	Wire rope	1 Set
	Note : One(1) set consists of quantity required for complete replacement for one(1) hoist of each type & capacity	

1.20.0 LIME STONE AND GYPSUM HANDLING

Sl.No.	Description	Nos./Sets
A)	**IDLERS**	
1	i) 350 Troughing idlers complete with base frame and mounting brackets etc.	2.5% of population of each type
	ii) Rolls for (i) above	1% of population of each type
2	i) Troughing idlers complete with base frame & mounting brackets ctc.(for belt feeder).	30% of population of each type
	ii) Rolls for (i) above	30% of population of each type
3	i) 350 impact idlers complete with mounting brackets and base frame etc.	25% of population of each type
	ii) Rolls for (i) above	25% of population of each type
4	350 troughing training idler complete with base frame and brackets etc. (if used)	10% of population of each type
5	Transition idler complete as in (1) above	10% of population of each type
6	Flat return idlers complete with mounting brackets etc.	2% of population of each type
7	Flat return idlers complete with mounting brackets etc.(for belt feeders)	30% of population of each type
8	Flat return trainer complete with mounting brackets etc.	10% of population of each type
9	Belt cleaning spiral rubber disc return idler complete with mounting brackets etc.	20% of population of each type
10	i) Two roll 100 troughing return idler assy	2% of population of each type
	ii) Rolls for (I) above	2% of population of each type
11	SS idlers	25% of population of each type
12	Any other type of idlers	10% of population of each type
B)	**CONVEYOR GEAR BOXES**	
i)	Input shafts with pinion	1 set of each type and rating
ii)	Oil seals	2 sets of each type and rating
iii)	Bearings	1 set of each type and rating
iv)	Hold back device	2 nos. of each type and rating
v)	Cooling fan with cover	2 nos.of each type and rating
vi)	Complete gear box assy with hold back device	1 set of each type and rating for population upto 10 nos.
		2 set of each type and rating for population more than 10 nos.

Sl.No.	Description	Nos./Sets
C)	**CONVEYOR DRIVE AND CONVEYOR BELT**	
a)	**Gear Coupling**	
i)	All type of drive couplings including gear Coupling	2 nos. of each type
ii)	Bolts for gear coupling	2 sets of each size
iii)	Seal kit for gear coupling (o-ring)	2 sets of each type
b)	**Fluid Coupling**	
i)	Fluid Coupling complete	1 no. of each type and size
ii)	Multi Disc assembly (for fluid coupling)	4 nos each type and size
iii)	Resilient Drive plate assy.	1 no. of each type and size
iv)	Bearings	1 no. of each type and size
v)	Seal kit for fluid coupling	2 sets of each size
vi)	Fusible plug	10 nos. of each size
vii)	Complete actuator and engaging assembly (including motor, gear box etc.)	1 set of each type
viii)	Oil Cooler assembly (if applicable)	1 set of each type
ix)	Oil pump-motor set (if applicable)	1 set of each type
x)	Oil filters	5 sets of each type
xi)	Oil/Cooler valves (if applicable)	2 nos. of each type
c)	**Belting**	
	Conveyor Belt	
	i) Main Conveyors	2 drum length of 250 m of each type, size and rating if total population of particular type, size and rating of conveyor is equal to or more than 2500 m
		1 drum length of 250 m of each type, size and rating if total population of particular type, size and rating of conveyor is less than 2500 m
	ii) Belt feeder & bunker seal belt, as applicable	one complete length of each type
	d) Brakes	
	i) Brakes	1 no of each size & type ii) Brake shoes 2 sets of each size
D)	**PULLEYS**	
	i) Pulleys complete with shaft excluding bearing & plummer blocks (complete with lagging)	1 no. of each type and size in pulley drum and shaft dia.(for population upto 10 Nos)

Sl.No.	Description	Nos./Sets
		2 no. of each type and size in pulley drum and shaft dia.(for population more than 10 Nos)
	ii) Plummer Block complete with bearings & sleeves	2 no. each type and size
	iii) SS Pulleys complete with shaft excluding bearing & plummer blocks (complete with lagging)	1 no. of each type and size in pulley drum and shaft dia.
E)	**BELT CLEANERS AND SKIRT BOARD**	
	i) Modular segments for belt cleaner	5 %of total population of each type & size
	ii) Modular segments skirt rubber for skirt board	5 %of total population of each type & size
	iiI) Skirt Rubber	5 %of total population of each type & size
	iv) Complete belt cleaner (internal / external)	2 %of total population of each type & size
F)	**IN-LINE MAGNETIC SEPARATORS**	
	i) Cleated conveyor belt	1 set
	ii) Motor, gear box drive assy. complete	1 set
	iii) Pulleys with plummer block & bearings	1 set of each size & type
	iv) Sheaves	1 no. of each size & type
	v) V-belts	2 no. of each size & type
G)	**LIME SAMPLER**	
	i) Plummer block	1 no. of each type and size
	ii) Hammers	1 set of each type and size
	iii) Liner plate	1 set
	iv) Cutter lip	1 no.
	v) Cutter seal	1 no.
	vi) V-belts (for crusher)	1 sets
	vii) Hammer pins	1 sets of each type and size
	viii) Pulley	1 no. of each type and size
	ix) Conveyor belt	1.2 times length of each type and rating
	x) Gear box assembly for conveyor	1 no. of each type and rating
	xi) Gear box drive assy, for primary and secondary samplers	1 set of each type and rating
	xii) Hydraulic pump with motor and coupling	1 set of each type

Sl.No.	Description	Nos./Sets
	xiii) Hydraulic motor	1 set of each type
	xiv) Hydraulic cylinder	1 set of each type
	xv) Cylinder sealing kit	2 set of each type
	xvi) Set of hoses	2 set of each type
	xvii) Coupling with grid for primary sampler	2 sets
	xviii) Screw conveyor gear box assembly	1 set
H)	**ELECTRIC HOISTS**	
i)	Brake linings	2 sets of each type
ii)	Rope guide & rope tightner	1 no. of each type
iii)	Limit switch	2 nos. of each type & size
iv)	Gear box/gear set	2 sets of each type
v)	Motor/geared motor	1 no of each type & rating
vi)	Drum bearing	1 set of each type & rating
I)	**FLAP GATES (INCLUDING THAT OF TRIPPERS)**	
i)	Limit switch	6 nos. of each type & rating
ii)	Actuator (complete with motor, gear box,limit switches etc.)	nos. of each type & rating
iii)	Oil seals of Actuator	nos. of each type & rating
iv)	Flap gate shaft	nos. of each type & rating
v)	Pressure nut	nos. of each type & rating
J)	**DUST SUPPRESSION, SERVICE WATER, POTABLE WATER, COOLING WATER**	
a)	Pump impeller with key & nut	set of each type & size
b)	Pump Shaft	no of each type & size
c)	Bearings	sets each type & size
d)	Wearing rings	sets of each type & size
e)	Shaft sleeve	sets of each type & size
f)	Bushings	sets of each type & size
g)	Coupling bolts & nuts (with bushes) 2 sets	sets each type & size
h)	Spray nozzles	nos.of each type & size
i)	Spray nozzles (for plain water dust suppression)	nos.of each type & size
j)	Solenoid valves	% of each type and size
k)	Globe valve / plug valves	% of each type and size
l)	Gate valve	nos. of each size

Sl.No.	Description	Nos./Sets
m)	Strainers	no. of each type
n)	Compressor	
(i)	Air filter element	8 Nos.
(ii)	Oil filter	6 Nos.
(iii)	Discharge Check Valve	3 Nos.
(iv)	Oil Pump Parts (including distance ring, eccentric rings, Pump element, Pin, Key O, Ring) as applicable	2 Sets
(v)	Inlet Valve Assembly	2 Nos.
(vi)	Electronic regulator	3 Nos.
K)	**BUCKET ELEVATOR**	
(i)	Buckets	10% of total population
(ii)	Belt for bucket elevator	10% of total length
(iii)	Linkages	20% of total population
L)	**VENTILATION SYSTEM**	
i)	V-Belt	1 set of each type
ii)	Pre-filter element of pressurizing fans	2 sets of each type
iii)	Foundation Rubber pads	1 sets of each type & size
iv)	Bearings	1 sets of each type & size
v)	Plummer Blocks	1 set of each type & size
M)	**TRAVELLING TRIPPER**	
I)	Complete drive assembly including gear box, coupling, brake etc.	1 Set
ii)	Complete internals of speed reducer (including input shaft, output shaft, gearset)	1 set of each size & type
iii)	Bearings for reducer	2 Sets
iv)	Drive axle with wheels, plummer blocks, bearings etc.	1 Set
v)	Oil seals	2 nos. of each size
vi)	Non-drive axle with wheels plummer blocks, bearings etc.	1 set of each type
vii)	Flap gate actuator with motor, gear box, position / thrust switches	1 set of each type
viii)	Chain assembly with sprockets	1 set of each type & size
ix)	Festoon Roller assembly for flexible cable	4 Nos
` x)	Pulleys and plummer block bearings	1 no of each type
xi)	Plummer block with bearing for cable reel drums	1 set of each type

Sl.No.	Description	Nos./Sets
N)	**ELEVATOR**	
a.	**Brake**	
	1. Tool to brake	1 No.
	2. Fan	1 No.
	3. Magnet coil with housing pads	2 Nos.
	4. Brake pads	6 Nos.
	5. Adjusting sleeve	2 Nos.
	6. Fixed brake disc	2 Nos.
b.	**Worm Gear**	
	1. Worm gear	1 no.
	2. 'O' ring	2 nos. of each type
	3. Sealing ring	2 nos. of each type
c.	**Door Front**	
	1. Bearing	2 Nos.
	2. Roller	3 Nos.
	3. Bushing	2 Nos.
d.	**Limit Cams**	
	1. Sensor	1 No.
	2. Switch	2 Nos.
	3. Switch arm	2 Nos.
e.	**CAD**	
	1. Guide roller	50 % of the total ones installed each type or minimum 1 no. whichever is higher
	2. Switch	1 no.
f.	**Sliding Door**	
	1. Rollers	4 nos. of each type
g.	**Machinery**	
	1. Guide roller	2 Nos.
	2. Pinion	1 no.
	3. Rubber inserts	6 nos
	4. Grove ring	6 nos.
	5. Brake motor	1 no.
h.	**Cable trolley**	
	1. Ball bearing	2 nos. of each type

Sl.No.	Description	Nos./Sets
O.	**Paddle feeder**	
1.	Rotor arm with liners & bolts	1 sets of each type
2.	Liners of rotor arms	2 sets of each type
3.	Gear box (including paddle wheel, Travel drive, cable reel drive)	
	(i) Complete assembly	1 set of each type
	(ii) Bearings	1 set of each type
	(iii) Oil seals	2 nos.of each size.
	(iv) Input shaft with pinion	2 set of each type
4.	Hydraulic power pack	
	(i) Rotor pump with electric motor, coupling, valves & servo motor (mounted on pump) etc.	2 set of each type & rating
	(ii) Solenoid valves complete with coils	2 set of each type & size.
	(iii) Filter element (1 no. pressure filter + 1 no. return filter)	10 sets of each type
	(iv) Hydraulic hoses	4 sets
	(v) Hydraulic motor (for feeder)	2 nos of each type.
	(vi) Hydraulic motor (for traverse drive)	2 nos of each type.
	(vii) Traverse pump with electric motor, coupling, valves (mounted on pump) & servo motor (on pump) etc	2 nos of each type.
	(viii) Dust suppression pump and motor assembly	1 no of each type.
	(ix) Spary nozzles of dust suppression system	10 nos. of each type.
	(x) Cooler	1 no. each type
5.	Carriage Wheel assembly	
	(i) Bearings	2 nos. each type & size.
	(ii) Plummer block	2 nos. each type & size.
	(iii) Oil seals	2 nos. each type & size.
	(iv) Carriage wheel with shaft (without plummer block)	1 set
	(v) Traverse drive aasy including electric motor, gear box, coupling etc, or geared motor as applicable.	1 set
	(vi) Tension roller of paddle feeder trolley	1 set
6.	(i) All type of coupling (including those between electric motor and pump, between hydraulic motor and gear box and paddle wheel & between carriage wheel and	2 nos, of each type.

Sl.No.	Description	Nos./Sets
	motor)	
	(ii) Coupling bolt with bushes / spider / inserts	2 sets of each size.
	(iii) Rubber bush/ spider/ inserts	8 sets of each size.
7.	(i) Brakes (if any)	2 sets of each type & size.
	(ii) Brake shoe	4 sets of each type & size.
8.	Cable reel drive	
	(i) Complete drive unit assembly including motor, gear box, coupling etc.	1 ses of each type & rating.
	(ii) Chain	2 nos.
	(iii) Plummer block and bearings for cable reel drum	1 sets
	(iv) Cable guide assembly	1 set
	(v) Torque regulator unit	1 set
	(vi) Friction pads	2 sets
	(vii) Spring stacks	2 sets
	(viii) Oil seals	4 sets
	(ix) Eddy current/magnetic coupling	1 set of each type & rating.
	(x) Spare festoon hanger cum roller assembly (below CRD)	10 nos.
	(xi) Spare energy chain links	5% of population
P	**Lime Crusher**	
	(i) Plummerblock assembly complete including bearing, lock nut, lock washer etc (DE+ NDE)	2 sets
	(ii) Shaft seal	4 sets
	(iii) Hammer sets	10 sets or 750 nos. whichever is more (1 set means hammers required for one crusher)
	(iv) Rotor assembly complete consisting of rotor shaft & keys, end discs, centre discs, distance rings, suspension bars, disc clamping nuts and shaft extension etc.but without hammers, bearings and pillow blocks	1 set
	(v) Cage bars/perforated screen plates as applicable	4 sets
	(vi) Breaker plate	4 sets
	(vii) Liners	2 sets
	(viii) Suspension bars	4 sets
	(ix) Kick-off plate	4 sets

Sl.No.	Description	Nos./Sets
	(x) Screen plate upper & lower	4 nos. each
	(xi) Tramp iron pick up plate	2 nos each
	(xii) Fluid coupling	
	a. Fluid coupling complete	1 set
	b. Bearing	2 sets
	c. Seal kit (sealing rings)	2 sets
	d. Fusible plugs	8 nos.
	e. Oil pump motor set (if applicable)	1 set of each type
	f. Oil filter	3 sets
	g. Complete actuator and engaging assembly (including motor, gear box etc.)	1 set
	h. Cooler assembly (if applicable)	1 no.
	i. Oil / water valves	2 nos. each type.
	j. Gear coupling/other flexible coupling of crusher drive along with bolts and sealing kit, as applicable	2 sets
	k. Multi disc assembly (for fluid coupling)	2 sets of each type & rating.
	l. Resilient drive plate assy	2 sets each type and rating.
Q	**Vibrating (grizzly/screening) feeder**	
	(i) Bearings	2 nos. each type & size
	(ii) Seals	2 nos. each size.
	(iii) Liners	1 sets
	(iv) Screen plates	10 sets
	(v) Complete vibrating assembly consisting of all rotating parts including drive & driven unbalanced shafts including bearings, casing, spring, vibrating blocks, main shaft, sheave & unbalanced weights as applicable	1 set of each type and rating and direction
	(vi) Hoses (if applicable)	2 sets
	(vii) Drive unit assembly (including electric motor, hydraulic pump, hydraulic motor, flexible shaft, gear box, as applicable)	1 set
	(viii) Base springs, rubber parts	2 sets of each type & size.
	(ix) V belts	4 sets of each type & size.
R	**Rack & pinion Gate**	
	(i) Limit switch	2 nos. each type & size

Sl.No.	Description	Nos./Sets
	(ii) Rollers with bearings	2 nos. each size
	(iii) Motor gear box assembly	1 set of each type
	(iv) Actuator (Complete with motor, gear box, limit switches etc)	1 no each type & size
S	**Sump Pump**	
	(i) Complete pump assembly with pump, motor, coupling base etc.	1 set
	(ii) Impeller with key & nut	2 nos. each type & size
	(iii) Oil seal	2 nos. each type
	(iv) Coupling bolt with bushes	2 nos. each type
	(v) Pump shaft	2 sets each size
	(vi) Shaft sleeve	2 sets each size
	(vii) Bearing bush	2 sets each type
	(viii) Set of bearings	2 sets

Note :

1. Unless stated otherwise a 'set' means items or sub-items required for each type/size range of the assembly/ sub-assembly, required for replacement in one main equipment. It is further intended that the assembly/ sub-assembly which have different orientation (like left hand or right hand, top or bottom), different direction of rotation or mirror image positioning or any other reasons which result in maintaining two different sets of the spares to be used for the subject assembly/ sub-assembly, these shall be considered as different types of assembly/ sub-assembly.

2. Wherever quantity has been specified as percentage (%), the quantity of mandatory spares to be provided by contractor shall be the specified percentage (%) of the total population of the plant. In case the quality so calculated happens to be a fraction, the same shall be rounded off to next higher whole number.

3. Whenever the quantities have been indicated for each type, size, thickness, material, radius, range etc., these shall cover all the items supplied and installed and the breakup for these shall be furnished in the bid.

4. In case spares indicated in the list are not applicable to the particular design offered by the bidder, the bidder should offer spares applicable to offered design with quantities generally in line with the approach followed in the above list.

5. Price of each and every item is to be given separately

1.21.0 AIR CONDITIONING AND VENTILATION SYSTEM

Sl.No.	Description	Nos./Sets
1.0	**Air handling unit (for each model)**	
1.1	V-belts for AHU Blower	2 Sets
1.2	AHU Blower bearing	1 Set
1.3	Blower motor bearing	1 Set
1.4	Filters at suction and discharge of all AHUs	25% of installed population
2.0	**Unitary air filtration unit**	
2.1	Supply Air fans	
2.1.1	V-belts for supply air fans	2 Sets
2.1.2	Supply air fan bearings	1 Set
2.2	UAF Pump	
2.2.1	Pump bearings	1 Set
2.2.2	Impeller for pump	1 no.
2.2.3	Pump Shaft	1 no.
2.2.4	Shaft sleeves	1 Set
2.2.5	Gland Packings for pumps	1 Set
2.2.6	Nylon Filter	1 Set
2.2.7	Spray nozzles	5% of total population or 50 Numbers whichever is higher.
2.2.8	Water strainer	1 No.
2.2.9	Brass suction screen/strainer for unitary air filtration tank.	1 Set
2.2.10	Motor for Centrifugal fan for UAF	1 No
3.0	**Control & Instrumentation**	
i)	Air-Conditioning System	
3.1	Electronic Transmitters	
3.1.1	Transmitters of all types and model no. (for the measurement of Pressure, differential pressure flow, level, temperature etc.)	5% or 1 No. of each type and model whichever is more. (to be divided into various ranges in proportion to main population)
3.2	Temperature elements	
	RTD's	5% or 1 No. whichever is more **
	Thermo well * (With head assembly, terminal block and nipple)	5% or 1 No. whichever is more ** ** (to be divided into various insertion lengths in proportion to main population)

Sl.No.	Description	Nos./Sets
	All types of Local Indicators	5% or 1 No. of each make, model and type whichever is more (to be divided to various ranges in proportion to main population of all make, model and type)
	Process Actuated Switch Devices Includes all types of Pressure, differential pressure, flow, and temperature, and differential temperature, level switch Devices.	5% or 1No. of each type and model whichever is more.
	Relative Humidity Sensors	1 No.
	Geyserstat	1 No.
	Local Humidity/Temperature indicators	2 Nos. each
4.0	**Process Connection Piping (for Impulse Piping / Tubing, Sampling Piping / Tubing and Air Supply Piping as Applicable**	
4.1	Valves	10% or 1 No. of each type, class, size and model whichever is more
4.2	2 way, 3way, 5way valve manifolds	2 way, 3way, 5way valve manifolds
4.3	Fittings	2 way, 3way, 5way valve manifolds
	(II) Ventilation System	
5.0	**Measuring Instruments**	
5.1	Pressure gauge	1 No. (for centrifugal pumps of UAF units).
5.2	Level transmitter	1 No. (for UAF units)
5.3	Pressure transmitter	1 No. (for UAF Units)
6.0	**Process Connection Piping (for Impulse Piping / Tubing, Sampling Piping / Tubing and Air Supply Piping as Applicable)**	
6.1	Valves	1 no. of each type, class, size and Model
6.2	2 way valve manifold	1 no. of each type, class, size and model
6.3	Fittings	1 no. of each type, class, size and model

1.22.0 FIRE DETECTION AND PROTECTION SYSTEM

Sl.No.	Description	Data
1.0	**DELUGE VALVE ASSEMBLIES**	
1.1	Complete deluge valve assembly along with internals and accessories	
1.1.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
1.1.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
1.2	Clapper assembly complete (consisting of clapper seat rubber, screws, etc.)	
1.2.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
1.2.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
1.3	Solenoid coils	
1.3.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
1.3.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
2	**VALVES (BUTTERFLY)**	
2.1	**Butterfly**	
2.1.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.1.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.2	**Disc (Butterfly)**	
2.2.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.2.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.3	**Stem for Butterfly Valve**	
2.3.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.3.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.4	**Gasket for Butterfly Valve**	
2.4.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.

Sl.No.	Description	Data
2.4.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.5	**Bushing/Bearing (butterfly valve)**	
2.5.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
2.5.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
3.0	**BASKET STRAINERS / Y-TYPE STRAINERS for HVW / MVW SPRAY SYSTEM**	
3.1	Strainer elements with o-rings and stiffeners.	
3.1.1	Y- Type strainer	
3.1.1.1	100 NB	10% or 1 No. of each type, class, size and model whichever is more.
3.1.1.2	80 NB	10% or 1 No. of each type, class, size and model whichever is more.
4	**MVW SPRAY SYSTEM**	
4.1	Spray Nozzles	10% or 10 No. of each type, class, size and model whichever is more.
4.2	QB Detectors	10% or 20 No. of each type, class, size and model whichever is more.
5.0	**HVW SPRAY SYSTEM**	
5.1	Spray nozzles	10% or 10 No. of each type, class, size and model whichever is more.
5.2	QB Detectors	10% or 20 No. of each type, class, size and model whichever is more.
6.0	**FIRE DETECTORS**	
6.1	Multisensor detectors (Addressable)	10% or 10 No. of each type, class, size and model whichever is more.
6.2	Indicators assembly for smoke detectors provided in false ceiling (Response indicator)	10% or 10 No. of each type, class, size and model whichever is more.
6.3	LHS cable for conveyors	10% of each type, class, size and model whichever is more.
7.0	**CONTROL AND INSTRUMENTATION**	
7.1	**MEASURING INSTRUMENTS**	
7.1.1	All types of Local indicators	1 no. of each make, model and type
7.1.2	Process Actuated Switch Devices : (All types of Pressure, diff. pressure, flow, temperature, level switch devices).	1 no. of each type and model

Sl.No.	Description	Data
7.1.3	All type of Electronic Transmitters and Ultrasonic Transmitters including sensors.	10% or 1 no. of each type and model whichever is more.
7.1.4	Limit switches for isolation valves	1 no. of each type
7.2	**PROCESS CONNECTION PIPING (For Impulse Piping / Tubing and Air Supply Piping as Applicable)**	
7.2.1	Valves	1 no. of each type, class, size and model.
7.2.2	2 way, 3 way, 5 way valve manifolds	1 no. of each type, class, size and model.
7.2.3	Fittings	5% or 1 no. of each type, class, size and model whichever is more.
7.3	**CABLES**	
7.3.1	Pre fabricated cable of each type.	1 no. of each type, size and model .
7.3.2	Pre fabricated cable connector	1 no. of each type and model
7.3.3	Other cables (including core cable, short term fire proof cable, fibre optic cables etc)	5% of each type, pair/ core and size of actual installed quantity.
7.4	**FIRE ALARM PANEL & REPEATER FIRE ALARM PANEL**	
7.4.1	Fuses	100% of population
7.4.2	Indicating lamps	100% of population
7.4.3	Push Button	10 Nos. of each type and rating
7.4.4	Power supply modules	10% or 1 No. of each type & rating whichever is more
7.4.5	Control modules, loop cards modules, isolator cards	10% or 1 No. of each type, whichever is more.
7.4.6	LCD display of each type unit of panel	1 No.
7.4.7	Cartridges for printers	2 Nos.
7.4.8	Interface unit / modules for non- addressable devices, auxiliary / output relay modules, control modules, supervisory control modules and any other electronic modules	10% or 1 No. of each type whichever is more.
7.4.9	LED's of each type	100% of population.
7.4.10	Power supervision relay	4 Nos. of each type.
7.4.11	Fire screen / alarm buzzer	1 No. of each type

1.23.0 COMPRESSED AIR SYSTEM

Sl.No.	Description	Nos./Sets
1.0	**Oil Free Screw Compressor**	
1.1	H.P Stage Complete HP stage assembly consisting of high pressure element, bearing for male and female rotors (drive end), bearing for male and female rotors (non-drive end), timing gears, graphite ring shaft for compressor chamber seals or white metal labyrinth, suction valve, discharge valve, packing set, axial thrust bearing, labyrinth oil seal or radial seals or double acting seals for drive shafts.	1 set of each type/rating.
1.2	L.P Stage Complete LP stage assembly consisting of high pressure element, bearing for male and female rotors (drive end), bearing for male and female rotors (non-drive end), timing gears, graphite ring shaft for compressor chamber seals or white metal labyrinth, suction valve, discharge valve, packing set, axial thrust bearing, labyrinth oil seal or radial seals or double acting seals for drive shafts.	1 set of each type/rating.
1.3	Motor bearings	2 sets
1.4	LP stage gear and pinion	1 set
1.5	HP stage gear and pinion	1 set
1.6	Air intake filter element with gaskets	4 sets
1.7	Oil filter element with gaskets & seals	4 sets
1.8	Safety valve springs and gaskets for HP stage	1 set
1.9	Safety valve springs and gaskets for LP stage	1 set
1.10	Valves (within compressor house with actuators).	2 nos. of each type/ratings/size.
1.11	**Oil pump/motor**	
1.11.1	Oil pump and motor complete assembly	1 set
1.11.2	Pump impeller/rotor with shaft	1 set
1.11.3	Set of bearings	2 sets
1.11.4	Set of seals	2 sets
1.12	Drain/moisture trap	2 set of each type/size.
1.13	Oil cooler gaskets & seals	2 sets
2.0	**Air Drying plant (Twin tower type) for IA system (as applicable)**	
2.1	Pre filter element	2 sets
2.2	After filter elements (ceramic candle or as applicable)	2 sets
2.3	Heater element(if applicable)	1 sets
2.4	Blower bearing (if applicable)	1 sets
2.5	Blower motor bearing (if applicable)	2 sets
2.6	Valves & valve actuators (Pneumatic/hydraulic)	2 sets
2.7	Heater coil for temperature stabilization (for HOC type, as applicable)	2 sets
3.0	**Rotary drum type air drying plant for IA(as applicable)**	
3.1	Drive assembly consisting of motor, gear boxes, drive shaft & coupling	1 set
3.2	Motor for air compressor	1 no.
3.3	Measuring Instruments	

Sl.No.	Description	Nos./Sets
	1. Electronic Transmitters	
	(i) Transmitters of all types, ranges and model no.(for the measurement of pressure, differential pressure, flow, level etc)	10% or 1 no. of each type and model, whichever is more.
	2. Temperature elements	10% or 2 no. of each type and model, whichever is more.
	(i) RTDs of each type & length	
	(ii) Thermocouples of each type like K-type, R-type, metal etc. and length	10% or 2 no. of each type and model, whichever is more.
	(iii) Thermowell	10% or 2 no. of each type and model, whichever is more.
	3. Local indicators like temperature gauges, pressure gauges, DP gauges, flow gauges, flow meters etc.	5% or 1 no. each make, model and type whichever is more (to be divided to various ranges in proportion to main of all make)
	4. Process actuated switch devices includes all types of pressure, Dp,flow, temperature, differential temperature, level switch devices	5% or 1 no. each make, model and type whichever is more
	5. Dew point meters	5% or 1 no. each make, model and type whichever is more
3.4	**Micro processor based/PLC based control/Electronic based control panel (if applicable)**	
	1. Fully programmed controller of electronic modules of each type (as applicable)	10% or 1 no. whichever is more.
	2. Power supply module (if applicable)	10% or 1 no. whichever is more.

ELECTRICAL MANDATORY SPARES

Sl.No.	Description	Nos./Sets
	LT Switchgear-Part-A	
1	Complete breaker	10% of each type & rating (min 1 no.)
2	Ammeter	2 nos. of each type, size and range
3	Voltmeter	2 nos. of each type, size and range
4	Relays	10% of each type (min 2 nos.)
5	Busbar support insulators	10 nos.
	Part-B	
6	Spring charging motors	3 nos. of each type and rating
7	Aux Contact set	6 sets of each type and rating
8	Limit Switches	10 nos. of each type
9	Arc chutes	10% of each type and rating
10	Fixed contact set	3 nos. set of each type and rating
11	Moving Contact set	3 nos. set of each type and rating
12	Arcing contact	3 nos. sets of each type
13	Charging spring	2 nos. of each type & rating
14	Current transformer	3 nos. of each type and ratio
15	Closing coil	6 nos. of each type & rating
16	Trip Coil	6 nos. of each type & rating
17	CT of Bimetal O/L Relay	3 nos. of each type & rating
18	Voltage Transformer	3 nos. of each type & rating
19	Control Supply Transformer	3 nos. of each type and rating
20 a.	Power Contactor	2 nos. of each type and rating
b.	Coil for above Contactor	2 nos. of each type and rating
21	Air Break switches/MCCB's	3 nos. of each type and rating
22	DP Air break switches(DC)	3 nos. of each type and rating
23	Control & Selector switches	3 nos. of each type and rating
24	Control Fuses and Neutral links	Total 50 nos. (Fuses) & 10 nos. neutral links to cover all the ratings
25	Indicating Lamps	Total 30 nos. to cover all the

Sl.No.	Description	Nos./Sets
		types and ratings
26	Vertical busbar dropper support insulators	25 nos.
27	Busduct flexible connectors (both transformer and switchgear end)	1 set for three phases of each type & rating
28 a.	Primary disconnect in MCC (Busbar end) (male/female contact)	Total 15 nos. proportionately divide for all ratings
b.	Secondary disconnect in MCC (Cable end)	Total 15 nos. proportionately divide for all ratings
29	Pushbuttons	10 nos. of each type
30	Power Fuses	Total 20% proportionately divide for all ratings (min 3 nos.)
31	Thermal Bimetal Relays	Total 5% proportionately divide for all ratings (min 1 no.)
32	Current Transducers	2 nos. of each type & rating
33	Voltage Transducer	2 nos. of each type & rating
34	Busbar Aluminium flat pieces	12 meters of each type & rating
35	Busbar angles / formed pieces for breaker	2 nos. of each type
36	Terminal Blocks	12 nos. of each type & rating
37	Electrical Actuators	1 no. of each type and rating
38	LED Fixture	5 nos. of each type & rating
	MV SWITCHGEAR	
39	Breaker of each rating	10% of each type & rating (min 1 no.)
40	Numerical Relays	10% of each type & rating (min 2 no.)
41	Aux Relays/ Lockout Relays/Timers (if applicable)	10% of each type & rating (min 2 no.)
42	Busbar support insulators	12 nos.
43	Energymeter of each type and range	1 no. of each type
44	Spring charging motor complete	2 nos. of each type
45	Current Transformer of each type and rating	3 nos. of each type
46	Potential Transformer of each type and rating	3 nos. of each type
47	Shunt Trip Coil	5 nos. of each type & rating
48	Closing coils	5 nos. of each type & rating

Sl.No.	Description	Nos./Sets
49	Moving contact assembly of each rating (one set means complete replacement for one breaker)	2 sets
50	Stationary (fixed) contact of each rating (one set means complete replacement for one breaker)	2 sets
51	Bus seal off bushings	3 nos. of each type & size
52	Limit Switches	10 nos. of each type
53	Control Switches	2 nos. of each type
54	Selector switches	2 nos. of each type
55	Isolation switch for control supply	2 nos.
56	Circuit Breaker auxiliary contact assembly	6 nos. of each type & contact
57	Indicating lamps with holders	20 set
58	a. Fuse base and holder	12 nos.
	b. Fuse Link	12 nos.
59	Isolating contact (fixed & moving)(one set means male and female contacts of one complete breaker)	4 sets of each rating
60	Terminal Blocks	6 nos.
61	Multiple pin plug contact assembly with cables (male & female)	6 nos.
62	Inter phase barrier	2 nos. of each type
63	Vacuum Contactors with HRC fuses (if applicable)	2 sets (one set=3 fuses)
64	Surge Arresters	3 nos. of each rating
	MV BUSDUCT	
65	Support insulators of each type	10 nos.
66	Three phase set of flexible terminal connectors for switchgear end of each type and rating	1 set
67	Three phase set of flexible terminal connector for transformer end of each rating & type	1 set
68	Seal off bushings of each type and rating	3 nos.
	TRANSFORMERS	
69	HV Bushing with metal parts and gaskets	2 nos.
70	LV bushing with metal parts and gaskets	2 nos.
71	LV Neutral bushing with metal parts and gaskets	2 nos.
72	WTI with contacts	1 no.
73	OTI with contacts	1 no.
74	Pressure relief device	1 no.
75	MOG	1 no.

Sl.No.	Description	Nos./Sets
76	Bucholz relay complete	1 no.
77	Set of gaskets	1 set
78	Set of valves	2 nos. of each type/size
79	Air cell for conservator	1 no.
80	Neutral grounding resistor w/o supporting structure	1 no.

CONTROL AND INSTRUMENTATION

1.00.00	**CONTROL AND INSTRUMENTATION**	
1.01.00	**MEASURING INSTRUMENTS**	
1.01.01	1.1 All type of Transmitters including sensors.	10% or 1 no. of each type and model whichever is more.
1.01.02	1. Temperature elements	
	1.1 RTD's* of each type and length(with head assembly, terminal block & nipple)	10% or 2 nos. of each type and length, whichever is more
	1.2 Thermocouples of each type like K-type, R-type, metal etc. * (with head assembly, terminal block & nipple)	10% or 2 nos. of each type and length whichever is more
	1.3 Cold junction compensation boxes of each model (if applicable)	10% or 2 nos. whichever is more
	1.4 Thermostatic units for each model of CJC box (if applicable)	10% or 2 nos. whichever is more
	1.5 Temperature transmitters	10% of each type and length
1.01.03	1.1 Limit switches for isolation valves	2 nos. of each type
	1.2 Local Indicators like temperature gauges, pressure gauges, differential pressure gauges, flow gauges, flow meters etc.,	5% or 1 no. of each make, model and type whichever is more (to be divided to various ranges in proportion to main of all make, model, type population)
	1.3 Process Actuated Switch Devices Includes all types of Pressure, differential pressure, flow, temperature, differential temperature, level switch Devices	5% or 1 no. of each type and model whichever is more
1.01.04	Any other instrument (Flow transmitter, Density meter) (as applicable)	10% or 1 no. of each type and model whichever is more
1.02.00	CEMS (SOx, NOx, CO, C02, Mercury, Stack opacity, flue gas flow):-	
(a)	Analyzer for SOx, NOx, C02, CO.	1 no complete instrument of each type and model.
(b)	Flue gas flow measurement	1 no. complete instrument along with sender/receiver unit
(c)	Stack Opacity measurement	1 no. complete instrument along with sender/receiver unit
(d)	Electronic card assembly/ PCBs, moisture/condensate monitor, power supply modules	10% of each type, model and rating
(e)	Set of gaskets/0-rings/ seals	200% of each type, model, rating and size
(f)	Temp. Sensor	20% of each type and model
(g)	Heater assembly, Cooler assembly	20% of each type and model
(h)	Complete Probe with shield assembly (Not applicable for In situ- path)	1 no. of each type and model
(i)	Solenoids	2 nos. of each type, model and rating
U)	Filters, light source, sensor, detector, etc.	200% of each type, model and rating
(k)	Calibration gases, Calibration cell and other consumables for calibration: - of all types and ranges.	One year supply
(l)	Heavy duty blower assembly	1 no. of each type, size and rating.
(m)	Rotameter/Air flow meter	2 nos. of each type, model and rating
1.03.00A	Analyzers (S02, pH) for FGD system	10% or 2 Nos of each type complete with accessories

1.04.00	**PROCESS CONNECTION PIPING** (For Impulse Piping / Tubing and Air Supply Piping as Applicable)	
	1. Valves of all types and models	10% or 1 no. of each type, class, size and model whichever is more.
	2. 2 way, 3way, 5way valve manifolds	10% or 1 no. of each type, class, size and model whichever is more.
	3. Fittings	10% or 1 packet of each type, class, size and model whichever is more.
	4. Purge meters	5% of each model or 1 no. whichever is more.
	5. Filter regulators	20% of each model or 2 nos. whichever is more.
1.05.00	**CABLES**	
	1. Pre-fabricated cable of each type.	10% of installed quantity
	2. Pre-fabricated cable connector of each type	10% or 1 no. of each type and model, whichever is more.
	3. Other cables	5% of each type, pair and size of actual installed quantity
1.06.00	**24V - DC POWER SUPPLY SYSTEM**	
1.06.01	AC/DC isolators, contactors, timers, relays	10% of each type and rating.
1.06.02	Fuses of each type and rating	200%
1.06.03	Fuse free Circuit breakers	5% of each type and rating.
1.06.04	Electronic modules of all types	10% of each type.
1.06.05	Cooling Fans	2 nos. of each type
1.06.06	Relays of all types including overload relays	10% of each type and rating
1.07.00	**PLC CONTROL SYSTEM**	
1.07.01	Power Supply Unit	1 nos. of each type and model
1.07.02	Electronic modules(I/O modules, communication modules and any other module used in the system)	10% or 1 no. of each type and model, whichever is more.
1.07.03	Central Processor Unit	1 nos. of each type and model.
1.07.04	Interconnecting Cables	10% of each type and size
1.07.05	Cooling Fan in PLC system I cabinet	2 Nos.
1.07.06	Indication lamps of all types	100%
	1. Keyboards/mouse	
	1.1 Keyboard	2 nos. of each type.
	1.2 Mouse	2 nos. of each type.
	2. Printers and their parts	
	2.1 Color laser printer (A4)	1 no
	2.2 Long term storage unit	1 no
	2.3 Blank COs	10 boxes
	3. HMIPIS Devices	
	3.1 OWS with licensed software loaded along with monitor	2 nos. of each type and model.
	3.2 Server for unit LAN or Information Work Stations (As applicable)	1 nos.
	3.3 Net work components like Switch /repeaters/hubs etc. (as applicable)	2 nos. of each type and model.
	3.4 Control units for LVS	1 no.
	4. Cables and Connectors.	
	4.1 Prefab interconnecting cables with connectors	2 nos. of each type and length.
	4.2 System bus cable with connectors	-do-
	4.3 I/O bus cable with connectors for remote I/O units	-do-
	4.4 Power Supply Modules & Power Packs for control system	10% of each type model and rating, whichever is more

	5. Electronic modules of each type and model for control system (This shall include all type of cards like I/O cards, controller cards, CPU module or Card, logic cards etc.)	10% or 2 nos. of each type and model whichever is more
	6. Bus coupler/Interface hardware and other communication devices.	10% of each type and model
	7. Relays	10% of each type and rating
	8. Batteries used for battery backup of RAMs.	10% of each type and model
	9. Fuses	200 %
1.08.00	**OTHER RELATED CONTROL AND INSTRUMENTATION SYSTEMS / EQUIPMENTS**	
	1. Lime Feeders	
	1.1 Motion monitor	10% or 2 nos. whichever is more.
	1.2 Speed pick-up	10% or 2 nos. whichever is more.
	1.3 Torque switch (if applicable)	10% or 2 nos. whichever is more.
	1.4 Load Cell	10% or 2 nos. whichever is more.
	1.5 Electronic cards & Power Supply cards	10% or 2 nos. whichever is more.
	1.6 Clutch (if applicable)	10% or 2 nos. whichever is more.
	1.7 Local indication lamps	200%
	1.8 Panel meters	10% or 2 nos. whichever is more.
	1.9 Limit switch assembly for lime-on- belt, no lime flow, shear pin failure, etc.	10% or 2 nos., whichever is more.
1.09.00	**CONTROL VALVES, ACTUATORS & ACCESSORIES** (Following items shall be provided under this clause for all modulating control valves being supplied under this package)	
	1. Pneumatic and electro-hydraulic actuator assembly	10% or 1 no. of each type, model and rating, whichever is more.
	2. Valve trim (including cage, plug, stem, seat rings, guide bushings etc.)	1 set for each type of control valve.
	3. Diaphragms, 0' rings, seals etc. of all types make etc.	100%
	4. Pressure Gauges of all types, make, rating etc.	10% or 2 nos. of each type whichever is more
	5. Solenoid valves (if applicable)	10% or 2 nos. of each type whichever is more
	6. Positioner units (complete unit) & accessories (link assembly)	10% or 1 no. of each type whichever is more
	7. Pneumatic air-filter/Regulator of each type, make rating etc.	10% or 2 Nos., whichever is more
	8. Air lock relays	10% or 2 nos. of each type whichever is more
1.10.00	**PNEUMATICS ISOLATION / BLOCK VALVES, ACTUATORS & ACCESSORIES** (For all ON/OFF valves supplied under this package)	
	1. Pneumatic actuator assembly	10% or 1 no. of each type, model and rating, whichever is more.
	2. Diaphragms, 0' rings, seals etc. of all types make etc.	100%
	3. Limit switches (complete unit)& accessories (link assembly)	10% or 2 Nos., whichever is more
	4. Pneumatic air-filter/Regulator of each type, make rating etc.	10% or 2 Nos., whichever is more

NOTE:

1. Wherever set is mentioned, one set of the spares of that item shall be for complete replacement of that particular item for one equipment.

2. Any fraction of an item shall mean the next higher integer.

3. Wherever quantity has been specified as percentage (%), the quantity of mandatory spares to be provided by contractor shall be the specified percentage (%) of the total population of the plant. In case the quantity so calculated happens to be fraction, the same shall be rounded off to next higher whole number.

4. Wherever the quantities have been indicated for each type, size, thickness, material, radius, range etc., these shall cover all the items supplied and installed and the breakup for these shall be furnished in the bid.

5. In case spares indicated in the list are not applicable to the particular design offered by the bidder, the bidder should offer spares applicable to offered design with quantities generally in line with the approach followed in the above list.

ANNEX - 1.6

CLEANING, PROTECTIVE COATING AND PAINTING

1.0 General

This specification covers the general requirements related to the cleaning protective coating and painting of equipment, components and systems that are covered under main equipment / system specifications. The components and/or equipment shall be mechanically and /or chemically cleaned during the following stages of the Contract.

- Cleaning in workshop
- Cleaning before painting and/or corrosion protection (application of prime coat)
- Cleaning before erection and during installation.

Cleaning of fabricated component items shall be carried out after fabrication and final heat treatment or welding at manufacturer's works or at site, as appropriate. No paint shall be applied surfaces within 75 mm of field welded connections. These surfaces shall be coated with a consumable preservative and marked.

For cleaning in workshop and before painting, mechanical cleaning by power tool and scrapping with steel wire brushes shall be adopted to clear the surfaces. However, in certain locations where power tool cleaning cannot be carried out, hand scrapping may be permitted with steel wire brushes and/or abrasive paper. Cleaning with solvents shall be resorted to only in such areas where other methods specified above have not achieved the desired results. Cleaning with solvents shall be adopted only after written approval of the Owner / Engineer.

Machined surfaces shall be protected during the cleaning operations.

In the event of the surfaces not being cleaned to the Owner's satisfaction, such parts of the cleaning procedures or agreed alternatives as are deemed necessary to overcome the deficiencies shall be carried out at the supplier's sole expense.

For reclining small areas, hand cleaning by wire brushing may be permitted.

1.1 Codes and Standards

Painting of equipment shall be carried out as per the Codes indicated below and shall conform to the relevant IS Code for the material and workmanship.

The following codes and standards shall be followed for the surface preparation, surface protection and painting works.

IS: 5	Colors for ready mixed paints and enamels.
IS: 101	Methods of test for ready mixed paints and enamels.
IS: 104	Ready mixed paint, brushing, Zinc Chrome, priming.
IS: 158	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and heat resisting.
IS: 161	Heat resistant paints
IS: 1303	Glossary of terms relating to paints.
IS: 1477	Code of practice for painting of ferrous metals in buildings (Parts I & II).
IS: 2074	Specifications for ready mixed paint, Air drying, red oxide zinc chrome priming.
IS: 2338	Code of practice for finishing of wood and wood based materials: Parts 2 schedules.
IS: 2339	Aluminum paint for general purposes, in dual container.
IS: 2395	Code of practice for painting of concrete, masonry and plaster

	surfaces: Part 2 schedules.
IS: 2524	Code of practice for painting of non-ferrous metals in buildings (Parts I & II).
IS: 2932	Specification for enamel, synthetic, exterior (a) undercoating, (b) Finishing
IS: 3140	Code of practice for painting asbestos cement building products.
IS: 6158	Recommended practice for design safeguarding against Embrittlement of hot dip Galvanized Iron & steel products.
IS: 6159	Recommended practice for design & fabrication of Iron &steel products prior to Galvanizing & metal spraying.
IS: 6278	Code of practice for white washing and Color - Washing.
IS: 10221	Code of practice for coating & wrapping of underground mild steel pipelines.
IS: 33	Inorganic pigments and extenders for paints –Methods of sampling & test.
IS: 13183	Aluminum paint, Heat resistant - specifications.
IS: 144	Specification for ready mixed paint brushing, petrol resisting, Air drying for Interior paints of tanks and containers, Red oxide.
IS: 9954	Pictorial surface preparation standards for painting of steel surfaces.
IS: 11883	Specification for Ready Mixed Paint, Air Drying, Red Oxide Priming for metals.
IS: 9404	Color code for identification of pipelines used in the Thermal Power Plants.
IS: 12744	Specification for Ready Mixed Paint, Air Drying, Red Oxide-Zinc Phosphate Priming.
BS: 2015	Glossary of paint selected terms.
BS: 5252	Final coat color.
BS: 7079A1/S1	Specification for rust grades and preparation grades of uncoated substrates after overall removal of previous coating.
BS: 7079A2	Preparations grades of previously coated steel substrates.
BS: 7079GrC	Surface roughness characteristics of blast cleaned steel substrates.
BS: 7079GrD	Methods for surface preparation.
BS-4232	Surface Finish of Blast cleaned steel for painting.
ASTM	American Standard for Testing Material.
ASTM A 780	Standard practice for repair of damaged galvanized coatings.
AWWA	American Water Works Association.
ASA-A-13.1-1981	Scheme for identification of piping system (American National Standard Institution).
DIN	Deutsehes Institute for Normung
S1S-055900-1967	Surface preparation standards for painting steel surfaces. (Swedish standard Institution)
SSPC-SP	Preparation Specifications (Steel structures painting council, U.S.A.).
	National Association of Corrosion Engineers, U.S.A. (NACE).

1.2 Scope of Work and General Requirements

This specification covers the surface preparation, method of application and material to be used for all coating of equipment, steel structures and piping. Steel material subjected to surface preparation on shop/site shall have minimum requirements in accordance with Rust Grade B (SSPC/SSPM Volume-2).

Coating materials according to SSPC, EN ISO, ASTM, BIS or DIN standards, shall be used. The paint shall comply with applicable laws, regulations, ordinances etc., of the local authority,

state or the nation pertains to the work. The materials shall be matched with each other so that they are compatible. Coatings deviating this specification shall be subject to approval.

Standards of surface preparation and painting shall give a time to first maintenance of minimum 10 years.

The paint to be applied shall be approved by Owner.

All paints & paint material used shall be procured from approved manufacturers. Paint shall be supplied in manufacturers original containers with the description of content, specification No., colour, ref no, date of manufacture, shelf life expiry date & pot life.

The paint manufacturers shall provide coating system data sheet for each coating system to be used containing the following information

a. Surface preparations
b. Film thickness (min and max)
c. Min and max recoating intervals at relevant temperatures
d. Mixing ratio, thinner details and coating repair systems

The sample for testing the paint being used may be taken by the Owner at any time.

In general Shop fabricated equipment will be delivered to the site coated with a shop applied system or the manufacturer's standard finish in accordance with the requirements of this specification.

For equipment that has received shop prime coat, all touch-up prime coat and additional coats shall be applied in accordance with the coating schedule. It is responsibility of the vendor to ensure compatibility between shop and field applied paint systems.

Necessary precautions shall be provided to all equipment, structures to protect other surfaces from abrasive blasting, coating over spray and spatter. Damage to other surfaces or equipment shall be repaired by the vendor.

The Contractor shall submit the following for review and approval by the Owner:

a. Manufacturer's recommended paint scheme for the project
b. Latest published product & instructions for application data,
c. Procedures for surface preparation and application.
d. Pre qualification for equipments and blasting materials, product, procedure and personnel qualifications for the paint and painting systems.
e. Painting repair procedures

Painting records shall contain:

- Equipment/components/location painted
- Date of painting
- Paint details such as specification No, colour, date of manufacture, shelf life, expiry date
- Application equipments
- Ambient conditions at the time of painting
- Surface temperature
- Drying time between coating, DFT and number of coatings
- Appropriate work plan for painting.

The supply of all necessary equipments, weather protection, and scaffolding for painting to ensure work is carried out in accordance with the specification and agreed programme.

Maintenance of the paint work until completion of the contract, this shall include repair of any damaged areas caused by third party.

Disposal of painting waste resulting from painting, shall comply with applicable laws, regulations, ordinances etc., of the local authority, state or the nation pertains to the work and coating materials.

It is a mandatory requirement that all operatives working to this procedure take full cognizance and implement necessary safety precautions.

2.0 Cleaning at manufacturer's works

Mechanical cleaning shall preferably be carried out by abrasive blasting. The Owner is prepared to consider alternative methods such as chemical cleaning provided they achieve the necessary surface condition.

In case of chemical cleaning, the detailed procedure for chemical cleaning as well as the system for which chemical cleaning is required shall be submitted by the contractor for Owner's approval. The procedure shall comprise of pre-treatment and acid treatment to achieve cleanliness equivalent to that specified for mechanical cleaning.

Surface condition:
The Metal surfaces shall be clean and free of mil scale, rust, dirt, grease and any other deleterious matter.

Where metal surfaces are to be painted the surface profiles shall conform to the painting specification requirements.

Where this does not apply, surfaces shall have a surface texture not coarser than Grade 80 abrasive paper.

Abrasives:
Abrasives containing silica, silicates or slag residues shall not be used for water/steam side surfaces of plant except for cleaning sand castings, where hydro blasting may be employed.

For austenitic materials only, abrasives containing 98% or more of alumina, $Al_2 O_3$, shall be used.

Removal of abrasive and debris:

After cleaning, abrasive and debris shall be thoroughly removed for components.

3.0 Protection at manufacturer's works

As soon as all items have been cleaned and within four hours of the subsequent drying, they shall be given suitable anti-corrosion protection.

All water, air and steam side surfaces shall be protected by the application of approved water soluble corrosion inhibitors, or vapor phase inhibitors that can be subsequently removed by site water washing or steam blowing.

The gas side of steam generating plant items shall be protected by the application of temporary protective that do not require to be removed before commissioning, but which are removed during initial firing.

The rate of application of volatile corrosion inhibitors shall be at least 10 grams per square meter or 35 grams per cubic metre, whichever is the greater, except for pipes up to 300 mm diameter for which the minimum application rates shall be 5 grams per square metre.

Immediately after the protective treatment has been applied all vessels and pipes shall be suitably sealed off by discs or caps or approved alternatives to prevent ingress from the surroundings. Cylindrical plugs shall not be driven into the ends of pipes. These protective covers shall not be removed until immediately before final connection is made to the associated equipment.

4.0 Weather conditions

Painting shall be done only when the surface temperature is above 5℃. Surface temperature must be at least 3℃ above dew point to ensure that condensation does not occur on the surface.

Reasonable protection against precipitation and seawater spray shall be exercised for the painting of outdoor parts.

Precautions shall also be taken against solar radiation to ensure that the specified dry film thickness of priming or finish coats is obtained.

Any prime coat exposed to excess humidity, rain, dust etc., before drying, shall be permitted to dry and the damaged area of primer shall be removed and the surface prepared and primed again.

Sheltered or unventilated horizontal surfaces on which dew may collect require more protection, and to achieve this additional top coat of paint shall be applied.

The temperature quoted as “normal” in the “Paint System Tables” refers to the average local climatic conditions.

5.0 Surface preparation

In preparing any surface to be coated, all loose paint, dirt, grease, rust, scale, weld slag or spatter or any other extraneous material shall be removed and defects repaired, so as to obtain a clean, dry, even surface to receive the priming or finishing coat (s) as called for in the painting schedules. Sharp edges should be rounded, especially when tank linings have to be applied.

All machined surfaces, including flange faces, shall be suitably covered to prevent damage during surface preparation.

All surfaces should be blast cleaned whenever possible.

Surface preparation methods:

Bare steel surfaces should be prepared by one of the methods described below in order of preference and in accordance with Swedish Standard SIS 05 59 00 or Steel Structures Painting Council, SSPC, Vis 1, or DIN 55928, section 4.

The relative humidity level should not be more than 60% & the steel surface temperature at least 3º C above the dew point during dry blast cleaning operations.

a. White metal blast cleaning Sa 3 or SSPC - SP 5

Sa 3 Blast cleaning to bare metal. Mill scale, rust and foreign matter must be removed completely. Subsequently, the surface is cleaned with vacuum cleaner, clean dry compressed air or a clean brush. It must then have a uniform metallic color and correspond in appearance to the prints designated Sa 3.

b. Near white metal blast cleaning Sa 2 1/2 or SSPC - SP 10

Sa 2 1/2. very thorough blast cleaning. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are slight imperfections in the form of spots or stripes. Subsequently, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It must then correspond in appearance to the prints designated Sa 2 1/2.

Mechanical cleaning should only be used when procedures (a) and (b) are not practicable.

c. Near white metal blast cleaning P Sa 2 1/2 DIN 55928

Very thorough blast cleaning. Very adhesive coatings remain. From all other surface mill scale and rust are to be removed to such an extent that the only traces remaining are slight imperfections in the form of spots or stripes. Further treatments see Sub b).

The adhesivity of residual coatings in the transition zone has to be tested even after the application of the primer.

d. Very thorough mechanical scraping and wire brushing St 3

St 3 very thorough scraping and wire-brushing - machine brushing - grinding - etc. are to be preferred. Surface preparation as for St 2. But much more thoroughly. After the removal of dust, the surface must have a pronounced metallic sheen and correspond to the prints designated St. 3.

e. Thorough scraping and wire brushing St 2

St 2 Thorough scraping and wire-brushing - machine brushing - grinding - etc. The treatment shall remove loose mill scale, rust and foreign matter. Subsequently, the surface is cleaned with a vacuum cleaner, clean dry compressed air or a clean brush. It should then have a faint metallic sheen. The appearance must correspond to the prints designated St 2.

f. Air Blasting with Non-Metallic Abrasives Powder

Whenever the "Duplex"-process is to be applied (hot dip galvanising followed by painting), prepare the hot dip galvanised surface by water washing to remove flux residues and careful air blasting with non-metallic abrasive powder. Use an abrasive with grain size from 0.1 to 0.5 mm, at a greatly reduced air pressure, max. 2 bar (g) (28 psig).

This procedure also applies to stainless steel and aluminium surfaces to be coated.

Surface preparation methods	SIS 055900	DIN 55928 Part-4	BS 4232 only for blasting	SSPC-Vis
Blasting acc to item (a),(b),(c),	Sa 3		First quality	White metal SP 5
Blasting acc to item (b)	Sa 2 1/2		Second quality	near White SP 10
Blasting acc to item (c)	Sa 2		Third quality	Commercial blast SP 6
Hand/or power tool derusting acc to item (e)	St 2		--	Hand tool cleaning SP 2
acc to items (d) and (e)	St 3		--	Power tool cleaning SP 3

Surface preparation methods	SIS 055900	DIN 55928 Part-4	BS 4232 only for blasting	SSPC-Vis
Flame jet cleaning		F1	--	Flame cleaning SP 4
Pickling		Be	--	Pickling

Steel structures to be blast cleaned have to be free of pitting and other severely corroded places in accordance with B.S. 4232 and SIS 055900.

The abrasives used for blast-cleaning shall be graded flint, grit, shot or silica sand and shall be such that they will produce an average keying profile on the blast-cleaned surface of not more than 40 microns.

An air pressure of 7 bar g at the nozzle shall be used.

After blast-cleaning, all accumulated grit, dust, etc., must be removed leaving the surface clean, dry and free of mill scale, rust grease and other foreign matter.

In the event of rusting after completion of the surface preparation, the surface must be cleaned again in the manner specified.

Oil, grease, soil, cement, salts, acids or other corrosive chemicals shall be cleaned from steel surfaces, by the use of solvents, emulsions or cleaning compounds. The final wiping shall be with clean solvent and clean rags or brushes. There shall be no detrimental residue left on the surface.

Primed areas which suffer damage must be spot blasted on site to a degree of cleanliness Sa 2 1/2 before, touching up.

Protective coating must be applied as quickly as possible after the completion of surface preparation no matter what cleaning method has been used.

No blast-cleaned surface shall be allowed to remain uncoated overnight.

Steel work protected by shop primer after arrival on site must be cleaned of salt, sand, oil etc. Before the first coat of paint is applied on site. Shop primer damaged during transport must be rectified by blast-cleaning and coating before application of the site coats.

Wood surfaces shall be sanded clean. All nail holes shall be puttied and sanded before priming.

Concrete: If a protective coating is required, concrete shall be allowed to cure before painting.

6.0 Preparation of coating materials

All containers shall remain un-opened until required for use.

Primers and paints which have livered, gelled or otherwise deteriorated shall not be used.

The oldest primer or paint of each kind shall be used first.

All ingredients in any container shall be thoroughly mixed before use, and shall be agitated frequently during application to keep the primer in suspension.

Primer or paint mixed in the original container shall not be transferred until all settled pigment is incorporated into the body of liquid.

Mixing in open containers shall be done in a well ventilated area.

Primer or paint shall be mixed in a manner ensuring the breakdown of all lumps, complete dispersion of pigment and uniform composition.

Two-component primers shall be mixed in accordance with the manufacturer's instructions.

Thinners shall not be added to primers or paints unless necessary for proper application according to the manufacturer's instructions.

When use of thinners is permitted, it must be added to the primer or paint during mixing.

6.1 Primer Paint

After the surface is prepared, one coat of suitable primer shall be applied. After this first coat is dried up completely, second coat of primer shall be applied.

Primer shall be applied by brushing to ensure a continuous film without 'holidays'. The dry film thickness of each coat shall be as specified in Paint System of this specification.

The primer should be worked by brush application to cover the crevices, corners, sharp edges etc. in the presence of inspector.

The shades of successive coats should be slightly different in color in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per specification approved by Engineer before application of successive coats.

The contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring.

Elko meter for measuring the Dry film thickness of each coat, surface profile gauge for checking of surface profile in case of sand blasting. Holiday detectors and pinhole detectors for checking the painted surface discontinuities should be provided by the contractor.

The contractor shall make arrangements for paint manufacturer to provide expert technical service at site as and when required free of cost and without any obligation to the Owner, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations.

Final inspection shall include measurement of paint dry film thickness, check of finish and workmanship.

6.2 Rub down and Touch Up of Primer

The shop coated surfaces shall be rubbed down thoroughly with emery paper to remove all dust, rust and other foreign matters, washed, degreased, then cleaned with warm fresh water and air dried.

The portions, from where the shop coat has peeled off, shall be touched up and allowed to dry before applying a coat of primer.

The compatibility between shop coat and field primer shall be ascertained from the paint manufacturer. In case degreasing with white spirit is not effective, the surface shall be finally wiped clean with aromatic solvent like xylol or light naphtha.

6.3 Non Compatible Shop Coat Primer

a) The compatibility of finishing coat shall be confirmed from the paint manufacturer. In the event of use of primer such as zinc rich epoxy, inorganic zinc silicate etc., the paint system shall depend on condition of shop coat. If the shop coat is in satisfactory condition showing no major defect, the shop coat shall not be removed. The touch up primer and finishing coat(s) shall be identified for application by Engineer. Shop coated (coated with primer & finishing coat) equipment shall not be repainted unless paint is damaged.

b) Shop primed equipment and surfaces shall only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer shall be completely removed before application of selected paint system for particular environment. For package units/equipment, shop primer shall be as per the paint system given for particular environment.

c) In case of existing paint, compatibility between finishing coat and new selected finish coat shall be ascertained before application of finish coat. In case, the coat is selected for upgrading existing alkyd coating to high performance coating then, surface preparation shall be by manual/mechanical means to remove loose rust, peeled off/damaged paint, but sound old coating need not be removed. It shall be touched with suitable primer wherever it has peeled of before application of tie coat. The tie coat shall be applied after 7 days of curing of the primer. If, new paint system is not suitable to upgrade existing coating then complete paint shall be removed by mechanical or blast cleaning before application of new coating system.

6.4 Finish Paint

Suitable Finish paints as per the schedule shall be applied for the jobs. The color/shade shall be as approved by the Owner. After cleaning the dust on the dried up primer, first coat of finished paint shall be applied. After this first coat dries up hard, the surface is wet scrubbed cutting down to a smooth finish and ensuring that at no place the first coat is completely removed. After applying second coat, allowing the water to get evaporated completely, third finish coat of finish paint may be applied(if applicable).

7.0 Steel Structures Painting

Generally, all steel structures shall receive two primer coats and two finish coats of painting. First coat of primer shall be given in shop after fabrication before dispatch to erection site after surface preparation as described below. The second coat of primer shall be applied (if required) after erection and final alignment of the erected structures. Two finish coats shall also be applied after erection.

Steel surface which is to painted shall be cleaned off dust and grease and the heavier layers of rust shall be removed by chipping to grade ST-2 as per SIS05-5900 or as per IS: 1477 (part -I) prior to actual surface preparation. Suitable primer of required DFT shall be applied as specified in the Paint system of this document- Annex-1.

Suitable finish paint of required DFT shall be applied as specified in the Paint system of this document- Annex-1. The undercoat and finish coat shall be of different tint to distinguish the same from finish paint. All paints shall be of approved brand and shade as per the Owner's requirement.

Joints to be site welded shall have no paint applied within 100 mm of welding zone. Similarly where Friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.

Surfaces inaccessible after assembly shall receive two coats of primer prior to assembly. Surfaces inaccessible after erection including top surfaces of floor beams supporting gratings or chequered plate shall receive one additional coat of finish paint over and above number of coats specified before erection. Portion of steel member embedded / to be encased in concrete shall not be painted.

8.0 Paint Materials

The paints shall conform to the specifications given in this Annex and class - 1 quality in the products range of any of the following manufacturers:

a. Asian Paints (India) Ltd.
b. Bombay Paints
c. Berger Paints India Ltd.,
d. Good lass Nerolac Paints Ltd.,
e. Garware Paints
f. Jenson & Nicholson
g. Shalimar Paints
h. Equivalent other country manufacturer after prior approval of Owner.

9.0 Storage

All paints and painting material shall be stored only in rooms to Engineer's approval. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separated from adjacent buildings. A signboard bearing the words "PAINT STORAGE - NO NAKED LIGHT - HIGHLY INFLAMMABLE - DANGER - NO SMOKING" shall be clearly displayed outside. All paints shall be stored in the safest manner so that no container rolls down and causes accidents. The shelf life of the paints shall be ensured so that the paint materials are not in storage and use after the date of expiry.

10.0 Application

Health and safety of work

The supplier has to check all painting work to be carried out according to the specification of the paint supplier further to all relevant prescriptions and regulations concerning the health and safety of work.

The paint supplier has to present a written specification including at least the flash point of the paints, ventilation requirements, handling precautions such as inhalation, eye and skin protection, and first aid procedure, storage requirements, spill or leak procedure, fire precaution, waste disposal.

Methods

Quality of the surface to be painted or coated has to be tested acc. to DIN 55928 and DIN 8202.

Temporary corrosion protections are to be completely removed prior to applying the definite one, in acc. with DIN 55928.

All prime coatings shall be applied by brush or airless spray or a combination of these methods, as approved by the coating manufacturer.

All doors, windows, stairways, handrails (if painted), bolts, flanges and equipment supports shall be finish painted by brush.

Spray guns should not be used outside in windy weather or near surfaces of a contrasting colour unless the latter is properly protected.

All cold-spray painting shall be done using standard equipment in accordance with accepted standards and methods.

Care has to be taken not to connect spraying devices for nitro and backelite paints simultaneously to oil based paints.

Paint applied to items that are not being painted shall be removed at the supplier's expense, leaving the surface clean, unstained and undamaged.

Dry film thickness (DFT)

To the maximum extent practicable the coats shall be applied as a continuous film of uniform thickness and free of pores. Overspray, skips, runs, sags and drips should be avoided. The different coats shall not be of the same colour.

For a composite paint or coating system consisting of several coats, the total DFT must be at least equal to the sum of the minimal DFT's for the individual coats. If, the paint system does not have the required minimum DFT those areas should be marked & repainted. If the occurrence of those areas is high, the complete surface must be repainted. It is also critically important to check the DFT of primers and intermediate coats and to correct them where necessary.

For paintings based on Zinc silicate the DFT is limited as well on minimum DFT as on maximum (150µm) because of the risk of mud cracking.

Consumption of paints

Has to be evaluated according to DIN 53220. The paints shall be tested as per IS - 101.

Each coat of paint shall be allowed to harden before the next is applied. For epoxy paint the hardening time normally is 12-14 hours. Suppliers' recommendations regarding hardening time of epoxy paints must be followed.

Particular attention must be paid to full film thickness at edges.

The minimum total dry film thickness of the paint systems shall be as recommended in the following tables below. The DFT is given in microns (millionths of a metre).

11.0 Protective coatings and paint systems

The colour coding for identification of pipelines should comply with IS-2379 & IS -9404.

The type and number of protective coats for any item requiring painting are to be in accordance with DIN 55928 and are to be at least of a quality as shown in the attached Annex-1- Paint System.

Alternative to the Annex-1- Paint System specified, are to be presented on the schedule Departure from Specification, as indicated elsewhere.

Generally, all parts shall receive the specified prime coat (s) at the supplier's works to ensure that no corrosion occurs during transport to the site and storage at the site.

Parts which cannot be damaged during transport shall receive the full number of coats.

Types of Substrate, Base metal:

- Ferrous (Surface Temperature during operation < 120º C, EN ISO 12944:1998)

  To this group belongs carbon steel, low alloyed steel & high alloyed steel. All paint systems are inevitable for corrosion protection.

- Hot dip galvanized surfaces.

  Hot dip galvanized surfaces do require painting in a wet, industrial, chemicals and/or marine environment

- SS (EN ISO 12944:1998 conditionally applicable)

  In general, SS surfaces do not require painting unless in a chemical and/or marine environment. In case of chemical and/or marine environments determination of whether or not the surface requires painting depends on the chemical content of the base metal.

  The following formula applies
  W = Cr + 3.3 x Mo + 22.45 N2

  If W < 23, then the surface has to be painted.

  If W < 28 & W > 23, then the surface to be painted if splash contact with the media (i.e. sea) is possible. This may also occur if there is a strong wind carrying drops to the surface.
  If W > 28, then the surface need not be painted.

- Aluminium

  By default such surfaces/components will not be painted. Exceptions are architectural/ aesthetic reasons and high corrosive conditions, which shall be evaluated separately depending on aluminum alloys.

12.0 Galvanizing

Galvanizing works shall conform in all respect to B.S. 729, B.S. 3083 and B.S.C.P. 2008 and to DIN 50976 whatever requires the higher quality and shall be performed by the hot dip process, unless otherwise specified.

It is essential that details of steel members and assemblies which are to be hot-dip galvanized should be designed in accordance with B.S 4479.

Vent-holes and drain-holes should be provided to avoid high internal pressures and air-locks during immersion, which may cause explosions, and to ensure that molten zinc is not retained in pockets during withdrawal.

Careful cleaning of welds is necessary before welded assemblies are dipped. The welds and the surrounding metal should be cleaned separately, preferably be blast-cleaning, because the usual preliminary pickling cannot be relied on to remove the welding slag.

All defects of the steel surface including cracks, surface laminations, laps and folds shall be removed in accordance with B.S. 4360. All drilling, cutting, welding, forming and final fabrication of unit members and assemblies shall be completed, where feasible, before the structures are galvanized. The surface of the steelwork to be galvanized shall be free from paint, oil, grease and similar contaminants in accordance with DIN 55928, part 4 and DIN 50976. The weight of zinc coating per unit area has to be noted in the manufacturing documents in accordance with DIN 50976.

The minimum average coating weight shall be as specified in Table 1 of B.S. 729 or Table 2, DIN 50976, whatever requires higher quality.

Structural steel items shall be initially grit-blasted to B.S. 4232, second quality, (Sa 21/2) or by pickling in a bath and the minimum average coating weight on steel sections 5 mm thick and over shall be 900 g/m^2.

On removal from the galvanizing bath, the resultant coating shall be smooth, continuous, free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross.

Galvanized contact surfaces to be joined by high-tensile friction-grip bolts shall be roughened before assembly so that the required slip factor (defined in B.S. 3294, part 1 and B.S. 4604, part 1) is achieved. Care shall be taken to ensure that the roughening is confined to the area of the mating faces.

Bolts, nuts and washers, including general grade high-tensile friction grip bolts (referred to in B.S. 3139, and B.S.4395 part 1) shall be hot dip galvanized and subsequently centrifuged (according to B.S. 729). Nuts shall be tapped up to 0.4 mm oversize after galvanizing and the threads oiled to permit the nuts to be finger-turned on the bolt for the full depth of the nut. No lubricant, applied to the projecting threads of galvanized high-tensile friction-grip bolt after the bolt has been inserted through the steelwork, must be allowed to come into contact with the mating faces of the steelwork,. A local remelting of the galvanized parts to achieve the nuts to be finger turned on the bolt is possible in accordance with DIN 50976.

Protected slings must be used for offloading and erection. Galvanized work which is to be stored at the works or on site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining (white rust).

Small areas of the galvanized coating damaged in any way shall be restored in accordance with DIN 55928, part A and DIN 50976 by:

- Cleaning the area of any weld slag rust and other impurities and by thorough wire brushing to give a metallic clean surface.

- Application of suitable number of coats of zinc-rich paint containing more than 90 % w/w of zinc in dried film. The dry film thickness shall exceed at least 50 % the thickness of the desired galvanization. In case of application of a low melting point zinc alloy repair rod, the rods shall be in accordance with DIN1707, the thickness of the alloy shall be at least as of the desired galvanization.

The restored area is not to exceed 1 % of the galvanized surface.

Surface restoration of parts in contact with drinking water is not allowed and the quality of the galvanization is to be in accordance with DIN 2444.

After fixing, bolt heads, washers and nuts shall receive two coats of zinc-rich paint. Connections between galvanized surfaces and copper, copper alloy or aluminum surfaces shall be protected by suitable preferably hydrophobe tape wrappings to the owner's approval.

13.0 Sprayed Metal Coatings

Corrosion protection may be also achieved by spraying of suitable metals as zinc and/or aluminum on the surfaces of structures. For special cases tin, copper, lead can be used as well. Methods of surface preparation have to conform to B.S. 2569 or to DIN 8567. A proper treatment of the surface followed by an immediate spraying is to apply to ensure adhesion of the sprayed metal. The surface has to be clean, free of impurities, rust, mill scale and rough enough to have binding properties to ensure good enticulation with the sprayed layer. Suitable

roughness can be achieved by blast cleaning acc. to BS 4232 or DIN 8567. Welds are to be cleaned and prepared with special care. All surfaces to be treated have to be dry and accessible.

Application of coatings, requirements for thickness, adhesion, composition of coating metals, and subsequent treatment have to conform to BS 2569, DIN 8565 and 8567.

Testing of the spray coated layers are to be carried out in accordance with DIN 8565.

The contractor has to specify the type, composition and thickness of the sprayed metal and of the sealing coating according to DIN 8565 including the corresponding warranties and tests if, sprayed metal coating will be applied.

Safety of work:

All precautions connected with this type of application of corrosion protection have to be in accordance with German regulation DVS 2307, page 1. 2.

Sprayed, unfused coating of metals and metallic compounds applied by combustion gas flame, plasma arc, detonation and similar processes, and the preparation of components, spraying techniques, sealing, finishing and inspection shall be according to B.S. 4761.

The hot galvanized surface has to be cleaned before the application of the coats to remove corrosion products, dirt, dust, grease.

The cleaning can be achieved by

- brush off
- washing with 1 - 1.5 % ammonia water with up to 0.1 % detergent added and followed by wet grinding to turn the foam to grey color,
- steam blasting.

14.0 Warning Notes / Signals

This Instruction serves the identification of the coated surfaces that are received from shop in assembled condition / module wise.

The warning note shall prevent any possible damage to the coated surfaces during transportation / assembly at site.

Eg.: Welding work OR Heat treatment work on the outside of coated or lined surfaces is prohibited.

15.0 Colour Code for Piping

a. The colour code scheme is intended for identification of the individual group of the pipeline. The system of colour coding consists of a ground colour and colour bands superimposed on it. The colour coding for the identification of pipelines shall comply with **Annex – 1** of this specification.

   Ground Colour shall be applied throughout the entire length for un insulated pipes. For insulated pipes, on the metal cladding or on the pipes of material such as non-ferrous metals, austenitic stainless steel etc., ground colour coating of minimum 2m length or of adequate length not to be mistaken as colour band shall be applied at places requiring colour bands. Colour band(s) shall be applied at the following location.

   i. At battery limit points

   ii. Intersection points & change of direction points in piping ways.

iii. Other points, such as midway of each piping way, near valves, junction joints of service appliances, walls, on either side of pipe culverts.

iv. For long stretch/yard piping at 50 M interval.

v. At start and terminating points.

b. Flow direction shall be indicated by an arrow in the location stated above and as directed by Engineer. Colors of arrows shall be black or white and in contrast to the color on which they are superimposed. The size of the arrows shall confirm to IS:2379. Product names shall be marked at pump inlet, outlet and battery limit in a suitable size as approved by Engineer. As a rule minimum width of color band shall conform to 75 mm up to 300 NB and to 100 mm over 350 NB. Whenever it is required by the Engineer to indicate that a pipeline carries a hazardous material, a hazard marking of diagonal stripes of red and golden yellow as per IS:2379 shall be painted on the ground color.

c. All uninsulated piping systems, hangers and supports shall have two coats of suitable primer coats and with suitable finish paints as per Annexure-3 Painting system. Shades shall be as per IS 5 or as indicated by Owner /Engineer. Service of the pipe/line designations shall be painted on all pipes at visible locations.

16.0 Identification of Vessels, Piping etc.

Equipment number shall be stenciled in black or white on each vessel, column, equipment and machinery after painting.

Line number in black or white shall be stenciled on all the pipelines of more than one location as directed by Engineer; size of letters printed shall be 150 mm (high) for column & vessels. 50 mm (high) for pump compressor and other machinery and shall be as per IS: 9404 for piping. The storage tanks shall be marked as detailed in the respective drawing.

17.0 Inspection and Testing

a) All painting materials including primers and thinners brought to site for application shall be procured directly from manufacturer as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable. Engineer at his discretion, may call for tests for paint formulations. Contractor shall arrange to have such tests performed including batch wise test of wet paints for physical & chemical analysis. All costs thereof shall be borne by the contractor. The paints shall be tested as per IS: 101 / equivalent international standard and approved by the Owner.

b) The painting work shall be subject to inspection by Engineer at all times. In particular, following stage wise inspection shall be performed and contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection shall be surface preparation, primer application and each coat of paint. In addition to above, record shall include type of shop primer already applied on equipment e.g. red oxide zinc chromate or zinc phosphate or Silicate primer etc.

c) Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of Engineer before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, contractor shall be responsible for making good of any defects found during final inspection/guarantee period/defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint shall be applied to make-up the DFT specified without any extra coat to the Owner.

18.0 Guarantee

The contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work. The contractor shall produce test reports from the manufacturer regarding the quality of the particular batch of paint supplied. The Engineer shall have the right to test wet samples of paint at random for quality of the same. Batch test reports of the manufacturer's for each batch of paints supplied shall be made available by the contractor.

19.0 Standard Final Colour of Equipment and Piping

19.1 Standard Colour Code for Mechanical Equipment

Sl. No.	Description	Ground Colour
A	**Service Water System**	Sea Green
B	**Crane & Hoist**	
1	EOT crane	Canary Yellow
C	**Compressed Air Plant**	
1	Air compressor	Sky Blue
2	Compressed air dryer	Sky Blue
3	Air receiver	Sky Blue
D	**Chemical Dosing**	Dark Admiralty Grey
E	**Fire Protection System**	Fire red
F	**Air Conditioning and Ventilation System**	
1	Refrigerant compressor	Sky Blue
2	Chilled / condenser pumps	Sea Green
3	Condenser water pipe	Sea Green
4	Fans	Grey

Notes:

This color code basically refers to IS:2379 for piping with necessary modifications
For any item left out, color coding will be decided after Owner's approval.

19.2 Standard Colour Code for Electrical Equipment

1	Transformers	Olive grey for power transformers and pebble grey for service transformer	RAL 7002 for power transformers and RAL 7032 for service transformers
2	Bus ducts	pastel turquoise for indoor and olive grey for outdoor	indoor 6034 and outdoor 7002
3	Junction boxes.	Pebble grey	RAL 7032
4	HT/LT Switchboards, Distribution boards, Control & Relay panels		
	a) Indoor	Pebble grey	RAL 7032
	b) Outdoor	Pebble grey	RAL 7032
5	UPS Panel, charger panels	Light grey	Exterior RAL 7032 Interior Brilliant white

7	LT Motor	Pebble grey	RAL 7032
8	HT Motor	Pebble grey	RAL 7032
9	Lighting fittings	As per manufacturer's standard	As per manufacturer's standard
10	Cable trays	Galvanized	

1. For interior coating, manufacturer's standard can be adopted subject to Owner's approval.
2. All panels that are to be erected at control room shall be painted using RAL 7032 (exterior colour). All Electrical, C&I, Fire alarm or any other panel shall have this colour.

19.3 Colour Coding for Identification of Pipelines used in Thermal Power Plants/FGD plants

		Ground Shade		Band Shade		
Sl.No	**Medium**	**Color**	**Color No. as per IS:5**	**Color**	**Color No. as per IS:5**	**Remarks**
1	Water system					
a)	Untreated or raw / service	Sea green	217	White	-	White is not included in IS - 5-2007
b)	Treated/dematerialized	Sea green	217	Light orange	557	
c)	Potable water	Sea green	217	French blue	166	
d)	Service & clarified water	Sea green	217	French blue	166	
2	Steam system					
a)	Auxiliary steam	Aluminum	-	Signal red	537	with aluminum
3	Air system					
a)	Instrument	Sky Blue	101	White	-	
b)	Service/Plant	Sky Blue	101	White	-	White not included in IS-5 - 2007
c)	Vacuum pipes	Sky Blue	101	Black	-	Black not included in
4	Transformer oil	Light brown	410	Light orange	557	
5	Fire services	Fire red	536	-	-	-
6	Effluent pipes	Black	-	-	-	-

19.4 Colour Code for Structural Steel

SL. NO	ITEM/SERVICE	COLOR	COLOR No. as per IS:5
1	Gantry girder & monorail	Brilliant green	221
2	Gantry girder & monorail stopper	Signal red	537
3	Building structural steel columns brackets, beams bracings, roof truss, purloin, side grit, louvers, stringers	Dark admiralty grey	632
4	Pipe rack structure & trestle	Dark admiralty grey	632
5	Chequered plate (Plain Face)	Black	-
6	Grating	Black	-
7	Ladder	Dark admiralty grey	632
	Hand railing		
8	Hand rail	Signal red	537
9	Middle rail	Signal red	537
10	Toe Plate	Signal red	537
11	Vertical post	Black	-
12	Structural steel for Silo	Smoke grey	692

Notes

1. Covering capacity and DFT depends on method of application. Covering capacity specified above is theoretical. Allowing the losses during application, min specified DFT shall be maintained.

2. All primers and finish coats shall be cold cured and air dried unless otherwise specified.

3. All paints shall conform to relevant Indian Standard and shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship shall be ensured.

4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.

5. In case of use of epoxy tie coat, manufacturer shall demonstrate satisfactory test for inter coat adhesion. In case of limited availability of epoxy tie coat, alternate system may be used taking into consideration the service requirement of the system.

6. Contractor will submit the final colour shade for all equipments & piping under his scope for final approval by client / consultant.

Painting Systems						
Cleaning, Protective Coating and Painting. - Systems designed as per ISO 12944 with service life of 10 yrs.						
Surface/ Location	**Temp**	**Surface prep**	**Coat**	**No. of coats**	**Generic Type**	**Dft/Coat**
Structural Steel work, piping (Oil + Water), tanks outside surface, transmission towers cranes, steel floors, galleries, stairways, Outdoor.	< 130 Deg	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1	75
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Mid coat	1	2 pack High build High Solid Lamellar MIO based Epoxy Mid coat.	200
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	**350**
Surface/ Location	**Temp**					
Structural Steelwork, piping, indoor and outdoor	130 to 200 Deg	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Sealer	1	Single pack Heat Resistant Silicon Acrylic Finish paint.	25
			Finish	2	Single pack Heat Resistant Silicon Acrylic Finish paint.	25
					Total	**150**
Alternative -2		SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
				1	Single pack Moisture Cured, Inorganic Silicate based heat resisting finish up to 400 Deg - Grey shade./ white/ Aluminium.	50
			Finish	1		50
					Total	**175**

Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
Alternative-3			Finish	1	Single pack Heat Resistant Silicon Acrylic Finish paint. - either Aviation White/ Aviation Orange.	80
					Total	**155**
Surface/ Location	**Temp**					
		Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
Structural Steel work Piping, Un-insulated Carbon Steel Indoor and Outdoor	200 to 400 mmmm mDeg C.	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level 2.	(75)
			Finish	2	Heat Resisting Silicon Aluminium Paint. VS to be min 28%.	20
					Total	**115**
Structural Steel work, Piping (Oil + water) , Tanks Indoor.	<130 Deg.C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Mid coat	2	2 pack High build High Solid Lamellar MIO based Epoxy Mid coat.	100
			Finish	2	Two component Polyamide Cured Epoxy Coating.	25
					Total	**325**
Surface/ Location	**Temp**					
Structural Steel work in the battery rooms, chlorination plant and water treatment plant, (extremely aggressive atmosphere)	Ambient	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1	75
			Touch up		Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)

Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
			Mid coat	1	Two component, high build rust encapsulating, aluminium pigmented modified epoxy coating.	125
			Finish	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	150
					Total	**350**
Steel Tanks inside Surface (Total) for Oil Storage	Normal	SA 2.5	Primer	1	Two component high build amine cured epoxy Primer with zinc phosphate pigment.	75
			Finish	2	Two component Self priming High Build Polyamine adduct cured epoxy coating.	125
					Total	**325**
Alternative-1			Finish	3	Two component Self priming High Build Polyamine adduct cured epoxy coating. **(No primer required. Self priming coating post blasting)**	125
					Total	**375**
Alternative-2			Finish	2	Two component High build high solid Solvent free epoxy coating - certified by CFTRI for Potable water usage.**(Primer same as above)**	150
					Total	**300**
Surface/ Location	**Temp**					
Steel Tanks inside Surface (Total) for Water Storage (Potable and Distilled Water)	Ambient	SA 3	Primer	1	Two component high build polyamide cured zinc phosphate Primer	75
			Finish	2	Two component Self priming High Build Polyamine adduct cured epoxy coating - certified by CFTRI for Potable water usage.	125
						325
Alternative 1			Finish	2	Two component High build high solid Solvent free epoxy coating - certified by CFTRI for Potable water usage. **(No primer required. Self priming coating post blasting)**	200
						400
Steelwork immersed in water such as inlet/	< 60 Deg C	SA 3	Primer	1	Two component High Build High Solid Rapid Curing Epoxy Zinc Phosphate Primer.	75

Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
outlet structures, dolphins, sheet piling			Finish	1	Two component High build High Solid Modified Epoxy coating.	500
					Total	**575**
			Wherever TAR based product is not to be recommended.			
			Finish	1	Two component High build High Solid Modified Epoxy coating	500
					Total	**500**
			Finish	1	Two component High build High Solid Modified Epoxy coating with Glass Flake.	500
					Total	**500**
Alternative 1						
Cast Iron Water pipelines - Outside surface, buried in Soil	< 60 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1	75
			Finish	2	Polyamide Cured Coal Tar Epoxy, Vs min 65% black.	200
					Total	**475**
Alternate-1			Finish	1	Two component High build High Solid Modified Epoxy coating	500
Alternate -2			Finish	1	Two component High build High Solid Modified Epoxy coating with Glass Flake	500
Surface/ Location	**Temp**					
Steel Pipes - Inside surfaces such as cooling water lines.	< 60 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Finish	2	Coal Tar Epoxy, Vs min 65% black.	225
					Total	**525**
Water Pipelines - Outside Surface, Indoor	< 60 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75

Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Finish	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
					Total	**275**
Oil pipelines - Outside surface, above ground	< 100 Deg C	SA 3	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Touch up		Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Mid coat	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	**350**
Surface/ Location	**Temp**					
Pumps, Motors, Turbine, Claddings, Steam Turbine Condenser, Indoor	Up to 90 Deg	SA 2.5	Primer	1	Catalysed Zn rich Primer with a VS of 60% min, complying to SSPC Paint 20 level 2.	75
			Finish	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
					Total	**275**
Alternative 1		SA 2.5	Primer	1	Catalysed Zn rich Primer with a VS of 60% min, complying to SSPC Paint 20 level 2.	75
			Mid coat	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
			Finish	2	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75

Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
					Total	**250**
Heat Exchangers - Inside Surface.	Up to 60 Deg	SA 2.5	Primer	1	Solvent based IZS - VS of 60%. Zn Dust - 1.77 kg/ltr minimum. Zn dust by weight - minimum 85%. Pot life 12 hrs / 21 Deg.- Paint to meet compositional & performance specifications for SSPC Paint 20 , Level 1.	75
			Finish	2	Coal Tar Epoxy, Vs min 65% black.	200
					Total	**475**
Instrument panels, Electrical cubicles and similar steel sheet – indoor **(Can be used on Aluminium, steel, stainless steel and galvanized substrates.)**	Ambient	Oil grease and contamin atnts must be removed	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	75
			Mid coat	1	Two component High Build Surface Tolerant Epoxy coating pigmented with Aluminium and Lamellar Micaceous iron oxide	100
			Top coat	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
					Total	**275**
Surface/ Location	**Temp**					
Instrument panels, Electrical cubicles and similar steel sheet – outdoor **(Can be used on Aluminium, steel, stainless steel and galvanized substrates.)**	Ambient	Oil grease and contamin atnts must be removed	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	100
			Mid coat	1	Two component High Build Surface Tolerant Epoxy coating pigmented with Aluminium and Lamellar Micaceous iron oxide.	150
			Top coat	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of atleast 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	**325**
Substrate, base metal: Carbon steel, HDG acc ISO 1461 Or. Equiv. Non Insulated. - Outdoor	<120 Deg	Air blasting with Nonmetallic	Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	50

Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
		abrasive Powder	Mid coat	1	Two component High Build Surface Tolerant Epoxy coating pigmented with Aluminium and Lamellar Micaceous iron oxide	150
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of atleast 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	**275**
Substrate, base metal: Carbon steel, HDG acc ISO 1461 Or. Equiv. Non Insulated.- Indoor	<120 Deg	Air blasting with Nonmetal lic abrasive Powder	Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level 2.	75
			Primer	1	Two pack, high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Finish	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
					Total	**225**
			For Outdoor Application			
			Touch up	1	Two component Zinc rich Primer meeting performance and compositional specifications of SSPC Paint 20 Level2	(75)
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	**200**
			For Indoor Application			
Substrate, Stainless Steel - Non insulated.	< 120 Deg	Air blasting with Nonmetal lic abrasive Powder	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Finish	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%	100
					Total	**225**
			For Outdoor Application			
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125

Surface/ Location	Temp	Surface prep	Coat	No. of coats	Generic Type	Dft/Coat
			Finish	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of atleast 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	**200**
Applicable for Water - Water Cooled heat Exchangers like Condensers, Flash box, Water - Water coolers etc. For Outdoor installations in corrosive atmosphere - like Chemical/ Marine.				**For Indoor Application**		
	< 120 Deg	Air blasting with Nonmetallic abrasive Powder	Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	75
			Top coat	2	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
					Total	**275**
				For Outdoor Application		
			Primer	1	Two pack , high build siloxane modified epoxy primer with zinc phosphate pigment.	125
			Mid coat	1	Two component High Build high Solid Aliphatic Amine Cured Epoxy coating. - Min VS 85%.	100
			Top coat	1	2 pack Acrylic Aliphatic Polyurethane top coat - with Gloss retention of at least 90% on QUVB exposure of minimum 1000 hrs.	75
					Total	**300**

ANNEX – 1.7

QUALITY ASSURANCE PLAN

The testing and inspection requirements of major equipment of FGD system to be followed by the bidder over and above the respective code/ standard requirements are given hereunder

1.0.0 MECHANICAL SYSTEMS

1.1.0 FLUE GAS SYSTEM

1.1.1 Booster fans

i) Rotor components shall be subjected to ultrasonic test at mill and magnetic particle examination/dye penetration examination after rough machining.

ii) Butt welds in rotor components shall be subjected to 100% UT and all welds shall be subjected to MPE or DPT after stress relieving.

iii) All rotating components of fans shall be dynamically balanced to quality grade 2.5 of ISO 1940.

iv) Test for natural frequency of all fan components, including fan blades shall be carried out for the fans.

v) Full range performance test shall be carried out on one fan as per BS 848, Part-1.

v) Hydraulic coupling of booster fan shall be checked for string test i.e., operational check of one fan assembly using hydraulic coupling to check temperature rise, smooth operation, vibration and noise level. Dry run test shall preferably be carried out during string test.

1.1.2 Type Test

Full scale type tests using actual equipment shall be conducted by the Contractor for the equipment mentioned in the subsequent clauses below:

Full range and full scale performance testing shall be conducted at shop on one number each of the following Fans as per BS 848, Part-1:

(a) Booster Fan

The performance testing at shop shall be conducted using actual fans Leak tightness testing of dampers for each type and size of damper at shop to demonstrate the guaranteed gas tightness efficiency (on flow). The minimum guaranteed gas tightness efficiency of dampers shall not be less than that indicated in clause no. 3.03.08 of this Sub-Section.

The Bidder shall indicate the charges for each of these type tests separately in the relevant price schedule of Bid Proposal Sheet (BPS) and the same shall be considered for the evaluation of the Bids. The type test charges shall be paid only for the test(s) actually conducted successfully under this contract and upon certification by the Employer's Engineer.

The type tests shall be carried out in presence of the Employer's representative. Contractor shall inform the Employer about his read iness for conducting the type test and issue such notice to the Employer 30 days in advance, along vvith schedule of the type tests. The Contractor shall obtain the Employer's approval for the type test procedure before notifying the Employer about his readiness for conducting the type test. The type test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.

Irrespective of the requirement of conducting the type tests under this contract, The Contractor shall submit the reports of the type tests carried out for the equipments listed above in clause no. 18.01.00 and These reports should be for the tests conducted on the equipment for the model / type / size / rating to those proposed to be supplied under this contract and the test(s) should have been either be conducted at an test facility/shop/independent laboratory or should have been 'Witnessed by a client. The Employer reserves the right to waive conducting of any or all of the specified type tests under this contract, in which case the type test charges shall not be payable for the type tests waived by the Employer.

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

1.1.3 Thermal insulation

i) Thermal insulation

a) Pre-formed fibrous pipe insulation and LRB mattresses/ sections of rock wool/ mineral wool from approved manufacturing sources conforming to and tested as per relevant standards shall be used.

b) For resin bonded mineral wool insulation, testing shall be carried out as per IS: 8183.

c) For resin bonded rock wool insulation, testing shall be carried out as per IS: 9842.

d) Type tests except thermal conductivity shall be regularly carried out once in three months.

e) Type test for thermal conductivity shall be carried out by the manufacturer minimum once in six months. Thermal conductivity (K value) shall be measured in line with IS: 3346.

1.1.4 Dampers

i) All the dampers shall be subjected to operational test/checks.

ii) Gas tight dampers shall be subjected to shop leakage test to demonstrate the guaranteed tightness (minimum one damper of each type and size offered). In case such type test is already done, the reports of the same shall be submitted for review.

iii) All dampers shall be checked for sealing dimensions to establish guaranteed tightness.

1.1.5 Structure, Ducts, Hoppers

i) All materials shall be tested for chemical and mechanical properties as per relevant standard. All plates above 40mm shall be 100% Ultrasonically tested.

ii) Visual inspection of all welds shall be performed in accordance with AWSDI .1.

iii) NDT requirements of structural steel welds shall be as under:

a) 100% RT/UT on butt-welds of plate thickness ≥ 32mm.

b) For plates of 25mm ≤ thickness<32mm: 10% RT and 100% MPI. c) For plates of thickness <25mm: 10% MPI/LPI.

iv) Edge for shop and field weld shall be examined by MPI for plate thickness ≥ 32mm.

1.2.0 ABSORBER

1.2.1 Metal Structures

i) Only material which has been identified against mill sheet or test certificates shall be used for construction. Check testing shall be carried out in the absence of MTC. All plates above 40mm shall be 100% Ultrasonically tested.

ii) Visual inspection of all welds shall be performed in accordance with AWSDI .1.

iii) NDT requirements of structural steel welds shall be as under:

a) 100% RT/UT on butt-welds of plate thickness>= 32mm.

b) For plates of 25mm<=thickness<32mm-10%RT and 100% MPI. c) For plates of thickness <25mm-10% MPI/LPI.

iv) Edge for shop and field weld shall be examined by MPI for plate thickness >= 32mm.

1.2.2 Spray Nozzles

i) Spray nozzles shall be tested for physical properties.

ii) Spray nozzles also shall be subjected to performance test.

1.2.3 Agitators

i) Rubber lining shall be tested for hardness and spark test.

ii) Impellers shall be tested for dimensional and balancing check.

iii) Gear Boxes shall be tested for run test as per standard practice.

1.2.4 Other Critical Equipment

Checks/ NDTs shall be done as per relevant Indian Standards or equivalent International Standards.

1.3.0 GGH

The details of the checks to be carried out for various components are to be submitted by the Contractor for Owner's approval. However, some indicative checks on different items are given below which should necessarily form part of the Quality Assurance Plan to be agreed with the Owner.

a) Chemical and mechanical properties for header plates, coils , tubes ,shafts ,etc.,
b) Weld inspection
c) Dimensional check of Rotor assembly, guide bearing assembly, support assembly, support bearing assembly m modular assembly ,rotor drive assembly, etc.,
d) Rotor assembly run test
e) Cold and Hot end trial assembly check

1.4.0 LIMESTONE & GYPSUM HANDLING SYSTEM

1.4.1 Crushers

The details of the checks to be carried out for various components are to be submitted by the Contractor for Owner's approval. However, some indicative checks on different items are given below which should necessarily form part of the Quality Assurance Plan to be agreed with the Owner.

i) All plates equal to or above 25mm thickness shall be ultrasonically tested.

ii) Shaft forgings and suspension bars to be checked for ultrasonic testing in addition to check for chemical, mechanical, hardness, microstructure etc. as per applicable material specification.

iii) Following minimum NDT requirements to be ensured for welds:

a) Butt welds : UT/RT and 100% MPI/DPT.
b) Fillet Welds : 10% MPI/DPT.

iv) Crusher rotor to be dynamically balanced. Procedure to be submitted for approval.

v) No-load trial run test to be carried out at shop to check for speed(RPM), temperature rise, noise level and vibration.

1.4.2 Metal Detectors

i) Functional test including sensitivity, Burn in test, operation of liquid spray marker, detection of smallest piece of different materials as specified.

ii) Test report for Degree of protection test to be furnished.

1.4.3 Belt Conveyor System

The details of the checks to be carried out in the various equipment are to be submitted by the Contractor for Owner's approval. However, some indicative checks on different items are given below which should necessarily form a part of the Quality Assurance Plan to be agreed with the Owner.

1) Idlers

i) Check for run out and free movement shall be carried out on idlers. Run out shall be restricted as per IS:8598

ii) Test for dust proofness, water proofness and dynamic friction factor of the Idlers shall be conducted at shop. The detailed procedures for the same shall be submitted for review and approval.

2) Belting

i) Rubber cover of finished belt shall be checked for tensile strength and elongation at break before and after ageing. Rubber cover shall also be checked for abrasion, tear strength and hardness.

ii) For finished belts, checks for elongation at 10% nominal tensile strength tensile and elongation at break in longitudinal (warp) direction and tensile in transverse (weft) direction shall be carried out.

iii) Adhesion test between ply to ply and cover to ply shall be carried out.

iv) Troughability test and Test for fire resistance shall be carried out.

v) Test for procedure qualification for belt vulcanizing joint (at site) shall be done. Procedure for belt vulcanizing joint shall be discussed and finalized during FQP finalization.

vi) There will be a limitation on the no. of repairs allowed on the belts.

Following will be the acceptance norm for the cover repairs.

a) The maximum size of a repair shall be limited to a size equivalent to one fifth the belt width. No single dimension shall exceed one fifth (1/5) of belt width.

b) Small local repair by dough filling of size 25mm x 25mm to a limited extent shall not be counted of repairs. However, in case of cluster of repairs, same shall be counted as a patch repair.

c) The maximum number of patch repair shall not exceed 5 per 100 meter. However, the total number of patch and dough filling repairs shall not exceed 10 per 100 meters.

vii) In addition to above, Steel Cord belt shall be tested for following also:

a) Cord dia and breaking strength

b) Finished belt shall be tested for cord pull-out strength before and after aeging, peeling resistance.

c) Dynamic cord pull out test

d) Cord dia, pitch and number of cords

viii) In no case shall the cover thickness or the width of belt be less than that given in specification.

ix) For testing purpose, belt sample shall be taken from anywhere of the belt roll length offered

3) Belt vulcanizing machine

i) Check for tensile strength shall be carried out on a sample vulcanized belt joint for each type of belt in shop. However, if such test has been done earlier, the report for same shall be submitted for verification.

ii) Complete assembly shall be tested at shop for temp. and pressure developed.

4) Pulleys

i) In addition to chemical, mechanical, hardness, microstructure as per applicable material specification, pulleys shaft forgings shall be subjected to ultrasonic testing.

ii) 100% MPI/DPT on all welds shall be conducted and RT/UT on butt welds shall be conducted.

iii) Static balancing of pulleys shall be carried out after rubber lagging.

iv) Checks on rubber lagging to include abrasion loss, shore hardness test, peel-off strength test and physical properties. Peel-off strength shall be 10 kg/cm, Abrasion loss shall be less than 250 cubic mm when tested as per DIN 53516.

5) Pull chord & belt sway switches

The following tests shall be carried out:

i) Over all dimension and functional test.
ii) HV & IR test
iii) Degree of protection test report.

6) Zero speed switch, under belt switch and chute blockage switch

The following tests shall be carried out:

i) Burn in test at 50 deg C for 48 hours shall be done for electronic switches. ii) Over all dimension and functional tests.
iii) HV & IR

iv) Degree of protection test

7) Drive Equipment

i) Gear Boxes

(a) In addition to checks for physical, chemical, hardness, microstructure as per relevant standard, the shaft and gear/pinion forgings shall be subjected to ultrasonic testing

(b) MPI to be carried out on Gears/Pinions after machining. Case depth, hardness and MPI after hard facing shall be checked to ensure freedom from defects.

(c) Gear reducer shall be checked for reduction ratio, backlash and contact pattern. No load shop trial run to be conducted on gear boxes to check for oil leakage, temperature rise, noise level and vibration.

ii) Flexible Coupling

(a) Ultrasonic testing shall be conducted on forgings for gear sleeve and gear hub, if gear coupling is provided.

(b) MPI shall be carried out after machining to ensure freedom from cracks.

iii) Fluid Coupling

(a) Dynamic balancing shall be carried out for the rotating parts.

(b) Check for leak tightness of the coupling shall be carried out.

(c) Functional test on fusible plug for each type of coupling shall be conducted at shop.

(d) All couplings to be run tested at shop on no load.

(e) Check for temperature rise, torque-speed, torque-slip characteristics and over speed test shall be included during performance test of one coupling of each type preferably at full load.

8) Belt Scales

The details of the checks to be carried out in the various equipment are to be submitted by the Contractor for Employer's approval. However, some indicative checks are given below which should necessarily form a part of the quality assurance plan to be agreed with the Employer.

i) Mounting arrangement/Overall dimensional check shall be carried out on the Belt Scales.

ii) Belt scale shall be calibrated with test weight/test chain in static at works and with test weight for dynamic condition at site.

iii) All electronic modules shall be subjected to burn in test at 50 Deg C for 48 hours.

iv) General check for load cell shall be carried out.

v) Test report for degree of protection on enclosure shall be furnished.

vi) Accuracy/performance check shall be demonstrated at site.

1.5.0 DUST CONTROL SYSTEM

The tests etc. shall be carried out various components of dust extraction system offered by the bidder in line with standard industry practice. The details of the checks to be carried out on the various equipment are to be submitted by the Contractor for Purchaser's approval.

1.6.0 BUCKET ELEVATOR

i) All plates equal to or above 25 mm thickness shall be ultrasonically tested.

ii) Castings and forgings, forged/rolled bar/section shall be subjected to ultrasonically test in addition to check for chemical, mechanical, hardness, microstructure etc. as per applicable material specification.

iii) Machined and hard faced surface of casting/forging and other hardened, stellited parts shall be subjected to DPT/MPI in addition to check for case depth, hardness as applicable for chain/sprocket/gear reducer/ rollers/wheel/ pan etc.

iv) Following minimum NDT requirements shall be followed for welds:

a) Butt Welds in Tension - 100% UT/RT and 100% MPI/DPT.
b) Butt Welds in Compression - UT/RT and MPI/DPT.
c) Fillet Welds - MPI/DPT.

v) For other items like drive system, motor, pulley, belt etc. relevant portion of specification shall be applicable.

vi) No load trial run test shall be carried out at shop on completely assembled Bucket Elevator to check for trouble free operation, temperature rise, Noise & vibration. The procedure for the No load trial run shall be submitted for approval.

1.7.0 SILOS/ BUNKERS

i) All material shall be tested for Chemical & Mechanical properties as per relevant standard. MPI/DP test on welding shall be carried out. Fit up assembly checks shall be carried out at shop for all despatchable segments.

ii) Bag Filters: Bag Leakage test shall be carried out for pressure parts. Pulsing and sequential test on bag filter shall be done.

1.8.0 BALL MILLS

i) Raw material for shaft, coupling, gears and pinions, top and bottom races and other rotating components shall be subjected to UT. MPI/LPI shall be carried out to check surface soundness.

ii) Wear-resistant parts shall be UT/RT tested to check soundness after suitable heat treatment. Check for chemical composition, hardness and microstructure shall be carried out.

iii) Butt welds in the tube/separator/body casing of the mill shall be tested by RT and MP'. All other welds in main tube/separator shall be tested by MPI/LPI for acceptance. The tube shall be statically balanced.

iv) All gearboxes shall be run tested for adequate duration to check rise in oil temperature, noise level and vibration. Check for leak tightness of gear case also shall be performed.

1.8.1 Gravimetric Feeders

i) Any welds in the casing/pulley fabrication shall be checked with MPI.

ii) Routine tests shall be done as per relevant Indian Standards or equivalent International Standards.

iii) All major items like plates for casing, head pulley, tail pulley, pulley shaft and major castings shall be procured with respective material test certificates.

iv) Calibration check shall be carried out on all feeders.

1.8.2 Lubricating oil systems

Complete lub oil system shall be checked suitably as per standard practice.

1.9.0 VACUUM BELT FILTER SYSTEM

i) Impeller, casing and shaft of vacuum pumps shall be tested for chemical and mechanical properties as per relevant standard. All plates above 40mm shall be 100% Ultrasonically tested.

ii) UT on shaft (if greater or equal to 40mm) and impeller shall be carried out.

iii) All vacuum pumps shall be tested at shop for capacity, power, pressure, efficiency, noise and vibration etc.

iv) Filter cloths and belts shall be tested for physical properties as per relevant standard

vi) Hydro cyclones shall be checked by visual, dimensional etc.

1.10.0 MONORAIL AND HOISTS

1.10.1 Hooks

i) All tests including proof load test as per relevant IS shall be carried out.

ii) MPE or DPT shall be done after proof load test.

1.10.2 Steels castings

Steel castings shall be subjected to DPT on machined surface.

1.10.3 Forgings

i) All forgings (wheel, gears, pinions, axles, hooks and hook trunion) greater than or equal to 50mm diameter or thickness shall be subjected to ultrasonic testing.

ii) DPT or MPE shall be done after hard facing and machining.

1.10.4 Wire rope

Wire rope shall be tested as per relevant standard.

1.10.5 Electric hoists

All electric hoists shall be tested as per IS-3938 and chain pulley blocks shall be tested as per IS-3832.

1.11.0 VENTILATION SYSTEM

i) Fans

a) 20% DPT of welding on fan hub, blades, casing and impeller as applicable shall be carried out.

b) DPT of fan shafts shall be carried out after machining.

c) UT of fan shafts (diameter greater than or equal to 50mm) shall be carried out.

d) Rotating components of all fans shall be statically and dynamically balanced to ISO-1940 Gr. 6.3.

e) All centrifugal fans shall be subjected to run test for 4 hour or till temperature stabilization is reached. Vibration, noise level, temperature rise and current drawn shall be measured during the run test.

f) One fan of each type and size will be performance tested as per corresponding IS code for airflow, static pressure, total pressure, speed, efficiency, power consumption, noise, vibration and temperature rise.

1.12.0 PACKAGED, SPLIT AND WINDOW AIR CONDITIONERS

i) Compressor of packaged air conditioner (PAC) shall be tested as per relevant code/standard.

ii) PAC shall be subjected to production routine test in accordance with IS:8148 for the following.

a) General running test.

b) Pressure or leakage test of refrigerant.

c) Insulation resistance test.

d) High voltage test.

e) Performance test on one PAC of each type/size at ambient condition to check for following:

- DBT and WBT of supply and return air.
- Air flow
- Current, voltage measurement and power consumption
- Noise and vibration measurement

iii) Manufacturer's standard test certificate or guarantee certificate shall be submitted for split and window air conditioners.

1.13.0 ELEVATORS

i) The details of the checks to be carried out in the various equipment are to be submitted by the contractor for owner's approval. However, some indicative checks on different items are given below which should necessarily form part of the quality assurance plan to be agreed with the owner.

ii) All forgings shall be subjected to ultrasonic test to ensure free from internal defects in addition to check for chemical and mechanical properties.

iii) 10% of the welds selected at random shall be subject to DP test.

iv) All forged components shall be subjected to DPI/MPI after machining.

v) Gear Reducer shall be checked for gear ratio, backlash, contact pattern.

No load shop trial run shall be conducted on gear boxes to check for oil leakage, temperature rise, noise and vibration.

vi) Buffer springs shall be subjected to load test as per relevant specifications. Material certificates for springs shall also be furnished

vii) All components prior to assembly shall be checked for dimensions.

viii) Car sling and car body in assembled condition shall be checked for position of all major components i.e. car sling, inside depth, width, height, positions of push box, indicator box lights, fans etc.

ix) Function test of Elevator assembly shall be carried out.

x) All electrical equipment shall be of proven quality.

xi) Galvanized components/parts shall be checked for weight of Zn coating, thickness of coating, uniformity of coating and adhesion test and visual examination as per IS 2633 and IS 2629.

1.14.0 FIRE DETECTION & PROTECTION SYSTEM

i) Hydrant System: Shop Tests

a) Hydrant Valve:

- All valves shall be hydro tested for body and seat.
- Capacity test / flow test shall be done as per relevant standard.

b) Water Monitor, Hoses, Branch Pipes, Couplings and Nozzles:

- All tests including hydraulic test shall be done as per relevant Indian/ International standard.

ii) High/ medium velocity water spray: shop tests

a) For Pipes, Fittings, Valves and specialties, requirements are indicated separately.

b) Deluge Valves and Spray Nozzles

- All valves shall be hydro tested for body and seat.
- Performance test / functional test of 'Deluge Valves' and 'Spray Nozzles' shall be carried out.

iii) Detectors

All 'Detectors' shall be tested as per relevant Indian / International Standards. Detectors shall also meet the requirements of UL / FM / LPC/VDS etc.

iv) Piping, valve and specialties

Refer clause 1.15.

v) Portable & mobile fire extinguishers

a. All fire extinguishers shall be tested as per relevant standard.

b. Performance / function test shall be carried out on sampling basis as per relevant code / standard.

vi) Site tests.

a) Fire Extinguishers: A performance demonstration test at site of five (5) percent or one (1) number, whichever is higher, of each type and capacity of the extinguisher

shall be carried out by the contractor. All consumables and replaceable items require for the contractor without any extra cost to employer would supply this test would be supplied by the Contractor without any extra cost to employer.

b) Piping Protection:

- Thickness, Holiday by spark test, Adhesion test shall be carried out as per relevant standard.
- Complete piping shall be Hydro pressure tested, at 1.5 X DP or 2

X MWP whichever is higher, before protection.

c) Welding of Pipes:

- ERW Black / rolled welded:
  - 100% DPT on root of butt and finish weld of butt and fillet.
  - RT on 10% randomly selected joints shall be carried out (for underground piping). GI Pipes

Welding on GI Pipes in general shall not be done. Welding of GI Pipes, if permitted by design, (butt / socket / fillet weld) shall be done strictly as per approved drawing and procedure approved by NTPC Engineering. For all such welds 100% DP test and random 1% RT shall be done.

1.15.0 MISCELLANEOUS EQUIPMENT

1.15.1 Pressure Vessels

i) NDT on weld joint shall be as per respective code requirements or the minimum as specified as below:

a) 100% DPT on root run of butt weld, nozzle welds and finished fillet welds.

b) 10% DPT on all finished butt welds.

c) 10% RT (covering all 'T'/cross joints) of butt welds.

ii) Butt welds of dished ends shall be stress relieved and subjected to 100% RT.

iii) Each finished vessels shall be hydraulically tested to 150% of the design pressure for a duration of 30 minutes.

1.15.2 Tanks

i) Tests shall be carried out on the materials of the tanks to establish their mechanical properties, and chemical compositions

ii) Plates shall be subject to 100% ultrasonic testing.

iii) Welding

a) Root run of butt welds shall be examined by 100% DPT or MPE.

b) Butt welds, full penetration joints and nozzle welds shall be checked by 100% RT and 100% MPE or DPT.

c) Fillet welds shall be checked by 100% MPE or DPT.

iv) Rubber lining shall be subject to hardness and spark test, as applicable.

v) Visual check and dimensional measurement shall be carried out on the completed equipment.

vi) The fabricated tank shall be subject to water fill test to check for the leakage.

1.16.0 LOW PRESSURE PIPING, VALVES AND FITTINGS ETC.

1.16.1 Pipes, fittings

i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials as required.

ii) Dye penetration test of welds of pipes and fittings (including welds of rolled and welded pipes) shall be carried out.

iii) All pipes and fittings shall be tested as per applicable codes/ standards at manufacturer's works.

1.16.2 Valves

i) Tests shall be carried out on the materials on various components to establish their mechanical properties and chemical composition. Further, heat treatment shall be carried out for materials as required.

ii) Shaft/ spindle of size ≥ 50 mm diameter shall be subjected to ultrasonic test.

iii) Machined surfaces of casing, disc and shaft shall be subjected to 100% MPI or DPT as applicable.

iv) All valves shall be hydraulically tested for body, seat and back seat (wherever provided) at 1.5 times the maximum pressure to which respective valves can be subjected during plant operation. Check valves shall also be tested for leak tightness test at 25% of the specified seat test pressure. For rubber lined valves, hydraulic test shall be carried out before rubber lining.

v) For butterfly valves, hydraulic test, seat and disc string test and proof of design test (if not carried out earlier) shall be carried out in accordance with latest edition of AWWA-C-504 standard.

vi) Visual and dimensional check shall be carried out for all valves as per relevant code/ approved drawing.

vii) Functional/ operational checks for and check for smooth opening and closing of the valves shall be carried out.

viii) Gate, globe and swing check valves

a) Machined surfaces of castings and butt welds shall be subjected to MPE or DPT.

b) Blue matching, wear travel for gates, valves, pneumatic seat leakage, reduced pressure test for check valves shall be done as per relevant standard.

vii) Diaphragm valves

a) Seat leakage test for actuator operated valves, shall be done with by closing the valves with actuator.

b) Tests on rubber parts per batch of rubber mix such as hardness, adhesion, spark test, bleed test and flex test on diaphragm, type test for diaphragm for 50,000 cycles.

viii) Cast butterfly valves

a) Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.

b) Actuator operated valves shall be checked for seat leakage by closing the valves with actuator. Seat leakage test shall be carried out in both directions.

ix) Fabricated butterfly valves:

a. UT shall be carried out on plate material for body and disc.

b. Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.

c. Butt welds of thickness above 30mm on body and disc shall be subject to 100% RT along with and post weld heat treatment for stress relieving.

d. Actuator operated valves shall be checked for seat leakage by closing the valves with actuator. Seat leakage test shall be carried out in both directions.

x) Dual plate check valves:

a. Dry cycle test (spring cycle test) for one lakh cycles shall be carried out as a type test.

b. Machined surfaces of casing, disc and shaft shall be subjected to MPE or DPT.

1.16.3 Rubber lining of pipes and valves

i) For rubber lining, the following tests shall be carried out as per IS-4682 part-I or acceptable equivalent standard:

a) Adhesion test

b) Measurement of thickness

c) Shore hardness test

d) Visual examination and spark test at 5 kV/mm of thickness

e) Bleeding resistance test (as applicable) with keeping the sample in 33% HCl, 48% NaOH and DM water for 72 hours.

f) Bleeding test and ozone resistance test shall be done on rubber material.

ii) Dimensional check shall be carried out as per relevant code/ approved drawing.

1.16.4 Coating and wrapping of pipes

Spark test, adhesion test and material test for primer and enameled and coal tar tapes, as applicable, shall be carried out as per AWWA-C-203-91.

1.16.5 Rubber expansion joints

i) Rubber compound test slab after valcanising shall be tested for tensile strength, elongation and shore hardness. Tests on rubber compound shall also include hydro stability test as per ASTM D-3137 and ozone resistance test as per ASTM D- 380.

ii) Fabric strength of synthetic fibre for reinforcement shall be checked, and test for rubber to fabric adhesion as per IS: 3400 or ASTM D- 413, rubber to metal adhesion as per IS 3100 or ASTM D-429 shall be carried out.

iii) All expansion joints in assembled condition shall be subjected to vacuum test at 730 mm Hg under conditions to ensure its suitability to withstand deflection in each axial transverse and longitudinal direction. Duration of test shall be of minimum 10 minutes.

iv) All bare bellows shall be subjected to hydraulic pressure test in normal condition at twice the design pressure for a duration of 30 minutes. Additionally, all bare bellows shall be subjected to deflection tests under pressure, pressure being raised from zero to the design value in regular steps and deflection measured at each step.

v) All expansion joints in assembled condition along with control rod assembly shall be subjected to deflection test under design pressure.

vi) Either during the hydraulic test or during the vacuum test, change in circumference at the top position of the arch shall not exceed 1.5% of measured circumference at normal position.

vii) Twenty four (24) hours after the above tests, the permanent set (variation in dimensions with respect to its original dimension) shall be measured and recorded. The permanent set shall not be more than 0.5%.

viii) Life cycle test and burst test shall be carried out on bellows of each type, design and size.

1.16.6 Dosing pumps/ metering pumps

i) Tests shall be carried out on the materials of the pumps to establish their properties, and chemical compositions

ii) Pump casings shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.

iii) Pumps shall be performance tested as per HIS, USA.

1.16.7 Horizontal centrifugal pumps

i) Tests shall be carried out on the materials of the pumps to establish their properties, and chemical compositions.

ii) 100% DPT or MPE shall be carried out for the rotor and machined surfaces of casing and impellers.

iii) UT on pump shaft (diameter greater than or equal to 50mm), MPI or DPT on pump shaft and impeller after machining shall be carried out.

iv) All rotating components of the pumps shall be statically and dynamically balanced to ISO-1940 Gr. 6.3.

v) Assembly fit up check, and dimensional check shall be carried out for the completed pump assembly.

vii) Pump casings shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher for a minimum duration of 30 minutes.

viii) All pumps shall be tested at manufacturer's works for head, capacity, power and efficiency as per requirements of HIS, USA or equivalent standard. Pump shall be given running test over the entire operating range covering from the shut-off head to the maximum flow. Acceptance shall be as per approved datasheet and HIS only.

ix) Pumps shall be subjected to strip down examination visually to check for mechanical damages after testing at shop in case abnormal noise level and/or excessive vibration are observed during the shop test.

1.16.8 Vertical sump pumps

i) All materials should be of tested quality and test certificates to be provided.

ii) Shaft forgings to be subjected to ultrasonic testing. iii) DPT to be done on machined shaft and impeller.

iv) Impellers to be dynamically balanced to ISO 1940 Gr.6.3.

v) All pressure parts shall be hydraulically tested at 150% of the shut-off head or 200% of rated head, whichever is higher for 30 minutes. No leakage is allowed.

vi) All pumps to be performance tested as per Hydraulic Institute Standard/ Indian Standard. Performance test to include check for noise, vibration level and bearing temperature rise.

1.16.9 Blowers

i) Tests shall be carried out on the materials of the rotary blowers/ compressors to establish their properties, and chemical compositions.

ii) 100% DPT or MPE shall be carried out for the rotor and machined surfaces of casing and impellers.

iii) The shaft and impellers shall be dynamically balanced.

iv) Assembly fit up check, and dimensional check shall be carried out for the completed blower assembly.

v) The blower/ compressor casing shall be subject to hydraulic test at 1.5 times the shut off pressure or 2 times the working pressure whichever is higher.

vi) The blowers/ compressor shall be performance tested as per relevant code/ standard.

1.16.10 Air Compressors

i) All pressure parts shall be hydraulically tested at not less than 150% of design pressure for a duration of 30 minutes prior to painting.

ii) All other parts including inter-connecting piping shall be hydraulically tested wherever possible, as per relevant codes.

iii) Ultrasonic testing shall be carried out on all forgings and rotor for dia 50mm and above. MPI/DPT shall be done on machined area of the components.

iv) During assembly all clearances and alignments shall also be checked and recorded

v) Rotor shall be statically and dynamically balanced.

vi) Performance test on the compressor shall be carried out in accordance with ISO: 1217/Eq. The test shall also include demonstration of loading and unloading mechanism (Capacity control) and operation of safety valve.

vii) Vibration and Noise level measurement shall be done during shop performance test.

viii) Air Receiver

a) Each finished vessel shall be hydraulically tested at 150% of the design pressure for a duration of 30 minutes

b) NDT on weld joints shall be as per respective code requirements or the minimum as specified below:

- 100% DPT on root run of butt welds
- 100% DPT on all finished butt welds and fillet welds
- 10% RT on butt welds which shall include all T-Joints

1.17.0 HANGERS AND SUPPORTS

i) All raw materials used shall have co-related mill test certificate meeting mandatory checks of material specification.

ii) Completed springs shall be tested for sagging test and load versus deflection test. For diameter more than 25mm, MPE shall also be carried out.

iii) Butt welds of thickness 32mm and above shall be tested for UT, and for butt welds of thickness less than 32mm MPE shall be done. Fillet welds shall be tested for MPE.

iii) Dampers with viscous fluids shall be checked for viscosity of liquid used, damping resistance of the damper, stiffness of the damper etc.

iv) Turn-buckle, pipe clamps and hangers of thickness greater than 25mm shall be checked by MPE or DPT on bent portions.

v) One hanger of each type and size shall be checked for variation in deflection and travel versus load test.

2.0.0 ELECTRICAL SYSTEMS

2.1.0 HT BUS DUCT

11kV, 6.6kV & 3.3kV Segregated Phase Bus ducts										
	Tests/ Checks									
		Properties		General						
Items/ Components/ Sub-systems	Visual and Dimensional Checks	Electrical, Mechanical, Chemical	WPS and PQR	NDT, DP or MPI, RT	Paint shade and Adhesion test	Galvanizing Test as per IS: 2629/	Electrical clearance and creepage	Functional/ Operational check	Make, Type, Rating, Model, TC, G physical inspection	Routine tests on complete busduct
Enclosure/ cubicle	Y	Y		Y	Y		Y			Y
Busbar flexible connector and disconnect or link	Y	Y		Y						
Steel structure and plate IS:2062	Y					Y				
Bushing, post and support insulator (IS:9431 and 2544)	Y	Y					Y		Y	Y
Welding of enclosure and conductor	Y		Y	Y						
Gasket, silicagel breather								Y	Y	
Complete busduct IS:8084	Y				Y		Y			Y

Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

a) Power frequency voltage withstand test b) Air leakage test
b) Water tightness test on outdoor portion of bus-duct
c) Insulation resistant measurement of equipment and all wiring
d) Milli-volt drop

2.2.0 AUXILIARY SERVICE TRANSFORMERS

2.2.1 Oil-filled Outdoor Transformers

	Tests/ Checks													
Items/ Components/ Sub-systems	Visual and Dimensional	Mechanical properties	Electrical strength	Thermal properties	Chemical Composition	Compatibility with oil	Core Loss (on first Job) Hot	NDT, DP or MPI, UT	Ageing Test	Voltage Ratio, Vector Group and	Make, Type, Rating, Model, TC,	WPS and PQR	Vacuum and Pressure Test	Routine Tests
Tank, HV and LV Cable Box/ Flange throat	Y	Y						Y					Y	
Conservator/ Radiator/ Cooler/ Pipes	Y	Y						Y						
Copper Conductor (IS:191)	Y	Y	Y		Y									
Insulating Material	Y	Y	Y	Y	Y	Y								
CRGO Lamination and Built Core	Y	Y	Y		Y	Y	Y							
Bushing / Insulator (IS:2544/ 5621)	Y	Y									Y			Y
Gasket	Y				Y	Y			Y					
Transformer oil (IS:335)														Y
Off-circuit tap changer	Y										Y			
Core coil assembly and pre-tanking	Y									Y				
Marshalling box	Y	Y						Y						
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Globe and Gate Valve,	Y										Y			
Welding (ASME Sect- IX)	Y											Y		
Complete Transformer (IS:2026)	Y													Y
Y =Test applicable														

2.2.2 Dry Type Indoor Transformers

Items/ Components / Sub-systems	Tests/ Checks											
	Visual and dimensional check	Mechanical properties	Electrical strength	Thermal properties	Chemical properties	Core loss (on first job), Hot Spot	NDT, DP or MPI	Voltage ratio, vector group and polarity	Make, Type, Rating, Model, TC,	WPS and PQR	Measurement of capacitance and tan delta between winding	Routine tests
Enclosure door, HV and LV Cable box/ Flange throat	Y	Y							Y			
Copper conductor	Y	Y	Y		Y							
Insulating material	Y			Y	Y							
CRGO lamination and built core	Y					Y						
Bushing/ Insulator (IS:2544/ 5621)	Y								Y			Y
Gasket	Y								Y			Y
Off-circuit tap changer	Y								Y			
Core coil assembly	Y							Y				
Marshalling box	Y											
WTI, Thermister, Terminal connector	Y								Y			
Welding										Y		
Complete transformer (IS:11171)	Y										Y	Y
Y =Test applicable												

Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

a) Dry out test
b) Resistance measurement of windings c) Ratio test
d) Vector group test
e) Tap changer test
f) Buchholz relay test
g) Low oil level alarm.
h) Temperature indicators
i) Marshalling kiosk
j) Protective relays
k) Magnetizing current

2.3.0 MOTORS

Item/ Components/ Sub-system	Tests/ Checks																	
	Visual	Dimensional	Make,Type,Rating,TC,General physical	Mechanical, Chemical properties	NDT, DP or MPI, UT	Metallography	Electrical characteristics	Welding/ Brazing (WPS/ PQR)	Heat treatment	Magnetic characteristics	Hydraulic, Leak, Pressure test	Thermal characteristics	Run out	Dynamic balancing	All tests as per IS:325/ IS:4722/ IS:9283	Vibration	Over speed	Tan delta, shaft voltage and polarisation
Plates for stator frame, end shield, spider etc.	Y	Y	Y	Y					Y									
Shaft	Y	Y	Y	Y	Y	Y			Y									
Magnetic material	Y	Y	Y	Y	Y		Y			Y		Y						
Rotor copper/ Aluminium	Y	Y	Y	Y		Y	Y		Y									
Stator copper	Y	Y	Y	Y			Y		Y			Y						
SC ring	Y	Y	Y	Y	Y	Y	Y	Y	Y									
Insulating material	Y		Y	Y			Y					Y						
Tubes for cooler	Y	Y	Y	Y	Y				Y		Y							
Sleeve bearing	Y	Y	Y	Y	Y				Y		Y							
Stator, Rotor coils	Y	Y	Y				Y	Y										
Castings, stator frame, terminal box and bearing housing etc.	Y	Y	Y	Y	Y			Y										
Fabrication and machining of stator, rotor, terminal box	Y	Y			Y				Y									
Wound stator	Y	Y					Y	Y										
Rotor complete	Y	Y					Y						Y	Y				

Item/ Components/ Sub-system	Tests/ Checks																	
	Visual	Dimensional	Make,Type,Rating,TC,General physical	Mechanical, Chemical properties	NDT, DP or MPI, UT	Metallography	Electrical characteristics	Welding/ Brazing (WPS/ PQR)	Heat treatment	Magnetic characteristics	Hydraulic, Leak, Pressure test	Thermal characteristics	Run out	Dynamic balancing	All tests as per IS:325/ IS:4722/ IS:9283	Vibration	Over speed	Tan delta, shaft voltage and polarisation
Stator, Rotor, Terminal Box assembly	Y	Y					Y											
Accessories, RTD, BTD,CT, Brushes, Diodes, space heater, antifriction bearing, cable glands, lugs, gaskets etc.	Y	Y	Y															
Complete motor (IS: 325/ IS:4722/ IS:9283)	Y	Y	Y												Y	Y	Y	Y

Y =Test applicable, Y1 = for 11kV and 3.3kV motors only

Note

This is an indicative list of tests/ checks. The manufacture is to furnish the detailed Quality Plan indicating the practices and procedure followed along with relevant supporting documents during QP finalization. However QP approval is not envisaged for 415V motors upto 50 KW.

Site Tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

i) Measurement of vibration.
ii) Measurement of insulation resistance and polarization index
iii) Measurement of full load current.
iv) Test running of the motors, checking the temperature rise and identifying the hot spot etc.

2.4.0 11KV, 6.6KV AND 3.3KV SWITCHGEAR

Items/ Components/ Sub- systems	Tests/ Checks													
	Make, Type, Model, Rating and TC	Electrical Properties	Mechanical properties	Chemical properties	Dimensions and Finish	Functional and operational features	Item to conform to relevant Standards	Pretreatment as per IS 6005	Paint shade, thickness, adhesion and finish	Functional Checks	HV and IR Test	Degree of Protection - Routine test	CB Operation timing check	All Routine Tests as per relevant standards
Aluminum busbar material (IS: 5082)	Y	Y	Y	Y	Y		Y							
Copper busbar material (IS :613)	Y	Y	Y	Y	Y		Y							
Bus bar support insulation (IS:9431)	Y	Y	Y		Y		Y				Y			
HT Circuit Breaker (IEC:56)	Y				Y	Y	Y			Y			Y	Y
HT Contactors (IS:9046)	Y				Y	Y	Y			Y				Y
Protection and auxiliary relays (IS:3231/ 8686)	Y				Y	Y	Y			Y				Y
HT CT's and PT's (IS:2705/ 3156)	Y				Y		Y							Y
HT Fuses (IS:9385)	Y				Y	Y	Y							
Surge arrester (IEC:99-4)	Y				Y		Y							Y
LT Contactors (IS:13947)	Y				Y	Y	Y			Y				
Control and selector switches (IS:6875)	Y				Y	Y	Y			Y				
Indicating meters (IS:1248)	Y				Y	Y	Y			Y				Y
Indicating lamps (IS:13947)	Y				Y	Y	Y			Y				
Push buttons (IS: 4794)	Y				Y	Y	Y			Y				
Control transformer (IS:12021)	Y				Y	Y	Y							Y
LT fuses (IS:13703)	Y				Y	Y	Y							
Energy meters (IS:722)	Y				Y	Y	Y							Y
Transducers (IEC:60688)	Y				Y	Y	Y							Y
Diodes	Y	Y				Y	Y			Y				
Terminal Blocks	Y	Y				Y	Y							
Synthetic Rubber Gasket (	Y	Y			Y		Y							
Breaker Handling Trolley	Y				Y	Y			Y	Y				
HT Switchgear Panel IS:3427)	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Y =Test applicable														

Site tests: The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

a) General

i) HV test on complete switchboard with CT and breaker/ contactor in position
ii) Check continuity and IR value of space heater
iii) Check earth continuity for the complete switchgear board

b) Circuit Breaker/ Contactors

i) Check control wiring for correctness of connections, continuity & IR values
ii) IR values, resistance and minimum pick up voltage of coils
iii) All functional checks and electrical & mechanical interlocks provided
iv) Checks on spring charging motor, correct operation of limit switches and time of charging

c) Current and Voltage Transformers

i) Insulation resistance test
ii) Ratio test on all cores
iii) Polarity test

d) Relays

i) Insulation resistance between AC to DC terminals and between all terminals and body
ii) Check minimum pick up voltage of DC coils
iii) Relay settings

2.5.0 415V SWITCHGEAR AND BUSDUCT

2.5.1 415V Switchgear

(MCC, PCC, ACDB, DCDB, Local push button station, Local motor starters)														
Items/ Components/ Sub- system	Tests/ Checks													
	Make, Model, Type, Rating and TC	Dimensions and Finish	Electrical properties	Mechanical properties	Chemical properties	Functional and Operational features	Item to conform to relevant standards	Pretreatment as per IS 6005	Paint shade, adhesion, thickness and finish	Functional checks	Milli-volt drop Test	IR – HV – IR Test	Degree of protection Routine test	All Routine tests as per relevant standards
Sheet steel (IS:513)	Y	Y		Y	Y		Y							
Aluminum bus bar material (IS:5082)	Y	Y	Y	Y	Y		Y							
Copper bus bar material (IS:613)	Y	Y	Y	Y	Y		Y							
Support insulator (IS:943, IS:10912, IEC: 660)	Y	Y	Y	Y			Y							
Air circuit breaker (IS:13947)	Y	Y				Y	Y			Y	Y			Y
Energy meters (IS:722)	Y	Y				Y	Y			Y				Y
Power and auxiliary contactor (IS:13947)	Y	Y				Y	Y			Y				
Protection and auxiliary relays (IS:3231)	Y	Y				Y	Y			Y				Y
Control and selector switches (IS:6875)	Y	Y				Y	Y			Y				
CT and VT (IS 2705/ 3156)	Y	Y					Y							Y
MCCB (IS:13947)	Y	Y					Y			Y				
Indicating meters (IS:1248)	Y	Y				Y	Y			Y				Y
Indicating lamps (IS:13947)	Y	Y				Y	Y			Y				
Air break switches (IS:13947)	Y	Y				Y	Y			Y				

(MCC, PCC, ACDB, DCDB, Local push button station, Local motor starters)														
Items/ Components/ Sub- system	Tests/ Checks													
	Make, Model, Type, Rating and TC	Dimensions and Finish	Electrical properties	Mechanical properties	Chemical properties	Functional and Operational features	Item to conform to relevant standards	Pretreatment as per IS 6005	Paint shade, adhesion, thickness and finish	Functional checks	Milli-volt drop Test	IR – HV – IR Test	Degree of protection Routine test	All Routine tests as per relevant standards
Control terminal blocks	Y	Y				Y	Y							
Fuse (IS:13703)	Y	Y				Y	Y			Y				
Control transformer (IS:12021)														
Push Buttons (IS:4794)	Y	Y				Y	Y			Y				
Transducer (IEC:60688)	Y	Y				Y	Y			Y				Y
MCB (IS:8828)	Y	Y				Y	Y			Y				
Breaker handling trolley	Y	Y				Y			Y	Y				Y
Synthetic rubber gasket (IS:11149)	Y	Y		Y	Y		Y							
415V Switchgear (IS:8623)	Y	Y				Y	Y	Y	Y	Y	Y	Y	Y	Y
Y =Test applicable														

2.5.2 415V Busduct

Items/ Components	Tests/ Checks														
	Dimension and surface finish	Make, Type, Rating and Test certificate	Electrical properties	Mechanical properties	Chemical properties	Item to conform to relevant IS	WPS approval, Welder qualification	Weld quality check (DP test and X-ray)	Paint shade, Thickness, Adhesion and	Tightness by torque measurement	Electrical clearances	Galvanizing test as per IS 2629/ 2633	IR – HV – IR test	Phase sequence check	Degree of protection routine test
Aluminum sheets/ plates/ strips / flexibles/ tubes (IS:5082/ 737)	Y	Y		Y	Y	Y	Y	Y							
CRCA flats/ ISMC (IS:2062)	Y	Y		Y	Y	Y									
Neoprene/ synthetic rubber gaskets (IS:11149/ 3400)	Y	Y		Y	Y										
Rubber bellows (IS:3400)	Y	Y		Y	Y										
Support insulator (BS:2782, IEC:660, IS:10912)	Y	Y	Y	Y											
Galvanized structure and GI earthing flat (IS:2629/ 2633/ 4749)	Y	Y				Y						Y			
Space heater and Thermostat		Y	Y												
LT busduct (IS:8623 Part 2)	Y	Y				Y	Y	Y	Y	Y	Y		Y	Y	Y
Y = Test applicable															

Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out.

a) General

i) HV test on complete switchboard with CT and breaker/ contactor in position
ii) Check continuity and IR value of space heater
iii) Check earth continuity for the complete switchgear board

b) Circuit Breaker/ Contactors

i) Check control wiring for correctness of connections, continuity and IR values
ii) IR values, resistance and minimum pick up voltage of coils
iii) All functional checks and electrical & mechanical interlocks provided
iv) Checks on spring charging motor, correct operation of limit switches and time of charging

c) Current and Voltage Transformers

i) Insulation resistance test
ii) Ratio test on all cores
iii) Polarity test

d) Relays

i) Insulation resistance between AC to DC terminals and between all terminals and body
ii) Check minimum pick up voltage of DC coils
iii) Relay settings

e) Bus duct

i) Power frequency voltage withstand test
ii) Insulation resistant measurement of equipment and all wiring
iii) Milli-volt drop test

2.6.0 POWER AND CONTROL CABLES

2.6.1 11kV, 6.6kV and 3.3kV Power Cables

Item/ Components/ Sub-system	Tests/ Checks																	
	Make, Type, Rating and TC	Dimension/ surface finish	Mechanical properties	Chemical composition	Spark test	Curing properties	Electrical properties	Hot set test, Eccentricity and Ovality	Lay length and sequence	Armour coverage, cross over, looseness, gap between two wire	Sequential marking/ surface finish/ cable length	Tensile strength and elongation before and after ageing on outer sheath and insulation	Thermal stability on outer sheath	Metallic screening (if applicable)	Anti termite coating on wooden	Constructional requirements feature	Routine and acceptance test as per	FRLS tests
Aluminium (IS-8130)	Y	Y	Y	Y			Y											
Semi conducting compound	Y		Y			Y	Y											
XLPE compound (IS-7098-Part-II)	Y		Y			Y	Y					Y						
FRLS PVC compound (IS-5831, ASTM-D2843, ASTM-2863, IEC-754 Part-1)	Y		Y									Y	Y					Y
Triple extrusion and curing/ Manufacturing of core		Y			Y			Y	Y									
Copper tape	Y	Y	Y				Y											
Polyster tape	Y	Y																
Armour wire/strip	Y	Y	Y															
Copper tapping	Y	Y						Y										
Inner sheath	Y	Y																
Armouring										Y				Y				
Outer sheathing		Y									Y	Y	Y			Y		Y
Power cable (Finished) (IS : 7098 Part-II) IEC:332, IS-5831, ASTM-D2843, ASTM-2863,IEC-754 Part-1)	Y								Y	Y	Y	Y	Y			Y	Y	Y
Wooden drum(IS:10418)/ Steel drum		Y													Y			
Y =Test applicable																		

Notes

1) Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample/ lot

2) Length measurement/ surface finish/ eccentricity/ ovality shall be checked on one length/ size/ lot

3) Routine test shall be carried out on each drum length as per specifications.

2.6.2 1.1 kV PVC and XLPE cables

Item/ Components/ Sub-system	Tests/ Checks															
	Make, Rating, Type and TC	Dimension/surface finish	Mechanical properties	Chemical composition	Electrical properties	Spark test	Hot set test (XLPE)	Lay length/ sequence	Armour coverage, cross over, looseness, Gap between two armour wire/ strip	Sequential marking/ surface finish/ cable	Tensile strength, elongation before and after ageing of insulation and outer	Thermal stability of insulation and outer	Anti termite treatment on wooden	Constructional/ requirement as per specification	Routine and acceptance test as per relevant standard and specification	FRLS Tests
Aluminum (IS-8130)	Y	Y	Y	Y	Y											
PVC compound (IS-5831)	Y		Y		Y						Y					
XLPE compound (IS-7098 Pt-II)	Y		Y		Y		Y				Y					
FRLS PVC compound (IS-5831) ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-I	Y		Y								Y					Y
Armour wire/strip (IS-3975)	Y	Y	Y													
Insulated core		Y				Y	Y					Y				
Laid up core		Y						Y								
PVC Inner sheath		Y														
Armouring		Y							Y							
Outer sheath		Y								Y	Y	Y				Y
Finish cable (IS-1554 and 7098 – Part-1) ASTM-D-2843/ ASTM- D-2863 IEC-754 Part-I Swedish Chimney SS 4241475 for (F3 category) Flammability test IEC-332 Part –3 Cat-B	Y	Y							Y	Y	Y	Y		Y	Y	Y
Wooden drum (IS-10418) / Steel drum		Y											Y			
Y =Test applicable																

Notes

1) (*) Not applicable for XLPE insulation
2) Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample /lot.
3) Length measurement / surface finish shall be checked on one length/size/ lot
4) Routine test shall be carried out on each drum length as per specifications.

2.6.3 1.1 kV PVC Control cables

Item/ Components/ Sub-system	Tests/ Checks														
	Make, Type, Rating, Test certificate (TC)	Dimension/ surface finish	Mechanical properties	Chemical composition	Electrical properties	Spark test	Lay length/ sequence	Armour coverage, cross over, looseness, gap between two armour wire	Sequential marking/ surface finish/ cable	Tensile strength, elongation before and after ageing of insulation and outer sheath	Thermal stability of insulation and outer	Anti termite treatment on wooden	Constructional feature as per	Routine and Acceptance test as per relevant standard and	FRLS test
Copper conductor (IS-8130)	Y	Y	Y	Y	Y										
PVC compound (IS-5831)	Y		Y		Y					Y					
FRLS PVC compound IS- 5831 ASTM-D-2843/ ASTM-D-2863 IEC-754 Part-1	Y		Y							Y					Y
Armour wire/strip (IS-3975)	Y	Y	Y												
Insulated core		Y				Y	Y								
Laid up core		Y					Y								
PVC Inner sheath		Y													
Armouring		Y						Y							
Outer sheath		Y							Y	Y	Y				Y
Finished cable (IS-1554) ASTM-D-2843/ ASTM-D- 2863 IEC-754 Part-1 Swedish Chimney: SEN SS 424-1475(F3 category) Flammability test IEC-332 Part-3 Cat-B	Y	Y						Y	Y	Y	Y		Y	Y	Y
Wooden drum(IS:10418)/ Steel drum		Y										Y			
Y =Test applicable															

Notes

1) Additional acceptance tests like FRLS, thermal stability, tensile strength and elongation after ageing shall be done on one sample/ lot
2) Length measurement / surface finish shall be checked on one length/ size/ lot
3) Routine test shall be carried out on each drum length as per specifications.

2.7.0 INSTALLATION OF CABLES, EARTHING SYSTEM AND LIGHTNING PROTECTION SYSTEM

Items/ Components/ Sub- systems	Tests/ Checks													
	Make, Type, Model, Rating and TC	Dimension	Pre-treatment of sheet	Paint shade, paint thickness, adhesion	IP protection	Bought out items/ Bill of material	HV and IR	Galvanize test	Functional test as per specification	Proof load	Deflection test	Constructional feature as per	All Routine and acceptance tests	Item conform to relevant standard
Switch box/ Junction box/ Receptacles (IS-513, IS:5, IS:2629, IS:2633, IS:6745)	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y	Y	
Cable glands (BS:6121)	Y	Y												Y
Cable lug (IS:8309)	Y	Y												Y
Lighting wire (IS:694)	Y	Y										Y		Y
Flexible conduits	Y	Y										Y		Y
Conduits (Galvanize and Epoxy) IS:9537, IS:2629, IS:2633 and IS:6745	Y	Y	Y					Y					Y	
RCC hume pipe (IS:458)	Y	Y												Y
Cable termination and Straight through joint (VDE-0278)	Y	Y			Y	Y						Y	Y	
Cable Trays, Flexible supports system and accessories IS:513, IS:2629, IS:2633 and IS:6745	Y	Y	Y			Y		Y		Y	Y	Y	Y	
Trefoil clamp	Y	Y												Y
GI flats for earthing and lightning protection (IS:2062, IS:2629, IS:6745 and IS:2633)	Y	Y	Y					Y						Y
GI wire (IS-280)	Y	Y	Y					Y						Y
Y =Test applicable														

Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

i) Cables
- a) Check for physical damage
- b) Check for insulation resistance before and after termination/ jointing.
- c) HT cables shall be pressure tested (test voltage as per IS:7098) before commissioning
- d) Check of continuity of all cores of the cables.
- e) Check for correctness of all connections as per relevant wiring diagrams. Any minor modification to the panel wiring like removing/ inserting, shorting, change in terminal connections, etc. shall be carried out
- f) Check for correct polarity and phasing of cable connections
- g) Check for proper earth connections for cable glands, cable boxes, cable armour, screens, etc.
- h) Check for provision of correct cable tags, core ferrules, tightness of connections

ii) Cable trays/ supports and accessories
- a) Check for proper galvanizing/ painting and identification number of the cable trays/ supports and accessories.
- b) Check for continuity of cable trays over the entire route.
- c) Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
- d) Check for earth continuity and earth connection of cable trays

iii) Earthing and Lightning protection system
- a) Earth continuity checks
- b) Earth resistance of the complete system as well as sub-system.

2.8.0 DC STORAGE BATTERY

2.8.1 Lead-Acid type battery

Item/ Components/ Sub-system	Tests/ Checks										
	Dimensions and finish	Conformance to relevant drawing	Chemical composition	Lead coating thickness (minimum 25 microns, IS:6848 and Adhesion check	Conformance to CPWD Specification for teak wood	Paint process checks, paint shade, thickness, adhesion	Constructional requirements as per specification	Insulation Resistance	Marking (Routine and Acceptance test)	Checking of polarity and absence of short circuit (Routine and Acceptance test)	Test for capacities for 10 hours discharge rate along with the test for voltage during discharge (Acceptance test)
Container and Lids (IS:1146)	Y	Y									
Vent plugs	Y	Y									
Sealing compound (IS:3116)		Y	Y								
Positive and Negative plates		Y	Y								
Separators (IS:6071)	Y	Y									
Electrolyte (water/ sulphuric acid) (IS:1069/ 266)		Y	Y								
Inter-cell connectors and fasteners	Y	Y		Y							
Battery stand	Y	Y			Y	Y					
Cell insulators	Y	Y						Y			
Stack assembly	Y	Y									
Lead-Acid battery (IS:1652)	Y						Y		Y	Y	Y
Y =Test applicable											

2.9.0 BATTERY CHARGER

Item/ Components/ Sub-system	Tests/ Checks												
	Make, Model, Type, Rating and Finish	Chemical and Mechanical tests	Sheet steel pretreatment and painting	Conform to relevant standard	Dimensional check and paint shade, thickness,	Complete physical examination for constructional	Temperature rise test	Dynamic response test	Ripple content test, load limiter and Annunciator and AVR operation test	Operational and functional checks	HV and IR test	Burn-in test at 50^0C for 48 hrs	Degree of protection test .
Rectifier transformer (IS:2026)	Y			Y			Y				Y		
Electronic components including potentiometer (vernier type)	Y			Y									
PCB and electronic cards	Y			Y									
19”standard racks for electronic card	Y					Y							
Control and selector switches (IS:6875)	Y			Y						Y			
Indicating meters (IS:1248)	Y			Y						Y			
Indicating lamps (IS:13947)	Y			Y						Y			
Air break switches/ Fuses (IS:13947/13703)	Y			Y						Y			
Control terminal blocks (IS:13947)	Y			Y									
Control transformer (IS:12021)	Y			Y						Y			
Push buttons (IS:4794)	Y			Y						Y			
MCB (IS:8828)	Y			Y						Y			
PVC insulated copper control wires (IS:694)	Y			Y									
Sheet steel (IS:513)	Y	Y	Y	Y									
Synthetic rubber gaskets	Y	Y		Y									
Annunciator	Y									Y		Y	
Battery charger	Y				Y	Y	Y	Y	Y		Y	Y	Y
Y =Test applicable													

Site tests :

The following minimum tests/ checks shall be conducted at site. Any other tests/ checks as per the manufacturer's recommendation shall also be carried out

i) Complete physical examination
ii) Checking of proper operation of annunciation system ii) Temperature rise test at full load
iv) Insulation resistance test
v) Automatic voltage regulator operation vi) Load limiter operation
vii) Dynamic response test

2.10.0 VFD MODULE

Attributes/ Characteristics / Items/ Components/ Sub-system assembly	Visual & Dimensional checks	Make / Type/ Rating etc.	Final Inspection as per IS/ IEC	Remarks
HT Breaker (IEC-56)	Y	Y	Y	
DC Reactor	Y	Y		For details refer table for DC Reactor
Transformer	Y	Y		For details refer table for Transformer
Motor	Y	Y		For details refer separate table for Motor
VFD Panel	Y	Y		For details refer table for VFD Panel

Note: 1) This is an indicative list of tests/checks. The manufacture is to furnish a detailed Quality Plan indicating the practices & Procedure followed alongwith relevant supporting documents during QP finalization

2) Make of all major Bought-out Items will be subject to purchaser's approval

2.10.1 DC Reactor

ATTRIBUTES/ CHARACTERISTICS ITEMS/ COMPONENTS, SUB_SYSTEM ASSEMBLY	Visual	Dimensional	Mechanical and Chemical Property	Electrical Characteristics	Pretreatment by seven tank	Painting by Stove Enamelling	Final inspection as per IS:2026	Welding/ NDT
1. Winding Material (Aluminium)	Y	Y	Y	Y				
2. Insulation Material	Y	Y		Y				
3. Sheet Steel	Y	Y	Y					
4. Winding	Y	Y		Y				
5. Fabrication of Enclosures	Y	Y			Y	Y		Y
6. Assembly	Y	Y						
7. Routine Tests	Y	Y					Y	

(R) - Routine Test (A) - Acceptance Test Y – Test applicable

Note:

1) This is an indicative list of tests/checks. The manufacturer is to furnish a detailed quality plan indicating the Practices and Procedure adopted along with relevant supporting documents during QP finalization of all items.

2) All major Bought-out items shall be subject to purchaser's approval.

2.10.2 Transformer (Oil Filled)

Attributes / Characteristics Items/Components Sub Systems	Visual & Dimensional Checks	Mechanical Properties	Electrical Strength	Thermal Properties	Chemical composition	Compatibility with oil	NDT/ DPT/ MPI/ UT	Ageing Test	Voltage Ratio, Vector Group & Polarity, Magnetic Balance Test	Make/ Type/ rating/ Model/ TC/ general Physical Inspection	WPS & PQR	Routine Test as per relevant test	Routine test
Tank, H.V. & L.V. Cable Box / Flange throat	Y	Y					Y						
Conservator / Radiator / Cooler / Pipes	Y	Y					Y						
Copper Conductor (IS:191)	Y	Y	Y		Y								
Insulating Material	Y	Y	Y	Y	Y	Y							
CRGO Lamination & Built Core	Y	Y	Y		Y	Y							
Bushing / Insulator (IS:2544 / 5621)	Y	Y								Y		Y	
Gasket	Y				Y	Y		Y				Y	
Transformer Oil (IS:335 / IEC296)												Y	
Off-Circuit Tap Changer	Y									Y			
Core Coil Assembly & Pre-tanking	Y								Y				
Marshalling Box	Y	Y					Y					Y	
WTI, OTI, MOG, PRD, Breather, Terminal Connector, Bucholz Relay, Globe & Gate Valve,	Y									Y			
Welding (ASME Sect- IX)	Y										Y		
Complete Transformer (IS:2026/ IEC-60076)	Y												Y

Note: 1) This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2) All major Bought Out Items will be subject to Purchaser's approval

2.10.3 Dry Type Transformer

Attributes / Characteristics Items/Components Sub Systems	Visual & Dimensional Checks	Mechanical Properties	Electrical Strength	Thermal Properties	Chemical Properties	NDT/ DPT/ MPI/ UT	Voltage Ratio, Vector Group & Polarity	Make/ Type/ rating/ Model/ TC/ general Physical Inspection	WPS & PQR	Routine Test as per relevant Standard	Measurement of Capacitance and tan delta between winding	Routine test
Enclosure door, H.V. & L.V. Cable Box / Flange Throat	Y	Y						Y				
Copper Conductor	Y	Y	Y		Y							
Insulating Material	Y			Y	Y							
CRGO Lamination & Built Core	Y											
Bushing /Insulator (IS:2544 / 5621)	Y							Y		Y		
Gasket	Y							Y		Y		
Off-Circuit Tap Changer	Y							Y				
Core Coil Assembly	Y						Y					
Marshalling Box	Y									Y		
WTI, Thermister, Terminal Connector	Y							Y				
Welding									Y			
Complete Transformer (IS:11171 / IEC 60076)	Y										Y	Y

Notes: 1) This is an indicative List of test/checks. The manufacturer is to furnish a detailed Quality Plan indicating his practice and procedure along with relevant supporting documents during QP finalization for all item.
2) All major Bought out Items will be subject to Purchaser's approval.

2.10.4 VFD Panel

Attributes Characteristics / Item/ Components/ Sub-system/ Assembly	Electrical Properties	Mechanical Properties	Chemical properties	Dimension/ Finish	Type/ Rating/ Functional Check	HV/ IR	Routine Test as per relevant Standard	Constructional Features	IS : 6005, Seven tank process	Paint finish/ Shade/ Thickness	Mounting/ BOM/ Make, Completeness	Interlock functional & operation testing/ Simulation check	Degree of Protection Test	Final testing as per relevant standard
Sheet Steel (IS-513)		Y	Y	Y										
Aluminum / Copper Busbar (IS-5082/IS- 613/IS-1987)	Y	Y	Y	Y										
Support Insulator (BS- 2782/ IEC-660/IS-10912)	Y	Y	Y	Y										
Control / Selector Switch (IS6875)					Y	Y	Y							
Contactor/ MCB (IS- 13947)					Y	Y	Y							
O/L Protection relays(IS- 3231)					Y		Y							
C.T /V.T/ Indicating Meter(IS2705/3156/1248)					Y	Y	Y							
Fuse/ Fuse carrier (IS- 13703)					Y	Y	Y							
Terminals/lugs/PVC wires(IS13947//IS-694)	Y			Y	Y	Y	Y							
Timers (IS-3231)					Y	Y	Y							
Push Button/ Lamp/ (IS- 6875)					Y	Y	Y							
Control Transformer (IS12021)					Y	Y	Y							
Mimic, Annunciator					Y		Y							
GASKET(IS-11149)		Y	Y	Y	Y		Y							
Fabrication								Y						
Pretreatment & Painting									Y	Y				
VFD panel										Y	Y	Y	Y	Y

NOTE:

1. This is an indicative list of Test/ Checks. The manufacturer to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2. All major Bought-out items will be subject to Purchaser's approval.

2.11.0 STATION LIGHTING

Attributes / Characteristics Items/Components Sub Systems	Make, Type, Rating/ TC	Dimension	Pre-treatment of sheet	Paint shade thickness Adhesion & Finish	Galvanization Tests	IP Test	Bought-out items/ Bill of Material	HV & IR	Functional check as per spec.	Constructional feature as per	Routine tests as per relevant standard & spec..	Acceptance tests as per relevant standard & spec.	Item to conform to relevant standard
Luminaries (IS:10322 Pt.5 Sec.1 (Non-LED type)	Y					Y		Y			Y	Y	Y
Electronic Ballast	Y										Y	Y	Y
Lighting wire (IS:694)	Y										Y		
Fans (IS:374)	Y										Y		
Pole (IS:2713)	Y			Y						Y	Y	Y	
Lamps (IS:9800, IS:9974)	Y										Y	Y	
Lighting Mast (with raise & lower lantern type)	Y	Y			Y					Y	Y	Y	
Wall mounted Lighting Panel (IS:513, IS:5)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Switch Box/ Junction Box/ Receptacles/ Local Push Button Station/ Lighting Panel (IS:513, 2629, 2633, 4759,6745)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Cable Gland (BS:6121)	Y	Y									Y		
Cable lug (IS:8309)	Y	Y									Y		
Flexible Conduit	Y										Y		
Lighting Transformer (IS:11171)	Y									Y	Y		
Epoxy & Galvanised Conduit (IS:9537, 2629, 2633, 4759, 6745)	Y	Y									Y		Y

3.0.0 CONTROL AND INSTRUMENTATION (C& I) SYSTEM

For C&I QA refer Volume II, Section – 4 Detailed Technical Specification.

4.0.0 CIVIL WORKS

4.1.0 SAMPLING, TESTING AND QUALITY ASSURANCE FOR CIVIL WORKS

4.1.1 General

i) This part of the specification covers the sampling, testing and quality assurance requirement for all civil and structural works including excavation and filling, cast in situ concrete and allied works, fabrication and erection of structural steel works, masonry / sheeting and allied works, finishing items, etc.

ii) The Contractor shall carry out all sampling and testing in accordance with the relevant Indian standards and / or international standards and this technical specification. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Purchaser. The Contractor shall establish the QA&QC laboratory at site. All sampling and all field tests shall be done in the presence of the Purchaser or his authorised representative. The tests which cannot be carried out in the field laboratory shall be done at a laboratory of repute such as CSMRS, NCBM, IITs, NITs, National Test House, Kolkata etc. as agreed by the Engineer. The cost of transportation and other associative cost including the test charges shall be borne by the contractor and be shall deem to be included in his contract price.

iii) The recommendations and suitability of material for concreting and other building materials like brick, cement, aggregates etc., shall be ascertained by contractor prior to start of work. Preliminary evaluation of aggregate and its evaluation for potential alkali-aggregate reactivity as per following shall be done:-

A. Evaluation of Aggregates:

- To carry out different tests on coarse aggregate sample i.e. specific gravity, water absorption, sieve analysis, deleterious material; soundness, crushing value, impact value, abrasion value, elongation index and flakiness index, as per IS: 2386.

- To carry out different tests on fine aggregate sample i.e. specific gravity water absorption, sieve analysis, soundness, deleterious material, silt content, clay content and organic impurities as per IS: 2386.

B. Evaluation of Aggregates for Potential Alkali-Aggregate Reactivity:

- To carry out petrographic analysis and accelerated Mortar bar Test on aggregate samples (1N NaOH at 80 deg. Centigrade for 14 days as per ASTM 1260, or the method established/ developed by CSMRS for 22days test.

All records shall be submitted, unless specified otherwise, as per the format developed by the Contractor and approved by the Engineer.

iv) The Contractor shall enclose a comprehensive list of bought out items (BOIs) envisaged in the contract for carrying out fabrication/ manufacturing/ erection/ construction / commissioning activities, procurement of forged, cast, semi-finished

and finished components/equipment etc. and shall indicate the names of reputed manufacturers for each of them in their bid proposal.

v) The list of manufacturers / sub-vendors of each of the BOIs identified/ indicated by the Contractor shall be discussed/ reviewed by the Purchaser during post bid discussions and the list of proposed manufacturers / sub-vendors shall be agreed/ approved. The Contractor's proposal shall include vendor's site facilities, expertise, facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified sub-Contractors proposed. The formats for furnishing above details shall be given to the Contractor at post bid discussion stage.

vi) Structural steel and reinforcement steel supply if in the scope of the contractor shall be procured from Main Steel Producers

vii) The Field Quality Plans shall detail out all the equipment, the quality practices and procedures etc. to be followed by the Contractor's "Site Quality Control Organization", during various stages of site activities starting from receipt of materials/equipment at site.

The contractor shall furnish complete QA & QC programme (QAP) for the work envisaged which may include the following :-

- The organisation structure for the management and implementation of the proposed Quality Assurance Programme.
- Document Control system
- The procedure for procurement of materials and source inspection.
- System for site controls including process controls.
- Control of non-conforming items and systems for corrective action
- Inspection and test procedures for site activities
- System for indication and appraisal of inspection status
- System for maintenance of records
- System for handling, storage and delivery.
- Quality Plan detailing out quality practices and procedures, relevant standards and acceptance levels for all types of work under the scope of this contract.

Based on the schedule of work agreed with the Purchaser and the approved FQP, the Contractor shall prepare a schedule of tests and submit them to the Purchaser and organise to carry out the tests as scheduled/ agreed.

viii) The contractor shall prepare and obtain approval of the Owner of the Field Quality Plan (FQP) well before the start of the work. This FQP shall cover for all the items / activities covered in the contract/schedule of items and required for completion of the work.

ix) All materials / components and equipment covered under the scope of work which are to be manufactured at shop/ factory of the vendor/subvendor shall be covered under a comprehensive quality assurance programme. Manufacturing Quality Plan (MQP) shall detail out all the components and equipment, various test/inspection, to be

carried out as per the requirements of this specification and standards mentioned therein.

x) All the equipment shall be duly calibrated by NABL/ NPL accredited laboratories/accreditation agencies.

xi) The Contractor shall submit to the Purchaser Field Welding Schedule for field welding activities, the format for Field Welding Schedule shall be furnished to the Contractor at pre-award stage. The field-welding schedule shall be submitted to the Purchaser along with all supporting documents, like welding procedures, heat treatment procedures, NDT procedures etc. at least ninety days before schedule start of erection work at site. The Contractor shall submit Welding Procedure Specification (WPS) for Purchaser approval/ acceptance, the format for the WPS shall be furnished to the Contractor during post bid discussion stage.

All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS- 4870 or other International equivalent standard acceptable to the Purchaser. All welding/brazing procedures shall be submitted to the Purchaser or its authorized representative for approval prior to carrying out the welding/brazing.

All brazers, welders and welding operators employed on any part of the contract either in the Contractor's/ sub-Contractor's works or at site or elsewhere shall be qualified as per AWSD1.1/ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Purchaser.

Welding procedure qualification and Welder qualification test results shall be furnished to the Purchaser for approval. However, where required by the Purchaser, tests shall be conducted in presence of Purchaser /authorized representative.

No welding shall be carried out on cast iron components for repair.

All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

All Non-destructive examination shall be performed in accordance with written procedures as per International Standards and as mentioned elsewhere in the technical specification; The NDT operator shall be qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job. The records of RT (Films) and UT (inspection records or printed reports if possible) shall be documented and produced to Purchaser.

xii) The Contractor shall associate themselves with the reputed specialized blasting agency such as CMRI, NIRM for trials blasts, design blasts, blasting pattern, monitoring of blast during the blasting operations at site. All blasting work shall be done as per approved blasting scheme/ design/ pattern in line with the technical specification requirements and all statutory laws, rules, regulations, relevant standards pertaining to the acquisition, transport, storage, handling along with use of explosives shall be strictly followed by the Contractor.

xiii) The Contractor shall install and operate equipments (such as tri-axial seismograph) for continuous monitoring and control of blast induced vibrations, noise level/ air pressure, dust, silica and noxious gases during all blasting operations in line with the Technical Specification requirements in association with the specialized blasting agency.

4.2.0 GENERAL QA REQUIREMENTS

4.2.1 Storage and handling of common building materials

All materials shall be stacked and stored by the Contractor as per IS-4082 and as per the requirements specified in Purchaser Technical Specification.

4.2.2 Excavation and filling works

i) The contractor shall submit a work methodology covering various items of works for all stages of excavation and filling works. This methodology shall broadly include the quantity wise and classification wise identification of source of excavation and filling, suitability tests as per specification requirements, method of stockpiling, transportation, placement, spreading, compaction, equipment, list of protocols, in- situ tests, third party lab test if required, acceptance checks for final clearance.

ii) Tolerance for finished surface level shall be within 20 mm of the level shown in the drawing. For an unimportant area, tolerance up to +75mm shall be acceptable at the discretion of the engineer. However, these tolerances shall be applicable for localized areas only.

Acceptance criteria shall be:

a) When only one set of sample is tested, then all individual samples collected and tested should pass without any deviation
b) For retest of any sample two additional samples shall be collected and tested, and both should pass without any deviation.
c) Where a large number of samples are tested for a particular test then 9 samples out of every 10 consecutive samples tested shall meet the specification requirement.

4.2.3 Masonry and allied works

Unless specified otherwise the tolerances in construction of masonry works shall be as below:

Sl. No.	Type of Check	Tolerance
1	Deviation in verticality in total height of any wall of a building	Shall not exceed 12.5mm (more than one storey) 6mm per 3m height (within a storey)
2	Deviation from the position shown on the plan of any brickwork	Shall not exceed 12.5mm (more than one storey)
3	Relative displacement between load bearing walls in adjacent storeys intended to be in vertical alignment	Shall not exceed 6mm
4	Deviation of bed joint from horizontal in any length, and it	Shall not exceed 6mm (upto 12m) Shall not exceed 12.0 mm total (in any length over 12m)
5	Deviation from the specified thickness of bed-joints, cross- joints or perpends	Shall not exceed 1/5th of the specified thickness
6	Finished plastered surface	Deviation not more than 4 mm when checked with a straight edge of 2 m length placed against the surface
7	The average thickness of plaster	Not be less than the specified thickness
8	The minimum thickness over any portion of the surface	Not less than the specified thickness by more than 3 mm for plaster thickness above 12mm and 1 mm for ceiling plaster

4.2.4 Concrete works

For concreting works provisions of technical specifications and IS: 456 shall apply. A detailed methodology for concrete works shall be submitted by the contractor to Purchaser for approval.

The methodology for concrete works shall broadly contain the suitability of source of aggregates, cement, admixture, water and reinforcement steel, etc. t he available concrete mix design, results of trial mix carried out at site, method / control of batching, mixing, transportation, layer wise placement, compaction, fixing / removal of form work, staging, fixing of water stops at appropriate locations along with specials, expansion joints, contraction joints and construction joints, cover blocks and method of curing, methodology of repair of newly placed hardened concrete, testing and sampling of concrete during production and placement and acceptance checks for final clearance.

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition for at least seven days from the date of placing concrete in case of ordinary Portland cement, not be less than 10 days for concrete exposed to dry and hot weather conditions, at least 10 days or period may be extended to 14 days where mineral admixtures or blended cements are used.

Approved curing compounds may be used in lieu of moist curing with the permission of purchaser.

Reinforcement steel shall conform to relevant IS codes. Lapping / spacing of reinforcement shall be so staggered that under no circumstances more than 50% of bars at any cross section shall be lapped. Corrosion resistance Steel shall be used for the foundations wherever specified in the technical specification. Sample test for 3% of the number of mechanical bars grips subject to a minimum of three, shall be carried out up to the yield strength of reinforcement of bars.

Test shall be conducted for the water tightness of the liquid retaining structures as per technical specifications, IS 3370 and IS 6494.

All the materials, equipment, processes used in pre cast concrete work shall conform to the requirements for the cast-in-situ concrete.

If fly ash is used in concrete, source of supply shall be checked for suitability as per IS 3812 (Part-I). Routine tests for retention of particles on 45µ sieve and loss on ignition shall be carried out on each lot of fly ash before its use. The storage of fly ash shall be similar to that of cement. Separate Silo for fly ash shall be provided in the batching plant. Validation of Mix design using fly ash shall be carried out by an approved specialist agency, before start of concrete production.

The acceptance criteria of concrete shall be in accordance with IS 456.

All records of concreting, reinforcement, testing of materials, as-built dimensions, the details of the rectification, etc. shall be maintained as given below. Four copies of such record in a bound form shall be submitted to owner for their record and future reference.

i. Testing data / report of aggregates including petrographic examination & potential reactivity of aggregate and repeated temperature cycle tests wherever specified.

ii. Testing records of admixture as per IS-9103 / ASTM C494 including third party test reports.

iii. Approved scheme for concreting

iv. Hourly records of concreting including pour card

v. Protocol indicating the dimensional tolerance and details of inserts

vi. Records giving the details of rectification giving the location of grouting, the quantity of grout used at each location, type of grout used

vii. Bar bending schedule

viii. Location and details of mechanical anchoring used for reinforcement

ix. Protocol giving the details of checking of reinforcements before concreting and conformance to the reinforcement details as shown in the construction drawings

x. Photographs showing the areas where rectification works have been carried out. Photographs should be taken before and after rectification

xi. Temperature control record of concrete at the time of placement if applicable.

xii. Details of curing, staging and fixing / removal of formwork, checklist for formwork as per IS 14687 including all machine foundations

xiii. Batching Plant shall be calibrated regularly at least once in a 3 months. Computerized output shall be taken for each batch of production of concrete. Production and supply of concrete from batching plant shall conform to the provisions of IS 4926.

xiv. Dimensions (length, cross sectional dimensions, straightness, squareness, and flatness) and tolerances for pre cast members as per Technical Specification. Load test on Pre cast members (except pre- cast tiles to be laid in the reservoir) shall be carried out @ 1% up to 1000 nos., @0.5% from more than 1000 nos. precast members of one type. The load test shall be carried out as per the provisions of IS-456 and relevant IS code.

4.2.5 Structural steel work

For structural steel works provisions of technical specifications and IS: 800 shall apply. A detailed methodology for structural steel works shall be submitted by the contractor to Purchaser for approval.

The contractor shall submit the welding procedures specification (WPS), heat treatment procedures, NDT procedures etc. at least ninety days before scheduled start of erection work at site. All welding and brazing shall be submitted to the Purchaser and carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the Purchaser.

All brazers, welders and welding operators employed on any part of the contract either in the contractor's / sub-contractor's works or at site or elsewhere shall be qualified as per AWSD1.1/ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the Purchaser.

The records of welding procedure qualification and welder qualification test results shall be furnished to the Purchaser for approval. However, where required by the Purchaser, the tests shall be conducted in presence of Purchaser / authorized representative.

No welding shall be carried out on cast iron components for repair. All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

All Non-destructive examination shall be performed in accordance with written procedures as per International Standards and as mentioned elsewhere in the technical specification. The NDT operator shall be qualified as per SNT-TC- IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job. The records of RT (Films) and UT (inspection records or printed reports if possible) shall be documented and produced to Purchaser.

Low hydrogen electrode (AWS E-7018) for welding of High/Medium tensile steel, for M.S (IS 2062 Gr. A/Gr. B, IS 8500) sections thickness above 20mm shall be used. Preheating and Post weld heat treatment requirements shall be complied as specified in the technical specification / approved WPS.

The requirements of pre-heating shall be as per relevant IS.

The following tests/ checks shall be carried out for structural steel works:

SL. NO.	TESTS / CHECKS	QUANTUM / STANDARD
1	Physical and chemical properties of material if supply in the scope of contractor	As per relevant codes, review of correlated mill test certificates or check testing in absence of MTC
2	Ultrasonic test on plates above 40mm	As per ASTM A435
3	Welding procedure & welders qualification test	AWSD1.1/ASME Section-IX or BS-4871 or other equivalent International Standards
	Fillet Weld	
4	Macro-etch examination on production test coupons for main fillet welds	Minimum one joint per built up beams, columns and crane girder etc.
5	Tension member of crane girder	Dye penetration test on 25% weld length
6	All other fillet welds	DPT on 5% of weld length with minimum 300mm at each location
	Butt Weld	
7	DPT	100% after back gouging on all butt welds
8	Mechanical testing of production test coupons	Minimum one joint per built up beam, column and crane
9	Radiography test on butt welds (In case of failure of any welds in SPOT/RT or UT the % of retesting shall be doubled at that particular location. Acceptance criteria of NDT on welds shall be as per AWS D1.1.	100% RT on butt welds of tension flange (bottom flange) of crane girders 10% RT weld length of each welder on butt welds,
10	Ultrasonic testing on full penetration welds (other than butt welds)	100% UT on the web to flange joint of crane girder 10% UT on other full penetration joints
11	Control assembly checkin shop before erection	1st and further every 10th set of identical structure
12	Dimensional tolerances during fabrication and erection	as per IS-7215 and IS-12843
13	Surface Preparation and Paint thickness	SA 2 1/2 , By elcometer random after each coat, each member

4.2.6 Painting works

Painting works shall be carried out as per the provisions of technical specifications. A detailed methodology for painting works shall be submitted by the contractor to Purchaser for approval.

The methodology for painting works shall broadly contain the source of approved brand of paints, shot / sand blasting as specified, minimum acceptable size of shot used for blasting, application of primer, intermediate coat and final coat, experience of applicator, etc. testing of painting work and acceptance checks for final clearance.

4.2.7 Sheeting works

All bought out items shall be procured from the manufacturer's approved by engineer and tested as per relevant IS Codes/ Specification. Raw material of colour coated sheets shall meet the chemical & physical properties as per relevant standards / codes referred in the approved data sheet. It shall be tested for colour match, bare metal thickness, weight of Z/AZ coating, thickness of painting system, reverse impact, T-Bend adhesion, scratch resistance, salt spray test for 1000 Hrs and any other test / properties as specified in the technical specifications. Colour coated sheets shall be marked with video jet printing at the interval not more than 2m bearing manufacturer's name, date and time of manufacturing. Fasteners shall also be tested for 1000 hrs salt spray test as per the requirement of technical specifications.

Bonded Mineral Wool Insulation shall meet the requirements of thickness, density, thermal Conductivity, all other tests as per the technical specifications and IS-8183.

For sheet installation no gas cut opening shall be allowed at the site, whenever opening is specified these shall be properly cut in the factory and shall be filled with lipping / flashing for true shape / dimension etc. The sheets/ packets shall be stacked neatly clear off the ground at an angle to the ground, over a base pallet to provide drainage. Water / moisture should not be allowed to stagnate on surface, or in between layers. This can damage the coating, and cause corrosion.

4.2.8 Tile works

The contractor shall submit the work methodology which shall include the type, grade and make of materials along with their technical data sheets, details, etc., clearance from E-I-C regarding leak proofness and damp proofness of parent concrete surface, surface preparation, the procedure of application, curing, testing and acceptance.

The tests shall be carried out on acid resistant bricks / tile- water absorption, compressive strength, resistance to acid, flexural strength, dimensions and all other tests as per IS 4860 and IS 4457, bitumastic ready mixed paint as per IS 158, bitumastic as per IS 9510, potassium silicate, resin type and sulphur type mortars as per IS 4832, part I, II and III, surface preparation for painting as per IS 2395, epoxy painting shall be carried for required coating thickness and dry film thickness.

4.2.9 Fire proof doors

Fire Proof doors shall be tested for the requirements mentioned in the Technical Specification. The type test of the doors shall be carried out at CBRI Roorkee for minimum 2 hours fire rating and its Fabrication drawing shall also be approved by CBRI, Roorkee. DFT of paint of Fire Proof Doors and its fittings and fixtures as per BOQ shall be checked. The doors shall be finished with suitable fire retardant painting system

4.2.10 Water proofing

Water proofing shall be tested for water tightness by creating a pond of water minimum 25 mm height on area of 6 m x 6 m, for the period of 48 hrs on fully dried elastomeric membrane surfaces. Minimum 5% area of the roof shall be subjected to water tightness test. Such test necessarily be conducted on vulnerable areas like drain channel / drain head. No dampness shall be visible on the underneath side of roof (i.e. ceiling), parapet and well junctions etc. which have been subjected for testing. The above testing shall be carried out prior to application of wearing course.

4.3.0 PILING WORK (IF APPLICABLE)

A detailed methodology for piling works shall be submitted by the contractor to Purchaser for approval. The methodology shall broadly contain the method of boring, stability of bore hole, termination criteria, tests / checks for termination level, fabrication of cage, cage lowering, concrete batching / mixing, transportation, placing, recording of the time of construction operations, method of conducting initial and routine load tests, testing and sampling of concrete during production and placement and acceptance checks on piles for final clearance.

The piling works shall be executed as per the technical specifications, approved drawings, relevant codes / standards, FQP and BOQ. In addition to the requirements of technical specifications, the following shall also be ensured while execution of piling works:

a) Time gap between completion of pile boring and start of concreting should be kept to the minimum. However, the maximum time gap shall not be more than 6 hours.

b) Muck Debris should be removed from the pile bore by air lift technique (by keeping the tremie & air pipe as close as to bottom of pile bore) i.e. after completion of boring, after completion of SPT (wherever applicable), after lowering reinforcement cage, but before start of concreting.

c) Density of bentonite slurry shall be checked from the sample taken from the bottom of pile bore (not at 1.0 m above the bottom of the pile bore)

d) While lowering the R/F cage into the pile bore, two hooks shall always be used to ensure balanced/symmetrical insertion of cage into the pile bore.

e) Concrete cover blocks at the junction of two R/F cage shall be ensured before lowering the second segment.

f) Surge concreting of about 1.0 cum shall be ensured at the start of concreting (i.e. in the first pour), by suddenly allowing to fall through the tremie pipe from the funnel. This will help in displacing left out muck/debris in the pile bore (by the impact).

g) Continuous feeding of concrete shall be ensured by deploying at least two transit concrete mixers (if required to be deployed) and mixing done through concrete batching plant (if deployed). Cold joints in the pile shall be avoided.

h) In a pile group, SPT shall be carried out at termination level in the pile, taken up first.

i) Bentonite slurry circulation to be ensured from start of boring to start of concreting.

j) Properties of drilling mud shall be checked prior to commencement of the piling work and thereafter, minimum once per week or as found necessary by the engineer. One sample consisting of 3 specimens shall be tested for the above.

k) Low strain pile integrity test on all job piles and test piles shall be conducted as specified in the Technical Specification. This test shall be suitably used to identify the piles for routine tests. High Strain dynamic test shall be done as per the technical specification. The frequency of the test shall be as per the BOQ

l) For Working Piles: Minimum one sample consisting of 6 test cubes shall be made for first ten piles. Out of these 3 shall be tested for 7 days' cube strength and 3 for 28 days cube strength. Minimum one sample of 6 test cubes for every 25 nos. of piles shall be tested, out of these 3 shall be tested for 7 days' cube strength and 3 for 28 days' cube strength.

4.3.1 Pile load test

Pile load testing shall conform to the requirements of IS-2911 (Part IV) and the technical specification. Initial load tests as specified in the contract documents shall be conducted to assess the safe load carrying capacity of pile before start of work. To verify the load carrying capacity of the working piles, routine load test shall be conducted.

Pile load-testing procedure and the test setup / scheme shall be submitted for approval of Purchaser.

All the gauges and instruments shall be calibrated before the start of the tests on test piles and working piles and the calibration record shall be verified before start of execution of the test.

4.4.0 WATER SUPPLY, DRAINAGE & SANITATION

Material used for sanitary and plumbing fittings and fixtures shall conform to and be tested as per the requirements of relevant IS Codes specified in t echnical specification.

The obstructions in sewer lines shall be checked by inserting a smooth ball, of diameter 13 mm less than the pipe bore at the high end of the sewer or drain. If absence of any obstructions, such as yarn or mortar projecting through the joints, ball shall roll down the invert of the pipe and emerge at the lower end. The straightness shall be checked by means of a mirror at one end of the line and lamp at the other. If the pipeline is straight, the full circle of the light may be observed. The mirror will also indicate obstruction in the barrel, if the pipeline is not straight.

The service pipes shall be slowly and carefully charged with water, allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under test / working condition of pressure and flow, when all draw-off taps are closed. The service pipes shall be checked for satisfactory support and protection from damage, corrosion and frost.

4.5.0 ARCHITECTURAL & MISC. WORKS

Material used for sanitary and plumbing fittings and fixtures, floor finishes and allied work shall conform and tested as per the requirements of relevant IS Codes specified in Purchaser technical specification.

Fabricated item like metal doors, windows, ventilators, louvers, rolling shutters and grills etc. shall be checked for correctness of locations and smoothness of operation and fixtures. All controls and locking devices shall give fault free performance. Door and window shutters shall operate without. jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm. For double leaf doors, the gap at the meeting stiles shall not be more than 2.5 mm.

Materials used in glass and glazing shall be procured from source approved by Purchaser and shall conform to the requirements of the Technical Specification and IS Codes.

False ceiling panels shall be best quality material in thickness and properties called for in the specification / schedule of items. Material Test Certificate to be submitted before bulk supply.

All bought items covered in the scope of contract shall be procured from sources approved by Purchaser and shall conform to the requirements of the technical specifications and referred standards /codes.

4.6.0 PRE CAST CONCRETE WORKS

i) All the materials used in Pre cast Concrete work shall be tested and conform to the requirements of IS codes and Purchaser Tech. Specification.

ii) Concrete mix for Pre cast members shall conform to IS-456-2000.

iii) All relevant QA requirements pertaining to cast in-situ concrete shall be applicable.

iv) Load test on Pre cast members shall be carried out for the type of members as decided by Purchaser Engineer as per IS-456-2000.

v) Pre Cast Concrete member shall be checked for dimensions (length, cross sectional dimensions, straightness, squareness, and flatness) and tolerances shall be as per Purchaser Technical Specification

Tamil Nadu Generation and Distribution Corporation Ltd.

Flue Gas Desulphurisation System & Auxiliaries for North Chennai TPP - Stage-III - 1x800 MW Supercritical Thermal Power Station Project

TENDER ENQUIRY DOCUMENT
FOR
EPC CONTRACT

[TENDER SPECIFICATION No. SE/E/PROJ-II/OT.NO.2/2018-2019]

VOLUME II

SECTION 5

DETAILED TECHNICAL SPECIFICATION –

CIVIL AND STRUCTURAL WORKS

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India

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DETAILD TECHNICAL SPECIFICATION - CIVIL

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SECTION 5

DETAILED TECHNICAL SPECIFICATION – CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

1.0.0 GENERAL

1.1.0 This specification covers design, preparation of general arrangement drawings, construction and fabrication drawings, supply of labour, materials and construction of all civil, structural and architectural works for FGD System & Auxiliaries Package - 1x800MW NCTPP Stage-III, Chennai, Tamil Nadu.

Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope is referred to as Civil Works. Various buildings, structures, plant and systems, facilities, etc., covered under the Civil, Structural and Architectural works irrespective of what is stated in this document, to complete the entire scope of work specified elsewhere within the battery limits (terminal points) in the bid documents shall be deemed to be in the scope of this contract.

The work to be performed under this specification consists of design, engineering and providing all labour, materials, consumables, equipment, temporary works, temporary storage sheds, temporary colony for labour and staff, temporary site offices, constructional plants, fuel supply, transportation and all incidental items not shown or specified but reasonably implied or necessary for the completion and proper functioning of the plant, all in strict accordance with the specifications including revisions and amendments thereto as may be required during the execution of work.

All materials including cement, reinforcement steel and structural steel, etc., shall be provided by the Bidder.

The scope shall also include setting up by the Bidder a complete testing laboratory in the field to carry out all relevant tests required for the Civil Works.

The work shall be carried out according to the design/ drawings to be developed by the Bidder and approved by the Owner/Engineer. For all buildings, facilities, systems, structures, etc., necessary layout and details are to be developed by the Bidder keeping in view the statutory and functional requirements and providing enough space and access for operation, use and maintenance. The Bidder's work shall cover complete requirements as per IS codes, fire safety norms, requirements of various statutory bodies, International Standards, best prevailing practices and to the complete satisfaction of the Owner/Engineer.

Site grading and leveling is excluded from the scope of Bidder. However Bidder to do micro leveling as required at site. The Bidder shall reinstate the finished ground level to the same conditions as was handed over at the end of all construction works under taken to fulfill the requirements of this specification.

The Bidder shall make the layout and levels of all structures from the general grid of the plot and the nearest GSI benchmark or other acceptable benchmark of Govt. dept. as per the directions of the Owner/Engineer. The Bidder shall be solely responsible for the correctness of the layout and levels and shall also provide necessary instruments, materials, access to works, etc., to the Owner/Engineer for general checking of the correctness of the civil works.

All the quality standards, tolerances, welding standards and other technical requirements shall be strictly adhered to.

The Bidder shall fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, soil conditions, local conditions and site specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications.

In case of any conflict between stipulations in various portions of the specification, most stringent stipulation would be applicable for implementation by the Bidder without any extra cost to the Owner.

1.2.0 Scope of Works

Please refer to Section 1, General Technical Specification

2.0.0 SUBMISSIONS

Please refer to Section 1, General Technical Specification

3.0.0 DESIGN CRITERIA

3.1.0 General

Structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, piping loads (static and dynamic), wind loads, seismic loads and temperature loads. In addition, loads and forces developed due to differential settlement shall also be considered.

All designs of RCC structures shall be carried out by limit state method as per IS:456 unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS:456.

RCC silos shall be designed as per IS:4995 (part 1 & 2).

For reinforcement detailing IS:5525 and SP:34 shall be followed.

The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

All steel structures shall be designed in compliance with IS:800-1984. If a type of structural steel design which is construed to be not in the ambit of IS 800 -1984, then the equivalent international standard shall be used.

a. Internationally accepted design codes and standards where Indian codes are not available and which are equivalent to Indian standards

b. National Building Code of India

c. Accepted Standards“ and “good practice“ listed in the appendix to National Building Code of India

d. IS:1256 Code of practice for Building Byelaws

General list of codes and standards to be used in the design of structures/ buildings is given below. In absence of any suitable provision for design loads, any other recognized code of practice may be followed subject to prior approval of the Owner/ Consultant.

S.No.	IS CODE.NO	SUBJECT
1	IS:456	Code of practice for plain and reinforced concrete
2	IS:875	Code of practice for design loads for buildings and structures
3	IS:1893	Criteria for earthquake resistant design of structures
4	IS:800	Code of practice for general construction in steel

Environmental protection

a. Charter on Corporate Responsibility for Environmental Protection (CREP) published in Gazette of India dated 27.08.2003
b. CEA guidelines for civil works for power plants of 500MW and above shall be followed.

3.1.1 The applicable codes for the design shall be as listed at the end of this specification.

3.2.0 Loading

3.2.1 Dead Loads (DL)

Dead loads shall include the weight of structure complete with finishes, fixtures and partitions, false- ceiling and shall be taken as per IS: 875 (Part- I).

S.No	Material	Unit Weight
1	Reinforced concrete	25 kN / Cum.
2	Plain concrete	24 kN / Cum.
3	Brick masonry	20 kN / Cum.
4	Soil	18 kN / Cum.
5	Grating	0.75 kN / Sq.m.
6	Chequered plate 6 mm thk	0.60 kN / Sq.m.
7	Structural steel	78.5 kN / Cum.
8	Floor finish	24 kN / Cum.

3.2.2 Equipment Loads (EL)

Loads of all equipment like water Tanks, Cooling Equipment, Motors, fan drive pulleys, Pumps, Monorails, Ventilation duct, air inlet & exhaust duct, Electrical control and relay panels, Cable load, Pipe load (static and dynamic), Tanks, AHU, Batteries, Air Washer, etc. shall be considered over and above the imposed loads. Equipment loads shall be considered as given by equipment supplier. Equipment loads, which are of permanent nature, shall be treated as dead loads. However, where the uniform floor live load adequately accounts for the equipment moving weight, the weight of such equipment as a dead load shall not be considered.

All equipment, tanks and piping design loading shall include hydraulic testing loading. Weight of equipment, ducts, tanks, pipes, conduits, etc. supported by structure shall include maximum possible loading conditions i.e. flooded conditions and associated impacts, test loading, anchorages and constraint effects.

Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and any other loads applicable.

3.2.3 Crane Load (CRL)

Monorail Loads

Impact factor of 10% of lifted load of hoist for monorail and support design. Impact factor of 25% of the lifted load for electric pulley and support design.

Elevator

i. A 100% of the lifted load including elevator live load plus the crab weight for the elevator support beams.

ii. Pedestals supporting gravity take-ups for conveyors and pedestals in elevator pits shall be designed assuming 100% impact factor.

iii. Rotating and reciprocating equipment load:-50% of the machine weight.

3.2.4 Live Loads (LL)

Live loads shall consist of uniform live loads and equipment live loads. Uniform live loads are assumed unit loads which are sufficient to provide for movable and transitory loads, such as the weight of people, portable equipment and tools, planking and small equipment, or parts which may be moved over or placed on floors during maintenance operations. These uniform live loads should not be applied to floor areas which shall be permanently covered with equipment.

Equipment live load are calculated loads based upon the actual weight and size of the equipment and parts to be placed on floor during dismantling and maintenance, or to be temporarily placed on or moved over floors during installation.

Floors and supporting members which are subject to heavy equipment live loads shall be designed on the basis of the weight of the equipment in addition to a uniform load of 500 kg/m2, or specifically defined live loads, whichever is greater. Each member in the floor which may carry these loads shall be designed for the heaviest piece or pieces of equipment arranged in the most critical position. For loads caused by moving equipment over the floor for installation, consideration shall be given to the shoring of beams and floor from floors below. When moving equipment over floors for installation, stress increases of 25 percent are permitted in beams and columns.

For consideration of imposed loads on structures, IS: 875 (Part – II) “Code of practice for design loads (other than earthquake) for buildings & structures” shall be followed. The following minimum imposed loads as indicated for some of the important areas shall, however, be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

Table 1: Live loads on floor shall be taken as follows:-

Sl.No.	Description	Live Load (KN/m2)
1	General (Unless Specified Otherwise)	
	Ground floor (supporting equipments)	15
	Ground floor and suspended floor	5
	Suspended floor (supporting equipments)	10 (or) actual; requirement whichever is more
	Stairs, Landings and Balconies	5
	Toilets	2
	Chequered plates, grating floors, etc.	5
	Flat roofs (where no equipment are located)	1.5
	Flat Roofs (where equipment are located)	5
	Inclined Roofs	As per IS:875 (Part-II)
	Walkways (General).	5 (or) a concentrated load of 3 T/m whichever is greater
	Cable and pipe trestles	2 for walkway and in addition, friction loads as applicable
	Walkways of conveyor galleries.	0.5
2	Floor of control room	10
3	Pump house –Operating floor	15
4	Underground Structures such as ground Channels, Sumps, Underground Pump House, Tanks, Trenches, Reservoirs, Cooling Water Ducts etc.	In addition to earth pressure and water pressure, the surcharge load of 2T/Sq.m.
5	Road Culverts / Bridges and its allied structures including RCC Pipe Crossings & Road Crossing of Trenches	Design for class 'AA' loading (wheeled & tracked both) and checked for class 'A' loading as per IRC Standard.
6	Covers for Channels / trenches	Trench cover at entry to building and road crossings shall be designed for live load of 100 kN at Center. Trench cover at other location shall be designed with a surcharge of 100 kN/m2) or a concentrated load of 100 kN at center which is worst.
7	Railway Supporting Structures, Rail Culverts	As per railway 'Bridge Rules'
8	Main control room/electrical buildings	
	Control Room Floor	10
	MCC Room	15
	Cable vault floor	5

Sl.No.	Description	Live Load (KN/m2)
	Battery Rooms	20
	AHU, AC & ventilation plant floors	10
	Switch gear room	15
	PLCC, relay room	15
9	Service platform around Chimney	5
	During erection/construction	10

NOTE :

i. Additional load for cable, piping / ducting, shall be considered as applicable.
ii. Hung load shall be based on minimum loading equivalents of 1 kN/ m² for piping and 0.5 kN/m² for electrical ventilation and air conditioning.
iii. Loading resulting from concentrations of facilities in specific areas shall be substituted where listed base loadings are excluded

3.3.0 Seismic Load (SL)

The seismic zone shall be Zone - III as per IS: 1893. Importance factor (1.75) shall be taken as Table 2 of IS: 1893: Part-4 & Response Reduction Factor will be taken from Table 7 of IS: 1893 - 2002 with 100% of mass participation. Ductile detailing in accordance with IS: 13920 shall be adopted for all concrete structure which is mandatory for Zone -III. Response spectrum method shall be used for seismic analysis using at least 5 modes of vibration. Damping factor shall be as per IS 1893.

Zone factor - 0.16

3.4.0 Wind Load (WL)

Wind loads for all structures shall be based on IS: 875 (Part 3). Basic wind speed shall be 50m/sec. A step function of pressure with height under different exposure conditions shall be used. For steel structures exceeding 25m height, diagonal wind analysis shall be carried out.

3.5.0 Temperature Load (TL)

For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation.

Suitable expansion joints shall be provided in the longitudinal direction wherever necessary. The maximum distance of the expansion joint shall be as per the provisions of IS: 800 and IS: 456-2000 for steel and concrete structures respectively.

Systems and system component design criteria which require ambient temperature extremes shall use the range from 22C to 40C for dry-bulb temperatures.

3.6.0 Earth Pressure Load (SP & SCL)

i. Earth pressure for all underground structures shall be calculated using coefficients of earth pressure at rest only.

ii. Angle of internal friction for foundation of underground structures for calculation of earth pressure shall be from soil report or 33 degrees whichever less is.

iii. For backfilled soil, angle of internal friction shall be limited to 30 degrees.

iv. In addition to earth pressure and ground water pressure, etc., a minimum surcharge load of 2.0 t/Sq.m shall also be considered for the design of all underground structures including channels, sumps, cable & pipe trenches, etc., to take into account the vehicular traffic in the vicinity of the structure.

v. Dynamic effect of earth pressure due to seismic conditions shall be considered along with hydrodynamic effect of liquid storage structures.

3.7.0 Hydrostatic Pressure Load (HP)

Ground water level shall be considered at finished grade level for design purpose.

3.8.0 Construction Loads

Construction loads to be considered for design shall include all loads expected due to plant and equipment, stacked materials, live loads due to movement of plant, materials and personnel etc.

3.9.0 Dynamic Loads

Each structure shall be designed to withstand the effects of vibration and impact to which it may be subjected. Each structure and foundation supporting a compressor, pump or other machinery having significant dynamic unbalance shall be designed to resist the peak loads specified by the manufacturer. Vibration amplitudes of the supporting structure or foundation shall be kept within acceptable limits for dynamic forces that occur during normal machine operation. In the case of a tall and slender structure, there may be a need to investigate the dynamic effects of wind gusts.

3.10.0 Miscellaneous Loads

Miscellaneous loads shall be defined as loads that do not fit into the categories listed in this section. Typical miscellaneous loads are loads, during erection, maintenance and repair or forces due to creep, shrinkage, or settlement.

For the design of individual structural components, realistic load combinations in accordance with the relevant design standards shall be considered.

All loadings considered in the design shall be justified with supporting details.

3.11.0 Increase in permissible stresses

The increase in permissible stress of materials and soil bearing pressure for different load combinations under wind, seismic and temperature loads shall be as per relevant IS Codes.

Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

Bearing capacity of the soil/pile capacity shall be allowed to increase by 25% under seismic/wind load condition except for chimney where increase in bearing capacity is not considered.

No increase in allowable stresses is permitted where the critical condition is mainly due to wind

4.0.0 LOAD COMBINATIONS

Structures shall be analyzed and designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, piping loads (static, friction and dynamic), wind loads, seismic loads and temperature loads. In addition, Erection loads, loads and forces developed due to differential settlement shall also be considered.

Different load combinations shall be taken as per IS: 875 and other relevant IS Codes.

5.0.0 CIVIL STRUCTURE FOR LIME STONE BASED FLUE GAS DESULPHURIZATION PLANT

5.1.0 General

The structures/buildings/areas/facilities described under this section are to be included in the contract. The description against each building/system is indicative only and not exhaustive. Although almost all the systems are covered here, but any other system (Civil, Structural and Architectural) required for successful completion of the FGD area of the project shall form a part of this contract and shall deemed to be included in the scope of works.

5.2.0 General Requirements

a. Wherever possible, cable vault shall be provided in ground floor instead of cable trenches.
b. Openings / Rolling Shutters / Wide doors shall be provided for erection and removal during maintenance of Panels, Indoor Transformers, Equipments, etc. and shall be considered in the layout of buildings.
c. All MCC Rooms, Switch Gear buildings shall have an air conditioned operator room with pantry and Tool Store Area with shelves.
d. Ceiling fans, Modular furniture with electrical wiring and network cabling shall be provided in all office / operating personnel rooms & in other rooms of FGD area.
e. Lifts and elevators shall be provided (irrespective of number of lifts/elevators provided elsewhere in the specification) as per statutory regulations.
f. Magnetic white boards of suitable size shall be provided in all conference, discussion rooms, training rooms and Officer Rooms.
g. Projector with electrically operated projector screens and audio system shall be provided in all conference and training rooms.
h. All toilets shall be provided with exhaust fans.
i. All electrical buildings shall have the following rooms in two floor construction
   - Electrical room
   - Battery room
   - Control room
   - Cable spreader room
   - Maintenance engineers room
   - Store cum tool room in ground floor
   - Toilet (Gents and Ladies)
   - Pantry
j. Canopy with metal sheeting shall be provided to all outdoor motors.
k. All battery rooms shall have shelves for proper storage of chemicals.
l. Suitable provisions shall be provided for doors where ever access control systems are required.

5.3.0 Site related works

a) Site levelling

Micro levelling shall be in the scope of Bidder.

b) Site development work

i. Site clearance

The plant and building areas in the site shall be cleared of all trees, shrubs or other vegetation, rubbish, slush etc. and other objectionable matters. If any roots or stumps of trees are met during excavation, they shall also be removed. Statutory clearance (if any) required for the same will be borne by the Owner. Where earth fill is intended, the area shall be stripped of all loose / soft patches or top soil containing objectionable matter before filling commences. Any structure or services existing at the site shall carry necessary modification (if required) with the permission of the OWNER by the Bidder at his own cost.

The BIDDER shall be deemed to have visited and carefully examined the site and surroundings and to have satisfied himself about the nature of the existing structures, underground services, general site conditions, and the site for disposal of surplus materials, debris etc. and all other items affecting the work. Claims due to ignorance of site conditions shall not be considered after submission of Bid.

ii. Site grading

Graded site will be handed over to Bidder. The finished ground level to me maintained at EL(-)0.50m (RL(+)10m). The grade level of the built up area of the entire plant has been considered at approximately same elevation.

5.4.0 Temporary Structures/Facilities for execution

A. Construction water

Construction water shall be as specified in General Technical Specification.

B. Construction Power

Power supply for the construction work shall be as specified in General Technical Specification.

C. Temporary site building

The Bidder shall provide at his cost the following building facilities for proper execution and quality control of the job, while meeting the provision stipulated by Factory Rules regarding staff welfare facilities. All these building shall have brick cladding, Steel / AC sheet roofing over steel roof truss with cement concrete flooring and false ceiling with A/C as required.

i. Site office

Bidder shall provide suitable site office with A/C and false ceiling for the use of Owner / Owner's representative (minimum area of 2500 sq feet) in addition to the Bidder's requirement. In addition to these, basic facilities like toilet for gents and ladies, potable water tanks, soak pit and septic tank for sewage disposal shall also be provided.

ii. Stores

A covered store shall be provided with brick cladding and G.I/colour coated sheeting to store at least one month requirement of cement. Covered storage area may also be provided to store other construction material which will be affected on exposure to wind, sun and rain.

Covered storage area shall be provided to store other construction material which shall be affected on exposure to wind, sun and rain.

Proper fencing (as per detail of fencing in Cl 7.0.0) and security arrangement shall be provided for the stores complex.

Bidder may consider using the existing building in the site with necessary repairs and restoration for use of this facility, provided the same does not interfere with construction of Permanent works. If any building / space available at site, it will be provided. This is subject to availability and at the discretion of the owner.

iii. Temporary workshop and garage

The Bidder shall provide for a temporary workshop and garage to attend to routine maintenance and repair of the construction equipments as well as his fleet of vehicles used for construction activities.

iv. Fabrication yard

Depending on the extent of fabrication envisaged at site, the Bidder shall establish a full-fledged structural fabrication yard with adequate handling facility during and after the fabrication. Portion of the yard shall have covered shed with H.O.T / E.O.T cranes so that fabrication work can proceed even during inclement weather.

v. Quality control laboratory

A fully equipped quality control laboratory shall be established at site with qualified personnel to conduct acceptance test on all construction material, weldments, concrete cubes etc. This laboratory shall be housed in a covered building with A/C facility as required by the testing facility. The Bidder shall establish the lab with all equipments, staff, etc. at his own cost. All testing equipment shall be periodically calibrated to the satisfaction of the OWNER.

vi. Fuel Storage area

Bidder shall obtain necessary permission from competent authorities and establish and operate a POL outlet with proper storage, dispensing and adequate firefighting facility.

vii. Staff Welfare facility

Bidder shall provide adequate facility for his staff inside the plant boundary such as Toilets for both gents and ladies, Canteens, drinking water facility, rest places, crèches, etc.

Necessary approach roads to the construction facility complex and internal roads within the complex as well as proper drainage of the area shall be the Bidder's responsibility.

Bidder shall also provide for proper disposal of sewage and other wastewater to meet with the requirement of Pollution Board.

Bidder shall identify sufficient area outside the plant boundary to locate his staff and labour colony. Construction and maintenance of the staff and labour colony to satisfy all statutory requirements is the sole responsibility of Bidder.

5.5.0 BUILDINGS AND STRUCTURES

5.5.1 Absorber Tower Foundation

The absorber tower shall be supported over open / raft foundation.

The RCC tank shall be designed as structures with an exposure condition “extreme” as per IS:456.

5.5.2 Process Water Pump House

The pump house shall be RC framed structure with crane provided for maintenance of pumps. The buildings columns shall be supported on open / raft foundations.

5.5.3 Electrical & Control Building

The Control Room cum MCC Room shall be of RCC framed building. It shall be provided with RCC slab roof, and brick wall cladding. The foundation shall be RCC. Plinth protection shall be given with necessary garland drain.

The building shall be provided with false ceiling and air conditioned for the control room portion. Doors, windows and ventilators shall be provided for light, as per the requirements and as per the provision of existing regulations. There shall be provision for toilet inside the control building for male and female.

The building shall be plastered and painted. The finishing material shall be approved by the OWNER before executing in the field.

Proper approach road shall be provided from the nearest existing road.

Plumbing shall be as per good practice of engineering. Provision of drinking water shall be made.

5.5.4 Bulk Limestone Silo and Day Limestone Silo

Limestone shall be stored in RCC Silos. The bidder shall arrive at the Capacity of Silos. External RC stair shall be provided to reach up to silo top level. It shall be supported on suitable foundation.

5.5.5 Limestone Slurry Preparation Building

This Building shall be of RCC framed building. It shall be provided with RCC slab roof, and brick wall cladding. . It shall be supported open / raft foundation. Plinth protection shall be given with necessary garland drain.

It shall house Ball mill, mill separator tank, Lime Slurry tank etc.

5.5.6 Fan / Equipment Foundation

Foundations shall be provided for the Gas to Gas Heat exchanger, booster fan, seal air fan and air blowers. These shall be supported by RCC foundation. The foundation for fans shall be designed as a rotating equipment foundation.

5.5.7 Limestone Unloading Shed

Limestone storage shed shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. The foundation shall be RCC. Plinth protection shall be given with necessary garland drain.

Adequate open paved area shall be provided for parking of 20 (Twenty) number of limestone trucks.

5.5.8 Limestone Crusher House

Limestone crusher house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. The foundation shall be RCC. Plinth protection shall be given with necessary garland drain.

It should be noted that for structural design, unit weight of lime shall be assumed as 1700Kgs./Cu.M., unit weight of gypsum shall be assumed as 1250 Kgs./Cu.M. considered for system sizing purpose

5.5.9 Gypsum Storage Shed

Gypsum storage shed shall be a steel building with color coated MS sheet. The foundation shall be RCC. Plinth protection shall be given with necessary garland drain.

5.5.10 Gypsum Dewatering Building

This Building shall be of RCC framed building. It shall be provided with RCC slab roof, and brick wall cladding. . It shall be supported open / raft foundation. Plinth protection shall be given with necessary garland drain.

5.5.11 Waste Water Building

This Building shall be of RCC framed building. It shall be provided with RCC slab roof, and brick wall cladding. . It shall be supported open / raft foundation. Plinth protection shall be given with necessary garland drain

5.5.12 Tanks

The following tanks shall be of RCC construction.

a) Limestone slurry tank
b) Emergency slurry tank
c) Process water tank

5.5.13 Pipe Supports

The pipe pedestals shall be made of RCC structures. The pipe pedestal shall be designed to carry the load from the pipe. All necessary fixtures shall be embedded during casting of the pedestals.

5.5.14 Trestle for Duct Support and Foundation

The ducts from the flue gas ducts to the absorber tower shall be supported on trestle. The trestle shall be of steel framed structures, which is supported on RCC foundation. Similarly, the return duct from the absorber tower to the chimney shall also be supported by trestle.

6.0.0 GENERAL DESIGN CONCEPTS

a. All buildings shall have framed super structure.

b. All buildings except pump houses may have either RCC or structural steel framework. However, pump houses shall have structural steel super structure with metal roofing. Walls shall be constructed with brick masonry/ concrete block masonry or metal cladding. Unless specified otherwise, all buildings shall have minimum 230mm thick masonry on exterior face.

c. Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion, etc.

d. Design detailing and fabrication of steel structures shall be done as per provisions of IS: 800.

e. Welding shall be used for fabrication and erection. Site connections shall generally be with welding/bolts. For bolted connection, IS: 4000, IS: 3757, IS: 6623 and IS: 6649 shall be followed. IS: 814, IS: 816, IS: 1024, IS:4353 and IS:9595 shall be followed for welding of structures.

f. The design and construction of RCC structures shall be carried out as per IS: 456. Working stress method shall be adopted for the design wherever specifically mentioned in this specification.

g. For reinforcement detailing, IS: 5525 and SP: 34 shall be followed.

h. Two layers of reinforcement (on both inner and outer faces) shall be provided for RCC wall sections having thickness 150 mm or more.

i. Two layers of reinforcement (on both top and bottom faces) shall be provided for RCC slab sections having thickness 150 mm or more.

j. All RCC liquid retaining/ conveying or handling structures shall be designed in accordance with IS: 3370 by the working stress method as un-cracked section.

k. All liquid retaining/ conveying structures shall be provided with 200 x 200 mm fillet at the junctions of walls and base slab.

l. Water proofing treatment shall be provided for liquid retaining/ carrying structures and basement type structures (requiring dry working condition).

m. Plasticizer/ super-plasticizer cum water proofing compound shall be added to the concrete. All the construction/expansion joints shall be properly treated with PVC water bar and/or chemical injection grouting as per IS: 6494.

n. For basement type of structures, internal/external surface shall be provided with acrylic based polymer modified cementitious composite coating system for critical structures. For external application wherever the surface is in contact with the earth, fine silica/quartz sand of 0.6 mm nominal size shall be added in the coating mix for better abrasion resistance and total nominal thickness of such coating shall be minimum 1.5mm. For non-critical structures minimum two coats of bitumen grade 85/25 as per IS: 702, mixed with 1% of anti-stripping compound meeting the requirement of IS: 6241, shall be applied. The total application of bitumen shall not be less than 1.7 kg/Sq.m.

o. Bidder shall submit a comprehensive scheme for water proofing treatment based on above or any other alternative scheme, internationally accepted for Owner/engineer/consultant's approval prior to commencement of work.

p. All liquid retaining/ carrying structures shall be tested for water tightness as per the provisions of IS: 3370 and IS: 6494 and in case of leakage, the same shall be rectified by chemical injection grouting through nozzles.

A. Grade of concrete

The minimum grade of concrete for various structures shall be as follows:

Concrete Mix / Grade	Type of structure
M15	Fill concrete
M15	Blinding layer below foundations, trenches and underground structures, foundation below brick wall, etc. Minimum thickness of layer shall be 75 mm
M20	Plinth protection work around buildings
M20	Base plate encasement, encasement of structural steel work, all RCC paving work, ground floor slabs, cable and pipe trenches, etc.
M25 / M30	All RCC structures and equipment foundations, super structure, grade beams, columns, roof slabs, all underground RCC structures, cable and pipe rack foundation, pedestals, water retaining structures below and above ground, precast concrete work, roads, etc.
M35	Structures in contact with sea water.
M40	Pile foundation

As per IS:456, exposure condition will be “severe” for all structures under the civil scope of work except for structures coming in contact with sea water, where in exposure condition shall be “very severe”

Washing and screening of coarse and fine aggregates to remove fines, dirt or other deleterious materials shall be carried out by approved means, if desired by the Engineer-in-Charge/Owner.

The water cement ratio by weight shall be 0.45 maximum including free moisture in the aggregate and slump should be suitably decided to provide good quality concrete work.

B. Clear cover

The minimum concrete clear cover to reinforcement bars in all RCC structures shall be as per IS: 456. However in no case the clear cover shall be less than stipulated below:

S.No.	Description	Value
1	Slab	20 mm
2	Beam	25 mm or dia of main reinforcement whichever is greater
3.	Foundation/base slab	Bottom 75 mm, for foundation in direct in contact with earth and 50 mm for foundation or raft / foundation resting on lean / blinding strip and foundation beams) concrete. For sides and top 75 mm.
4.	Column (above and below ground level)	50 mm
5	Sump/pit walls	25 mm on liquid face & 40 mm on soil face
6	Walls above ground	25 mm on either face

C. Deflection Criteria

The maximum deflection for various structures shall not exceed and be limited to the following:

i. Steel Structure

The following limiting deflection criteria shall be considered in sizing of structures as per IS:800.

ii. Vertical deflection

S.No	Description	Max. Value Of
1	For all structures, floor beams except as in S. No.2	Span/325 or Height/325 as be the case unless noted otherwise
2	For all beams directly supporting equipment	Span/500
3	For all roof purlins	Span/250
4	For all grating/chequered plate	Span/200
5	For roofing/cladding components i.e. runners, roofing/cladding sheets	Span/250
6	Vertical & Horizontal deflection for cladding runners	Span/250
7	Crane Girders and monorails	
	a. E.O.T. cranes less than 50T capacity	Span/750
	b. E.O.T. cranes more than 50T capacity	Span/1000
	c. OHT cranes (for manually operated cranes and monorails)	Span/500
8	Grating / chequered plate	6mm.

iii. Horizontal deflection

The permissible horizontal deflections shall be as mentioned below, unless specified otherwise:

S.No	Description	Max. Value Of
1	Single storey building (without crane load)	Height/325
2	Multi-storeyed building (without crane load)	Height/500
3	Open structures	Height/200
4	Crane gantry girder due to surge	Span/2000 limited to maximum of 15 mm
5	Building main columns at crane rail level due to action of crane surge	Height/2500 limited to maximum of 10 mm
6	Trestles	Height/1000

Provisions of IS: 800 and relevant IS Code shall be followed for limiting deflections of structural elements not listed above.

iv. RCC Structures

The following deflection criteria shall be considered in sizing of structures as per IS: 456.

a. The final deflection due to all loads including effects of temperature, creep, shrinkage as measured from as-cast level of the supports of floors, roofs & all other horizontal members shall not normally exceed span/250.
b. The deflection including effects of temperature, creep & shrinkage occurring after erection of partitions and the application of finishes shall not normally exceed span/350 or 20mm whichever is less.

D. Minimum Thickness and Sizes of Steel Elements

i. Minimum Thickness

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgment in each instance.

Trusses, purlins, girts and bracing	:	8 mm
Columns and beams	:	8 mm
Gussets	:	8 mm
Stiffeners	:	8 mm
Base plates	:	10 mm & above
Chequered plates	:	8 mm o/p & above
Grating flats	:	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

ii. Minimum Sizes

a. Flange width of members:
Supporting light weight concrete slab : 65 mm
Supporting roof sheeting and wall cladding: 50 mm
b. Width of steel rolled section connected to other members : 50 mm.
c. The depth of beams for platform of all structures : 125 mm

iii. Slenderness and Depth Ratio

a. The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

b. The following limiting ratios of depth to span shall be considered as a general guide.

Truss	: 1 / 10
Rolled beams/ girders for Ordinary floors and rafters	: 1 / 24
Supporting floor beams for vibrating Machinery / equipment	: 1 / 15
Roof purlins and girts	: 1 / 45
Gable columns	: 1 / 30

iv. Anchor Bolts and Insert Plates

a. Anchor bolts shall be designed for working stress, in tension and shear, for embedded length of the anchor bolts and pipe sleeves. Shear and crushing strength of concrete shall also be checked. Increase in allowable stress for loading including seismic and wind loads shall not be permitted in design of anchor bolts.

b. Insert plates shall be designed/ checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall be checked. Lugs using steel bars shall preferably be fillet welded to the plate to transfer full strength of the lug.

c. Supply & fixing of all insert plate required for FGD area shall also be in Bidder's scope.

v. Headroom

All accessible areas shall be provided with minimum clear headroom as follows, unless otherwise specified.

S.NO	Description	Value
1	Finished floor to ceiling (building)	3500 mm
2	In case of building with false ceiling, total height from floor to roof	4500 mm
3	Doors, walkways, platforms, staircase, etc.	2500 mm
4	Safety cage for ladders	2500 mm
5	Pipe and cable racks	3000 mm

6.1.0 Equipment Foundations

i. Detailed static and dynamic analysis shall be carried out for the foundations of rotating/vibrating equipment. The static analysis shall include all operating conditions, load cases and abnormal loads like short circuit, loss of blade unbalance and seismic forces. Unbalance loads for normal operating condition as given by machine manufacturer and/or VDI 2060 whichever is more conservative shall be used for calculating dynamic response. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Transient analysis shall be carried out for the short circuit condition with an appropriate force function. Frequency separation criteria and amplitude criteria as laid down in IS: 2974 and/or DIN 4024 and/or VDI 2056 and/or as required by the machine manufacturer, whichever is more stringent shall be satisfied. RCC design shall be done by the working stress method for all machine foundations. A fatigue factor of 2.0 shall be considered for dynamic forces. Minimum reinforcement shall be governed by IS: 2974 as well as IS: 456. However minimum reinforcement in bottom face of the foundation raft resting on soil or pile shall not be less than 0.2% of effective cross sectional area of the raft.

ii. In case steel helical springs are provided; the foundation arrangement shall be such that the spring units are located above the finished floor level by at least 200mm.

iii. The isolation efficiency of the foundation system comprising RCC deck and steel helical springs shall be at least 90%. The ratio of actual spring supported weight to the nominal spring capacity shall be at least 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

iv. All approved drawings of equipment foundation shall be vetted by execution agency of equipment erection, to match equipment sizing & foundation.

The special requirements for concreting including grade, type of aggregate, use of admixture, temperature control, ultrasonic testing, etc., shall be as mentioned elsewhere in this specification.

The specification requirements for steel helical springs shall be as specified elsewhere in this specification.

All block foundations supporting rotating equipment resting on soil or piles shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times the mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all the modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down in the relevant codes and/or by machine manufacturer, whichever, is more stringent shall be satisfied. Minimum reinforcement shall be governed by IS:2974 and IS: 456. Minimum Reinforcement in base raft in either direction shall be as follows:

i) At bottom face - 0.2% of gross cross- sectional area
ii) At top face - 0.12% of gross cross- sectional area

For the foundations supporting minor rotating equipment weighing less than one tonne or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structure, floors, etc., suitable vibration isolation shall be provided by means of springs, neoprene pads, etc., and such vibration isolation system shall be designed suitably.

Factor of Safety against Overturning and Sliding

The structure shall be checked for minimum factor of safety of 1.5 against overturning conditions (ratio of stabilizing moment to overturning moment) and sliding conditions (ratio of horizontal frictional resistance to horizontal sliding force) under static loads. To ensure an adequate factor of safety under earthquake conditions, the factor of safety against sliding shall not be less than 1.2.

6.2.0 Detailing

For detailing of Reinforcement IS: 5525, IS: 13920, IS: 4326 and SP: 34 shall be followed.

Two layers of reinforcement (on inner and outer face) shall be provided for RCC sections having thickness of 150 mm and above.

Minimum diameter of main and distribution Reinforcement bars in different structural elements shall be as follows:

S. No.	Structural Element	Main Reinforcement	Distribution Reinforcement / Anchor bars
1	Foundation	12 mm	12 mm
2	Beam	12 mm	12 mm/8 mm
3	Column	12 mm	

Spacing of reinforcement bars in walls and slabs of liquid retaining / conveying structures shall not be more than 200 mm.

Suitable shrinkage reinforcement shall be provided at top face of foundations. Minimum shrinkage reinforcement shall be 10 mm dia. @ 200mm c / c.

Minimum Reinforcement in all elements of liquid retaining / conveying structures shall be IS 3370.

Minimum tensile Reinforcement in each direction for all foundation slabs / rafts shall be 0.12% of cross sectional area.

Minimum thickness of foundation slab / raft and base slab of all liquid retaining tanks / pits shall not be less than 250 mm.

Minimum thickness of all elements of RCC liquid retaining / conveying structures (except effluent drains, launders and aerator waste slab) shall be 200mm. Effluent drains (depth more than 500mm), aerator waste slab and launders shall have minimum element thickness of 150mm.

All Insert plates (except edge protection angles) provided in liquid retaining structures shall be 12 mm thick GI with lugs not less than 12 mm diameter.

All water retaining structures shall be tested for water tightness as per provisions of IS: 3370 and IS: 6494.

All liquid retaining structures shall be leak-proof. Water proofing of all liquid retaining structures shall be done by addition of plasticiser cum water proofing admixture conforming to IS: 9103, in the concrete at the time of mixing and through external treatment by chemical injection grouting at all construction joints as described in the specification. Addition of admixture should not reduce the strength of the concrete below the specified strength in any case. In addition, limit on permeability as given in IS: 2645 shall also be met with.

Further if required, chemical injection grouting treatment shall be applied to make the structure leak proof, if leakage is observed during hydro - test or otherwise, with no cost implication to the Owner.

Plywood formwork shall be used for all water retaining/ conveying structures (only on the face having contact with water) and for all over ground concrete works. It shall also be used for the inner face of sump of pump (i.e. faces of piers back walls, breast walls and baffle walls having contact with water. For all other areas steel/ plywood formwork shall be used.

6.3.0 Foundation System

1. General Requirements

a) All equipment/ structures shall be supported either on suitable open foundations or on pile foundations as required.

b) The ground floor slabs, trenches, channels and other lightly loaded structures with foundation base pressures less than 5.0 t/Sq.m may be supported on open/ shallow foundation resting on virgin/ controlled compacted filled up soil (cohesive non-swelling soil).

c) No major foundation shall rest on filled up ground/ soil.

d) A combination of open and pile foundations shall not be permitted under the same equipment/ structure/ building.

2. Open Foundations

In case, open foundations are adopted following shall be adhered to:

a) Minimum width of foundation shall be 1.0 m.
b) Minimum depth of foundation shall be 1.5 m below NGL / FGL which is at lower level.
c) It shall be ensured that all foundations of a particular structure/building/ facility shall rest on one bearing stratum, i.e. either overburden or rock.
d) Wherever the intended bearing structure is weathered rock but the actual stratum encountered during foundation excavation consists of both overburden soil and weathered rock at founding level, under such cases either the foundation shall be lowered completely into the weathered rock or the overburden soil upto the weathered rock level shall be removed and built up through PCC up to designed foundation level.
e) The net allowable bearing pressure values to be adopted for design upon Owner's approval shall correspond to total permissible settlement as mentioned under para "permissible settlement of foundations" or the permissible settlement from functional requirement, whichever is more stringent.
f) Permissible settlement of foundations: The total permissible settlement and differential settlement shall be governed by IS: 1904 and IS: 13063 and from functional requirements, whichever is more stringent.

However, total settlement shall be restricted to the following:

1	Building including isolated/ strip/ continuous/ raft foundation	25 mm
2	Other footings of width upto 6m	40 mm
3	Other footings of width greater than 6.0m raft	75 mm
4	Footings on rock	12 mm

All foundation shall be so designed that the settlements are within permissible limits as per relevant Indian standard or from consideration of safe equipment/machine operation whichever is critical. In case of open foundations without piles, ground improvement methods opted by contractor, like band drains / stone columns, etc., to reduce settlement and increase the rate of settlement, detail methodology of such installation supported by calculation based on relevant field data shall be furnished for approval of Owner/Consultants before execution. In the event, the Bidder adopts any patented method of ground improvement or retain any specialized agency for such purpose, the same can be done subject to prior approval of Owner.

In case the total permissible settlement is to be restricted to less than as above specified from functional requirements, then the net allowable bearing pressure shall be reduced / reviewed accordingly in consultation with Owner/Engineer.

3. Pile

The following shall be the design criteria for the working piles:

i. Piles shall be designed in line with approved soil investigation report as single vertical piles acting under a design load as deemed fit.
ii. Driving formula (where relevant) may be adopted interalia as criteria for acceptance. But the minimum founding requirements shall be based on recognized methods of soil mechanics design, appropriate to the type of pile.
iii. The piles shall be designed for a minimum factor of safety of 2.5 against failure under the design load specified.
iv. Piles shall be designed for a limiting settlement of a single pile under vertical design load of 8 mm at the head.

v. Piles shall be designed to resist a maximum force due to critical load combination in any direction applied to the head of the pile at cut-off level. For this design condition it shall be assumed that the pile head is effectively as a fixed-end by the pile-cap.
vi. Earth pressure coefficient (k) for vertical load carrying capacity for bored cast-in-situ piles shall have to be limited to 0.7.

4. Other Requirements

In case of high ground water table, for excavations comprehensive dewatering arrangement shall be required. Scheme for dewatering and design with all computations and back-up data of dewatering and sheet pilling shall be submitted for Owner's information.

The founding level for trenches/ channels shall be decided as per functional requirement. The bottom of excavation shall be properly compacted prior to casting of bottom slab of trenches / channels.

The founding level to be adopted including the allowable bearing capacities, measures to be adopted as mentioned in the specification shall be submitted to the Owner for approval.

6.4.0 Stability of Structures

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like underground tanks, pits trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area shall be taken in to consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. The following minimum factor of safety shall be followed.

a. Factor of safety against overturning due to wind, seismic or other lateral load shall be1.5 minimum.

b. Factor of safety against siding shall be 1.5 minimum.

c. Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5.

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In case where dead load provides the restoring force, only 0.9 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

7.0.0 FENCING

Fencing layout drawing shall be prepared and got approval from Owner. The layout shall contain all the details including access for facilities inside fenced area.

i. Minimum 3m height fencing above toe wall shall be provided.

ii. The fence shall comprise of PVC coated G.I. chain link fencing of minimum 8 Guage (including PVC coating) of mesh size 75mm and of height 2.4m above toe wall with a 600mm high galvanised concertina at the top, such that total fence height of 3.0m

above toe wall is achieved. The diameter of the tie wire for chain link fence (excluding PVC coating) shall not be less than 12G.

iii. The PVC coated chain link will be stretched by the clips at 0.5m intervals to three strands of galvanised high tensile spring steel wire (HTSSW) of 12G interwoven with chain link wire mesh and kept under tension which in turn is attached to the fence post with security nuts and bolts. On every fourth post a clamping strip will be threaded through the links of chain link and bolted to the fence post with the help of security nuts and bolts.

iv. Above the chain link a tensile serrated galvanised wire (HTSW) concertina will be stretched to 6m and attached to two strands of galvanised HTSSW by means of clips at 1m intervals.

v. All nuts, bolts, fasteners, clamping strips, clamps, clips, etc. shall be hot dip galvanised. Weight of zinc coating shall be at least 900 gms / Sq. M.

vi. All fence posts shall be pre-cast RCC of minimum M20 grade & minimum size of 100 x 100mm. All corner posts will have two stay posts and every tenth post will have transverse stay post suitable RCC foundations for the post and stays shall be provided based on the prevailing soil conditions.

vii. Galvanized steel entry gate shall be provided. Top of the wall shall be min. 200 mm above formation level.

viii. Removable type of fencing shall be provided at suitable location to permit entry and exit of equipment.

ix. Toe walls either of brick masonry with bricks of class designation 50 with minimum crushing strength 50 Kg/m2 or of hollow concrete block masonry shall be provided between the fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200mm above the formation level with 50 thick PCC coping (1 : 2 : 4) and shall extend minimum 300 below formation level. Toe wall shall be plastered with cement sand mortar (1 : 6) on both sides and shall be painted with coats of texture cement paint (Sandtex matt or equivalent) of approved colour & make. Toe wall shall be provided with weep holes at appropriate spacing.

8.0.0 TECHNICAL SPECIFICATION

8.1.0 Materials

i. Samples of all materials to be used on the work shall be got approved by the Bidder from the Owner/Consultant/Engineer-in-Charge well in time. The approved samples duly authenticated and sealed shall be kept in the custody of the Engineer-in-Charge till the completion of the work. All materials to be provided by the Bidder shall be brand new and as per the samples approved by the Owner/Consultant/ Engineer-in-Charge.

ii. Materials obtained by the Bidder from the sources approved by the Owner/Consultant / Engineer-in-Charge shall be subjected to the Mandatory tests. Where such materials do not conform to the relevant specifications, the matter shall be taken up by the Owner/ Consultant/ Engineer-in-Charge for appropriate action against the defaulters. In all such cases, necessary documents in original and proof of payment relating to the procurement of materials shall be made available by the Bidder to the Owner/Consultant/Engineer-in-Charge.

iii. Samples, whether submitted for approval to govern bulk supplies or required for testing before use and also the sample of materials bearing 'Standard mark,' if required for testing, shall be provided free of cost by the Bidder. All other incidental expenditure to be incurred for testing of samples e.g. packaging, sealing transportation, loading, unloading etc. except testing charges shall be borne by the Bidder.

iv. Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric effects due to rain, sun, wind and moisture to avoid deterioration.

v. Materials like timber, paints etc. shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials and explosives shall be stored in accordance with the relevant rules and regulations or as approved by Owner/Consultant/Engineer-in- Charge in writing so as to ensure desired safety during storage.

vi. The unit weight of materials unless otherwise specified shall be reckoned as given in IS: 1911.

A. Structural Steel

Steel will confirm to Grade-A of IS:2062 (latest) for rolled steel members or plates upto 20 mm thickness. For plates above 20 mm thickness and welded construction steel conforming to Grade-B (killed and normalized) of IS: 2062(latest) shall be used except for crane girders where Grade-C (IS: 2062) steel shall be used. Steel shall be procured from primary produces like SAIL / VIZAG / TATA. Rerolled steel is not to be used in the project works.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc. shall be 8 mm O/P.

B. Cement

Ordinary Portland Cement (OPC) shall be used for all structures except for foundations, underground structures & structures coming in contact with sea water where in sulphate resistant cement with C3A content limited to 5% or ordinary Portland cement with C3A content 5% to 8% shall be used depending on the presence of sulphate and chlorides in water/ soil. Grade of cement shall be 43 conforming to IS: 8113. Chemical nature of subsoil & ground water shall also be a factor.

C. Reinforcement

The reinforcement used shall be Corrosion resistant thermo-mechanically treated (TMT) high strength deformed bars of grade Fe 415 / Fe500 conforming to IS:1786 – latest.

Intermixing of different grades of rebar or rebar of different material composition in same structure shall not be allowed.

Welding of reinforcement shall not be carried out without the permission of the Owner. Projecting reinforcement or dowel bars for future connection of the structural works shall be protected by cement paint, if they are to be left exposed for a long time.

8.2.0 Safety in construction

i. The Bidder shall employ only such methods of construction, tools and plant as are appropriate for the type of work or as approved by Owner/Consultant/ Engineer-in-Charge in writing.

ii. The Bidder shall take all precautions and measures to ensure safety of works and workman and shall be fully responsible for the same. Safety pertaining to construction works such as excavation, centering and shuttering, trenching, blasting, demolition, electric connections, scaffolds, ladders, working platforms, gangway, mixing of bituminous materials, electric and gas welding, use of hoisting and construction machinery shall be governed by relevant safety codes and the direction of Owner/Consultant/Engineer-in-Charge.

8.3.0 Statutory requirements

Bidder shall comply with all the applicable statutory rules pertaining to Factories Act, Fire Safety Rules of Tariff Advisory Committee, and Water Act for pollution control, Explosives Act, Environmental requirements, etc.

Provisions of safety, health and welfare according to Factories Act shall be complied with. These shall include provision of continuous walkway of minimum 500mm wide along the crane - girder level on both sides of building/ pump house, comfortable approach to EOT crane cabin, railing, fire escape, toilets, etc.

Statutory clearances and norms of State Pollution Control Board shall be followed. Bidder shall obtain approval of Civil/ Architectural drawings from concerned authorities before taking up the construction work.

Adequate no. of fire escapes shall be provided in a building. Fire proof doors, no. of staircase, fire separation walls, lath plastering on structural steel member (in fire prone areas) shall be made according to the recommendation of TAC.

Obtaining statutory approval clearance/ license from relevant agency will be within the scope of Bidder.

For fire safety requirements of buildings IS: 1641 and IS: 1642 shall be followed in addition to TAC requirements. All masonry firewalls shall be minimum 345 thick and RCC firewall shall be minimum 200 mm thick.

8.4.0 Carriage of materials

A. List of applicable codes

S.NO	IS CODE NO	SUBJECT
1	IS:4082	Stacking and Storage of Construction Materials and Components at Site- Recommendations
2	IS:1141	Seasoning of Timber - Code of Practice

B. General

The carriage and stacking of materials shall be done as directed by the Owner/Consultant/Engineer-in-Charge. Any tools and plants, required for the work shall be arranged by the Bidder. The carriage of materials includes loading within a lead of 50 meters, unloading and stacking within a lead of 50 meters.

Responsibility for loss or damage

Loading, carriage, unloading and stacking shall be done carefully to avoid loss or damage to the materials. In case of any loss or damage, recovery shall not be recovered from the Owner.

C. Mode of carriage

Depending upon the feasibility and economy, the Bidder shall determine the mode of carriage viz. whether by mechanical or manual labour. The mode of carriage shall be indicated to owner.

D. Lead

All distances shall be measured over the shortest practical route and not necessarily the route actually taken. Route other than shortest practical route may be considered in cases of unavoidable circumstances and as approved by Owner/Consultant/Engineer-in-Charge along with reasons in writing.

E. General consideration for stacking and storage

i. **Planning of Storage Layout**

For any site, there should be proper planning of the layout for stacking and storage of different materials, components and equipments with proper access and proper maneuverability of the vehicles carrying the material. While planning the layout, the requirements of various materials, components and equipments at different stages of construction shall be considered. The storage & stacking check list is given in Table below. For further details refer IS: 4082.

ii. Material shall be stored in such a manner as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

F. Protection against atmospheric agencies

Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric actions, such as rain, sun, winds and moisture to avoid deterioration.

G. Protection against fire and other hazards

Materials like timber, paints, etc. shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials like kerosene and petrol shall be stored in accordance with the relevant rules and regulations so as to ensure the desired safety during storage. Stacks shall be more than 4.5 m in height. The provisions given in IS: 13416 (part 5) shall be followed.

H. Stacking and storage of materials

i. **Cement**

a. In case cement is received in bags, cement shall be stored at the work site in a building or a shed which is dry, leak-proof and as moisture proof as possible. The building or shed for storage should have minimum number of windows and close fitting doors and these should be kept closed as far as possible.

b. Cement shall be stored and stacked in bags and shall be kept free from the possibility of any dampness or moisture coming in contact with them. Cement bags shall be stacked off the floor on wooden planks in such a way as to keep about 150 mm to 200 mm clear above the floor. The floor may comprise of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A space of 600 mm minimum shall be left all-round between the exterior walls and the stacks. In the stacks the cement bags shall be kept close together to reduce circulation of air as much as possible. Owing to pressure on the bottom layer of bags sometimes 'warehouse pack' is developed in these bags. This can be removed easily by rolling the bags when the cement is taken out for use. Lumber bags, if any should be removed and disposed off.

c. The height of stack shall not be more than 10 bags to prevent the possibility of lumping up under pressure. The width of the stack shall be not more than four bags length or 3 metres. In stacks more than 8 bags high, the cement bags shall be arranged alternately length-wise and cross-wise so as to tie the stacks together and minimize the danger of topping over. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received; a lable showing date of receipt of cement shall be put on each stack to know the age of cement.

d. For extra safety during the monsoon, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a water proofing membrane such as polyethylene, which shall close on the top of the stack. Care shall be taken to see that the waterproofing membrane is not damaged any time during use.

e. Cement in gunny bags, paper bags and polyethylene bags shall be stored separately.

f. In case cement is received in drums. These shall be stored on plane level ground, as far as possible near the concrete mixing place. After taking out the required quantity of cement, the lid of the drum shall be securely tied to prevent ingress of moisture.

g. In case cement is received in silos. The silos shall be placed near the concrete batching plant. Proper access shall be provided for the replacement of silos.

h. Different types of cements shall be stacked and stored separately.

ii. **Bricks**

a. Bricks shall be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement. These shall not be dumped at site.

b. Bricks stacks shall be placed close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows. Building bricks shall be loaded or unloaded a pair at a time unless palletized. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall not be permitted.

c. Bricks shall be stacked on dry firm ground. For proper inspection of quality and ease in counting the stacks shall be 50 bricks long, 10 bricks high and not more than 4 bricks in width, the bricks being placed on edge, two at a time along the width of the stack. Clear distance between adjacent stacks shall not be less than 0.8 m. Bricks of each truck load shall be put in one stack.

d. Bricks of different types, such as clay bricks, clay fly ash bricks, fly ash lime bricks, sand lime (calcium silicate) bricks, auto-clave bricks etc. shall be stacked separately. Bricks of different classification and size consideration (such as, conventional and modular) shall be stacked separately. Also bricks of different types, such as, solid, hollow and perforated shall be stacked separately.

iii. **Floor, wall and roof tiles**

a. Floor, wall and clay roof tiles of different types, such as, cement concrete tiles (plain, coloured and terrazzo) and ceramic tiles (glazed and unglazed) shall be stacked on regular platform as far as possible under cover in proper layers and in tiers and they shall not be dumped in heaps. In the stack, the tiles shall be so placed that the mould surface of one faces that of another. Height of the stack shall not be more than one metre. During unloading, these shall be handled carefully so as to avoid breakage.

b. Tiles of different quality, size and thickness shall be stacked separately to facilitate easy removal for use in work. Tiles when supplied by manufacturers packed in wooden crates shall be stored in crates. The crates shall be opened one at a time as and when required for use.

c. Ceramic tiles and clay roof tiles are generally supplied in cartons which shall be handled with care. It is preferable to transport these at the site on platform trolleys.

iv. **Aggregates**

a. Aggregates shall be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of planks or old corrugated iron sheets, or a floor of bricks, or a thin layer of lean concrete shall be made so as to prevent contamination with clay, dust, vegetable and other foreign matter.

b. Stacks of fine and coarse aggregates shall be kept in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed. On a large job, it is desirable to construct dividing walls to give each type of aggregates its own compartment. Fine aggregates shall be stacked in a place where loss due to the effect of wind is minimum.

c. Unless specified otherwise or necessitated by site conditions stacking of the aggregates should be carried out in regular stacks. The suggested sizes for stacks are as follows :

1) Cement and densified silica fume shall be stored in separate weather- tight buildings, bins or silos that will exclude moisture and contaminants. At least two cement silos are required with enough storage for a total of 400 metric tonnes of cements.

2) Aggregate stockpiles shall be arranged and used in a manner to avoid segregation and to prevent contamination with other materials or with other sizes of like aggregates. Aggregate delivery trucks shall be covered to prevent windblown contamination. Aggregate stockpiles shall be located relative to prevailing winds to mitigate the accumulation of wind-borne dust.

3) Adequate storage shall be provided for each aggregate. The aggregate storage area shall be on concrete pavement sloped to drain excessive moisture. The aggregate storage area shall provide bulkheads to separate piles and protect against windblown contaminants. Provision shall be made to shade and sprinkle the aggregates with potable water.

4) Aggregate stockpiles shall be built in successive horizontal layers not exceeding 1 m in thickness, with each layer being completed before the next is started. No vehicles shall be allowed to operate on top of the stockpiles.

5) Re-screening and washing of coarse aggregates is required, if necessary, to reduce total chloride and/or sulphate contents to a level less than the maximum allowed by the specifications. If re-screening is required, the screening and washing shall be just prior to transferring aggregate to batch plant bins. Aggregates shall be dewatered over a screen to remove excess water before being stored in the batch plant bins.

6) Natural or manufactured sand shall be allowed to drain until it has reached somewhat uniform moisture content before it is used.

7) Liquid admixtures shall be stored in suc a manner to avoid contamination, evaporation and segregation in accordance with the manufacturers' recommendations.

d. **Fine aggregate**

1) Fine aggregate source shall be manufactured crushed stone or rock sand, excluding fines which are by products/rejects of coarse aggregate production. The crushed stone sand shall be graded from fine to coarse with the coarse sizes predominating to give maximum density.

2) The amount of fine particles as ascertained by the laboratory sedimentation method shall not exceed 10% for crushed stone or 4% for natural sand.

3) The amount of material passing a 75 micron sieve (IS test sieve) shall not exceed the following limits:-

4) **Crushed stone sand**

i. Concrete subject to abrasion 1% by weight

ii. All other concrete 3% by weight

iii. There shall be no clay or fine silt present.

iv. The amount of hollow shells like to form voids or remain partially unfilled and present in material retained on a IS 2.36 mm sieve, determined by direct visual separation, shall not exceed 3% by weight of the entire sample.

v. Fine aggregate shall not contain appreciable amounts of flaky and/or elongated particles.

vi. The water absorption of fine aggregate, shall be as per relevant standards.

vii. Fine aggregate subjected to five cycles of the soundness test, specified in IS: 2386 (part-5), shall not show a loss exceeding 10% when sodium sulphate solution is used and 15% when magnesium sulphate solution is used, except where approved otherwise.

5) Tests are to be executed in accordance with IS: 2386. The grading of fine aggregate for concrete work shall comply with the requirements of IS:383.

6) The grading of the aggregates should be such as to produce a concrete of the specified proportions which will work readily into position without segregation and without the use of excessive water content. The grading should be controlled throughout the work so that it conforms closely to that used for the preliminary tests.

7) A check on the moisture content of sand should be made at least once a day before concreting. The amount of water to be added to the concrete mix should be adjusted accordingly. Any washing, screening, classifying and other operations on the fine aggregate required to meet this specification shall be done by the Bidder. Washing is required if the content of salt adhering to the aggregate is found to be unacceptably high.

e. **Coarse aggregate**

1) Coarse aggregate shall be crushed rock and shall be free from decomposed stone, clay, earth or other deleterious substances. The specific gravity of the coarse aggregate shall not be less than 2.5 t/m^3. Aggregate of crushed natural

stone is deemed adequate if the stone reveals a crushing strength of 1000 kg/cm^2 when tested. Friable, flaky and laminated pieces, mica and shale shall only be present in such quantities as not to affect the strength and durability of the concrete.

2) The grading of coarse aggregate for concrete shall comply with the requirements of IS: 383.

3) Samples of aggregates shall be submitted to the purchaser, together with sieve analysis showing the proportion by weight passing sieves. When aggregates which are satisfactory to the purchaser have been selected, the Bidder shall secure his entire supply of each material from the same source so as to maintain the same quality and grading throughout the work. Should it become necessary to change the source or characteristics of the material supplied this shall only be done after additional tests.

v. **Reinforcement Steel**

a. For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colours.

b. Steel reinforcement shall ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting.

c. Bars of different classification, sizes and lengths shall be stored separately to facilitate issues in such sizes and lengths so as to minimize wastage in cutting from standard lengths.

d. In case of long storage, reinforcement bars shall be stacked above ground level by at least 150 mm. Also in coastal areas or in case of long storage a coat of cement wash shall be given to prevent scaling and rusting.

e. Structural steel of different classification, sizes and lengths shall be stored separately.

It shall be stored above ground level by at least 150 mm upon platforms, skids or any other suitable supports to avoid distortion of sections. In coastal areas or in case of long storage suitable protective coating of primer paint shall be given to prevent scaling and rusting.

vi. **Aluminium sections**

Aluminium sections of different classification, sizes and lengths shall be stored separately, on a level platform under cover. The aluminium sections shall not be pulled or pushed from the stack nor shall be slided over each other, to protect the anodizing layer.

vii. **Doors, windows and ventilators**

a. **General**

While unloading, shifting handling and stacking timber or other lignocellulosic material based, metal and plastic door and window frames and shutters, care shall be taken that the material is not dragged one over the other as it may cause damage to the surface of the material particularly in the case of decorative shutters. The material should be lifted and carried preferably flat avoiding damage of corners or sides.

b. Metal and plastic doors, windows and ventilators shall be stacked upright (on their sills) on level ground preferably on wooden battens and shall not come in contact with dirt and ashes. If received in crates they shall be stacked according to manufacturer's instructions and removed from the crates as and when required for the work.

c. Metal and plastic frames of doors, windows and ventilators shall be stacked upside down with the kick plates at the top. These shall not be allowed to stand for long in this manner before being fixed so as to avoid the door frames getting out of shape and hinges being strained and shutters drooping.

d. During the period of storage all metal doors, windows and ventilators shall be protected from loose cement and mortar by suitable covering such as tarpaulin. The tarpaulin shall be hung loosely on temporary framing to permit circulation of air to prevent condensation.

e. All timber and other lignocellulosic material based frames and shutters shall be stored in a dry and clean covered space away from any infestation and dampness. The storage shall preferably be in well ventilated dry rooms. The frames shall be stacked one over the other in vertical stacks with cross battens at regular distances to keep the stack vertical and straight. These cross battens should be of uniform thickness and placed vertically one above the other. The door shutters shall be stacked in the form of clean vertical stacks over the other and at least 80 mm above ground on pallets or suitable beams or rafters. The top of the stack shall be covered by a protecting cover and weighted down by means of scantlings or other suitable weights. The shutter stack shall rest on hard and level ground.

f. If any timber or other lignocellulosic material based frame or shutter becomes wet during transit, it shall be kept separate from the undamaged material. The wet material may be dried by stacking in shade with battens in between adjacent boards with free access of dry air generally following the guidance laid down in IS:1141.

g. Separate stacks shall be built up for each size, each grade and each type of material. When materials of different sizes grades and types are to be stacked in one stack due to shortage of space, the bigger size shall be stacked in the lower portion of the stacks. Suitable pallets or separating battens shall be kept in between the two types of material.

viii. **Roofing / cladding sheets**

a. Roofing sheets shall be stored and handled in such a manner as not do damage them in any way.

b. Corrugated galvanized iron sheets and aluminium sheets shall be stacked horizontally to a height of not more than 0.5 m on a firm and level ground, with timber or other packing beneath them. To protect them from dust and rain water, these shall be covered with tarpaulin or polyethylene sheets.

b. Plastic sheets and glass reinforced plastic (GRP) sheets shall be stacked under a shed to a height of not more than 0.5 m on a firm and level ground with timber or other packing beneath them.

ix. **Water**

Wherever water is to be stored for construction purposes this shall be done in proper storage tanks to prevent any organic impurities getting mixed up with it.

x. **Oil paints**

All containers of paints, thinners and allied materials shall preferably be stored in a separate room on floors with sand cushions. The room shall be well-ventilated and free from excessive heat, sparks of flame and direct rays of sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using. The containers of paints have expiry date marked by the manufacturers, which should be highlighted so as to facilitate use of paint within due period.

xi. **Handling & Storage of steel**

No dragging of steel shall be permitted.

Scratched or abraded steel shall be given a coat of the primer for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust/ corrosion by suitable coating and also from getting damaged.

xii **Storage of steel**

a. All steel shall be stored 300 mm above ground on suitable packing to avoid damage. It shall be stored in the order required for erection, with erection marks visible. All storage areas shall be prepared and maintained by the BIDDER. Steel shall not be stored in the vicinity of areas where excavation or grading will be done and if so stored temporarily this shall be removed by the BIDDER well before such excavation and/ or grading commence to a safe distance to avoid burial under debris.

b. For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colours.

c. Structural steel of different classification, sizes and lengths shall be stored separately.

It shall be stored above ground level by at least 150 mm upon platforms, skids or any other suitable supports to avoid distortion of sections. In coastal areas or in case of long storage suitable protective coating of primer paint shall be given to prevent scaling and rusting.

xiii. **Other materials**

Small articles like nails, screws, nuts and bolts, door and window fittings, polishing stones, protective clothing, spare parts of machinery, linings, packing, etc., shall be kept in suitable and properly protected store rooms. Valuable small material such as, copper pipes and fittings shall be kept under lock and key.

xiv. **Earth**

a. In loose stacks such as cart loads, lorry loads, etc. – 20%

b. In fills consolidated by light mechanical machinery – 10%

c. In fills consolidated by heavy mechanical machinery but not under OMC (Optimum Moisture Content) – 5%

d. In fills consolidated by heavy mechanical machinery at OMC – Nil

e. Consolidated fills in confined situation such as under floors. etc. – Nil

Storage and stacking check list

Sl. No.	Material / Component	Base			Stack				Type of cover		
		Firm level ground	Hard Floor	Off Floor	Heaps	Tiers	Flat	Vertical	Open	Open but covered	Under shed
1	Cement			√		√					√
2	Stone and Aggregates										
a)	Stones, aggregate, fly ash and cylinder	√			√				√		
3	Bricks	√				√			√		
4	Steel	√					√		√		
5	Aluminium Sections		√				√				√
6	Door, windows and ventilators		√					√			√
7	Roofing sheets										
a)	GI and aluminium sheets	√				√	√			√	
8	CI, GI and AC pipes & fittings										
a)	Pipes	√				√	√		√		
b)	CI and fittings		√				√				√
9	Oil paints		√			√					√

8.5.0 Earthwork

I. List of applicable codes

S.NO	IS CODE NO	SUBJECT
1	IS:632	Gamma – BHC (Lindane) emulsifiable concentrates
2	IS:1200 (Pt 1)	Method of measurement of earth work
3	IS:1200 (Pt-27)	Method of measurement of earth work (by Mechanical Appliances)
4	IS:4081	Safety code for Blasting and related drilling operation
5	IS:4988 (Part IV)	Excavators
6	IS:6313 (pt.-II)	Anti-Termite measures in buildings (pre – constructional)
7	IS:6313(pt.-III)	Anti-Termite Measures in Buildings for existing buildings

S.NO	IS CODE NO	SUBJECT
8	IS:6940	Methods of test for pesticides and their formulations
9	IS:8944	Chlorpyrifos emulsifiable concentrates
10	IS:8963	Chlorpyrifos – Technical specifications
11	IS:12138	Earth moving Equipments

II. Definition:

Deadmen or Tell Tales:

Mounds of earth left undisturbed in pits dug out for borrowing earth.

Burjis:

Short pillars of brick/ stone having top surface finished with cement plaster for marking etc.

Formation or Profile:

Final shape of the ground after excavation or filling up.

Foul condition:

Filthy and unhygienic conditions where physical movements are hampered such as soil mixed with sewage or night soil.

Lead:

All distances shall be measured over the shortest practical route and not necessarily the route actually taken. Route other than shortest practical route may be considered in cases of unavoidable circumstances and approved by Engineer-in-charge along with reasons in writing. Carriage by manual labour shall be reckoned in units of 50metres or part thereof. Carriage by animal and mechanical transport shall be reckoned in one km. unit. Distances of 0.5 km. or more shall be taken as 1 km. and distance of less than 0.5 km. shall be ignored. However, when the total lead is less than 0.5 km., it will not be ignored but paid for separately in successive stages of 50metres subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km. by mechanical/ animal transport.

Lift:

The vertical distance for removal with reference to the ground level. The excavation up to 1.5metres depth below the ground level and depositing the excavated materials upto 1.5metres above the ground level are included in the rate of earth work. Lifts inherent in the lead due to ground slope shall not be paid for.

Safety rules:

Safety rules as laid down by the statutory authority and as provided in National Building Code (NBC) shall be followed.

III. Classification of soils

For purposes of work to be executed in accordance with this specification, the following classification only shall apply.

i. **Soil**

a. This shall include all types of soils which can be excavated by pick axes or spades or earth moving equipment such as dozer, poclains, shovels, draglines, etc.

b. It shall include, but not be limited to, vegetable or organic soil, turf, sand, silt, mud, moorum, shingle, clay, gravel, cobbles, talus, loam, macadam, peat, ash, marsh, brick bats, tar / bitumen surfaces, etc.

ii. **Rock**

a. Rock shall include materials, which are not classified under soil.

b. Rock excavated by mechanical means - any rock / boulder / PCC which can be excavated by earth moving equipment, (i.e. without blasting, wedging) such as poclains, shovels, draglines, grafting tools, etc.

c. Rock (requiring blasting) - any rock / boulder / RCC for the excavation of which blasting is required. Excavation of such rock has to be carried out by controlled blasting.

iii. **Rock level**

After complete removal of soil overburden, the Bidder shall inform the Engineer about the rock level. The excavation / blasting in rock shall proceed only after establishing the rock level by Engineer and complete removal of soil over burden by Bidder.

iv. **Levelling**

Bottoms of excavation shall be cut sharp and true to line and level. Undercutting shall not be permitted. The last 300mm in soil / rock before reaching the required level shall be excavated carefully by such equipment so that the soil / rock at the required final level will be left in its natural condition.

IV. Protections

i. Excavation where directed by the Engineer-in-Charge shall be securely barricaded and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with red lights and/or written using fluorescent reflective paint as directed by engineer in charge during the night to avoid accident.

ii. The Bidder shall take adequate protective measures to see that the excavation operations do not damage the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes and chambers, communication cables, power supply cables etc. met within the course of excavation shall be properly supported and adequately protected, so that these services remain functional. However, if any service is damaged during excavation shall be restored in reasonable time.

iii. Excavation shall not be carried out below the foundation level of the adjacent buildings until underpinning; shoring etc. is done as per the directions of the Engineer-in-Charge for which payment shall be made separately.

iv. Any damages done by the Bidder to any existing work shall be made good by him at his own cost. Existing drains, pipes, culverts, overhead wires, water supply lines and similar services encountered during the course of execution shall be protected against damage by the Bidder. The Bidder shall not store material or otherwise occupy any part of the site in manner likely to hinder the operations of such services.

V. Site clearance

Existing structures and services such as old buildings, culverts, fencing, water supply pipe lines, sewers, power cables, communication cables, drainage pipes etc. within or adjacent to the area if required to be diverted/removed, shall be diverted/dismantled as per directions of the Engineer-in- Charge and payment for such diversion/dismantling works shall not be made separately.

VI. Water other than Ground water (i.e. Surface water)

The Bidder shall control the ground in the vicinity of all excavations so that the surface of the ground will be properly sloped or dyked to prevent surface water from running into the excavated areas during construction. The Bidder shall have to constantly pump out any water collected in excavated pits and other areas due to rain water, springs, drain, etc. and maintain dry working conditions at all times until the excavation, placement of reinforcement, shuttering, concreting, waterproofing, testing, backfilling is completed. The Bidder shall remove all slush / muck from the excavated areas to keep the work area dry. Sludge pumps, if required, shall be employed by the Bidder for this purpose.

VII. Coffer dam, sheeting, shoring etc.

The Bidder shall ascertain for himself the nature of materials to be excavated and the difficulties, if any, likely to be encountered in executing this work. Coffer dams, sheeting, and shoring, bracing, and maintaining suitable slopes draining etc. shall be provided and installed by the Bidder, to the satisfaction of the Engineer. The Bidder shall submit drawings to the Engineer, showing arrangements of bracing, sheeting or shoring etc. and details of proposed installation. The Bidder shall also furnish all supporting calculations as called for and shall not proceed until he has received written approval from the Engineer. However, the responsibility for adequacy of such bracing, sheeting, shoring etc., will rest with the Bidder, irrespective of any approval of the Engineer. For deep and huge excavations and any other excavation, if required by the Engineer, the Bidder shall submit for Engineer's approval "excavation scheme" showing the methodology to be adopted for excavation in order to maintain the stability of side slopes, means for ensuring safety of existing nearby facilities, dewatering arrangement as described in subsequent clause, etc. However, the Bidder shall be fully responsible for the scheme irrespective of any approvals granted. Benching shall be provided for deeper excavation wherever required.

VIII. Trimming of Excavation bottom

Excavation for foundations shall be to the bottom of lean concrete as shown on drawings or as directed by the Engineer. The bottom of all excavations shall be trimmed to required levels and when excavation is carried below such levels, by error, it shall be brought back to specified level by filling with concrete of nominal mix 1:3:6 (cement: coarse sand: 40mm down aggregates) for excavation in rock and by stone aggregate with interstices filled with sand for excavation in soil by the Bidder at his own cost including arranging of the cement.

IX. Stacking

The Bidder shall dispose of all materials arising from excavations from the vicinity of the work either by direct filling, or by stacking and subsequently filling or by ultimate disposal as directed by the Engineer. In no case the excavated soil shall be stacked within a distance of 1.50 m from the edge of excavation or one third (1 / 3) of the excavation depth, whichever is more. Material to be kept for subsequently filling / backfilling shall be stacked at location (s) as directed by the Engineer.

Disposal of Earth shall be disposed of at the specified location or as decided by the Engineer-in- Charge. The Bidder has to take written permission about place of disposal of earth before the earth is disposed of, from Engineer-in-Charge.

X. Excavation below ground water table

Wherever Ground Water Table is met with during excavation, the Bidder shall immediately report this fact to the Engineer. The Bidder shall dewater and maintain dry working conditions by maintaining the water table at least 0.5m below the bottom of the excavation level by well-point dewatering or deep well dewatering or any other method. Bidder shall prepare the detailed scheme for dewatering in line with IS: 9758 and submit the same to the Engineer for approval. The dewatering work shall be done as per approved scheme. He shall continue dewatering i.e. maintain dry working condition till excavation, concreting, curing, water proofing, back filling / filling, testing and all other operations included in the scope of work, which require dry condition in the area, are completed.

XI. Earth work by mechanical means

Earth work by mechanical means involves careful planning keeping in view site conditions i.e. type of soil, nature of excavation, distances through which excavated soil is to be transported and working space available for employing these machines. The earth moving equipment should be accordingly selected.

The earth moving equipment consists of excavating and transporting equipment. Excavating equipments may be further classified as excavators and tractor based equipments.

i. Excavators

Excavators generally used at site are as follows:

a. **Dipper-shovel:** It is used for excavating against a face or bank consisting of open-top bucket or dipper with a bottom opening door, fixed to an arm or dipper stick which slides and pivots on the jib of the crane. It is suitable for excavating all clay chalk and friable materials and for handling rock and stone. However, it is not suitable for surface excavation for which a skimmer is used.

b. **Backhoe:** It is similar to face shovel except that the dipper stick pivots on the end of the jib and the dipper or bucket works towards the chassis and normally has no bottom door but is emptied by swinging away from the chassis to invert the bucket. It may be designed to carry both a front–mounted bucket loading mechanism and a rear mounted backhoe. It is mainly used to excavate trenches and occasionally used for the excavation of open areas such as small basements.

In the backhoe mode the bucket lifts, swings and discharges materials while the undercarriage is stationary. When used in the 'loader' mode, the machine loads or excavated through forward motion of the machine, and lifts, transports and discharges materials.

c. **Skimmer:** This arrangement is similar to the face shovel except that in this case the bucket slides on rollers directly along the jib and thus has a more restricted movement. It is used for surface excavation and levelling in conjunction with transport to haul away the excavated material.

d. **Dragline:** It is usually fitted with a long slender boom or jib and the bucket, which in operation faces towards the machine and has no door, is supported by cable only as on a crane. It works from the side of the excavation at normal ground level and is used for excavating large open excavations such as basements when the depth is beyond the limit of the boom of a backhoe. It is commonly used for open cast mining operations.

e. **Clamshell:** It consists of two hinged half-buckets or jaws pivoted to a frame which is suspended by cable from a long jib of an excavation. The grab is used for deep excavations of limited area on all types of soil except rock. Crane and Grab is a variant of this type of equipment.

ii. **Tractor–based Equipment**

It is a self–propelled crawler or wheeled machine used to exert a push or pull force through mounted equipment. It is designed either as attachments to normal tracked or wheeled tractors or as machines in which the earth moving attachments and the tractor are designed as a single integrated unit. A tractor, which is hydraulically operated, can be rigged as:

a. **Loaders:** It is used for loading, light dozing, scraping and grabbing operations, lifting and transporting the materials (loose earth, rubble, sand, gravel aggregate etc.) at various sites through forward motion of the machine.

b. **Tractor Shovel:** This consists of a tipping bucket at the front attached by strong pivoted arms or booms to the frame of the machine. It is used for stripping top soil, excavating against a face, bulldozing and for loading spoil or loose materials. It is similar to crawler dipper-shovel.

c. **Trench Digger:** It operates on the same principle as a backhoe excavator except that the bucket is controlled by hydraulic rams instead of cables and pulleys.

d. **Scraper:** Scrapers provide unique capability to excavate, load, haul and dump materials.

Scrapers are available in various capacities by a number of manufacturers with options such as self – loading with elevators, twin engines or push-pull capability. They are cost effective where the haul distance is too long for bulldozers, yet too short for trucks. This distance typically ranges from 120 m to 1200 m; however, the economics should be evaluated for each project.

Scraper has an open bowl with a cutting edge positioned between the axles, which cut, loads, transports, discharges and spreads through forward motion of the machine. Loading through forward motion of the machine can be assisted by a powered mechanism (elevator) fixed to the scraper bowl.

e. **Bulldozer and Angle-dozer:** The most common equipment used for clearing and levelling activities is a bulldozer. The terms bulldozer is used to define a tractor mounted with a dozing blade.

The bulldozer consists of a rectangular steel blade with renewable cutting edge set at right angles (capable of only tilting but not angling) to the direction of travel and attached by steel arms to the side frames of a crawler tractor. It may be used for excavating natural soil or for moving loose soil or debris, which is pushed forward as the tractor forces it ahead.

f. **Angle dozer** is capable of both tilting and angling

XII. Transporting Equipment

This implies horizontal movement primarily but it can involve some vertical movement too.

i. **Dumpers:** These are self-propelled wheeled machines, having an open body. It is designed for the transport of excavated materials and consists of a shallow tipping hopper or skip mounted on a wheeled chassis, such as, power barrow, dumper, multi-skip dumpers, high discharge dumpers, dump truck, etc. These can be rear dump, side dump or bottom dump.

ii. **Vibratory Roller:** It is a single Drum Vibratory Roller for compaction of embankments, etc. The smooth drum version is for compaction of granular and mixed soil. The sheep foot Roller consists of a hollow cylindrical steel drum or drums on which projecting feet are mounted. These feet penetrate into the fill as a roller moves forward and cause compaction. The geometry of the foot may be sheep, club pyramid, and cone or cylinder foot. Such rollers are employed for compaction (densification) of cohesive and semi-cohesive soils.

8.6.0 Filling and Backfilling

i. Using selected excavated materials

Excavated selected materials to be used for backfilling / filling purposes shall have the prior written approval of the Engineer.

A.1 **Material**

a. Selected excavated materials to be used for backfilling / filling purposes shall consist of soil, broken stone, sand or other inorganic materials and they shall be clean and free from shingle, organic matter, large roots and excessive amount of sod, lumps, concrete or any other foreign substances which could harm or impair the strength of the substructure in any manner. All clods shall be suitably broken to small pieces.

b. When the material is mostly rock boulders, these shall be broken into pieces not larger than 200 mm size. Such material shall be used in back filling of areas / layer where the compaction of 85 % of original volume is specified.

B.1 **Filling / Back Filling operations**

a. Filling / back filling shall begin only with the written approval of the Engineer. The areas identified for backfilling shall be cleared of all soft pockets, vegetation, bushes, slush all temporary shoring, timber, etc. Backfill materials shall not be dropped directly upon or against any structure or facility where there is danger of displacement or damage.

b. Filling / back filling shall be accurately finished to line, slope, cross section and grade as shown on the drawings. Finished surface shall be free of irregularities and depressions. Filling / backfilling shall be compacted to the required degree of compaction and level as shown in drawing.

c. Fill / backfill adjacent to pipes shall be free of stones, concrete, etc. and shall be placed and compacted uniformly on both sides of the pipe and where practicable up to a minimum depth of 300mm over the top of pipes. While tamping around the pipes. Care shall be taken to avoid unequal pressure.

C.1 **Transportation**

Selected excavated material will involve loading from the stack pile of excavated material including excavation of soil which may become hard due to lying in the stock pile for a period of time, for all lifts and lead upto 1000m, carriage and unloading.

D.1 **Watering and Compacting**

a. All space between foundation (concrete or masonry) and the sides of excavation shall be filled to the specified level after making allowance for settlement. Fill shall be placed in horizontal layers not exceeding 300 mm compacted thicknesses. However, higher layer thickness (up to 500 mm) can be adopted for compaction where special types of equipment like vibratory rollers are used and the required degree of compaction is achieved. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction / density as specified. The methods of compaction shall be subject to the approval of the Engineer.

   i. Only manual compaction shall be by flooding and ramming. The Bidder at his discretion may use the mechanical means.
   ii. Where compaction upto 85% standard proctor density is called for, such compaction shall be by mechanical means but the Bidder may be permitted to adopt manual means only if the Engineer finds that the desired compaction is achievable in the field.
   iii. Where compaction of 85% or more of standard proctor density is called for, it shall be by mechanical means only. Where access is possible, compaction shall be by 10 Tonne rollers smooth wheeled, sheep foot wobbly wheeled or vibratory roller as directed by the Engineer. Where access to the heavy roller is not possible, a smaller vibratory roller (drum width 500 mm to 1000 mm) and / or plate vibrator shall be used for compaction. Each layer shall be watered, rammed and compacted to the density / volume as specified in the schedule of items.
   iv. Where rock boulders, construction debris have been used for filling, it shall be compacted to minimum of 85% of original stack of material after filling the interstices with the selected excavated material.

b. The degree of compaction of compacted fill in place will be verified by tests as the work progresses, and the Bidder shall conduct such tests as per the approved Field Quality Plan. If any test indicates that the compaction achieved is less than the specified, the Engineer may require all fill placed subsequent to the last successful test to be removed and re compacted by the Bidder. Compaction procedure shall be amended as necessary to obtain satisfactory results.

E.1 **Dressing**

After filling, the top surface shall be dressed by light rolling.

ii. Filling using selected Borrowed material

A.1 **Material**

a. For materials to be borrowed from pits / quarries, then it shall be the Bidder's responsibility for identification and arranging of such quarry areas, obtaining approval for their use from concerned authorities, the Bidder shall pay any levies, royalties, etc., that may have to be paid for utilisation of borrow areas.
b. Ash may be used wherever required. Ash shall be excavated by the Bidder from the ash pond and brought to the site.
c. Sand for filling shall be clean, medium grained and free from impurities. Fines less than 75 microns shall not be more than 20%.
d. Selected soil brought from borrow area shall be free from stone, boulders and other organic material. It shall be non-expansive type of soil free from presence of harmful chemical, salt, vegetation, etc.
e. Stone / gravel used for filling shall be broken hard stone of specified nominal size and shall be free from all types of organic materials.
f. Moorum brought from borrow area shall be free from stone, boulders and other organic material.

B.1 **Filling**

Filling shall begin only after approval of the Engineer of the borrow area and the material to be used for filling.

C.1 **Transportation**

Selected borrowed material will involve excavation / quarrying, loading and carriage of such material for all leads and lifts, unloading etc.

D.1 **Watering & Compaction**

a. Filling, watering and compacting, dressing and consolidating of selected soil brought from borrow area shall be done in the same manner as specified for the filling using the selected excavated material.

b. For compaction of each sand layer, water shall be sprayed over it to flood it and it shall be kept flooded for 24 hours to ensure maximum compaction. Vibrators shall also be used if necessary to obtain the required degree of compaction. Any temporary works required to contain sand under flooded condition shall also be undertaken by the Bidder at his own cost. The surface of the consolidated sand shall be dressed to required levels and slope.

c. Filling with 63mm downgraded stone shall be done with 63 mm nominal size stone laid in 200 mm loose thick layers, interstices filled with properly graded material consisting of selected stone and sand / soil. Each layer shall be watered and roller compacted by giving at least 10 (Ten) passes of 8 - 10T roller achieve the specified volume with respect to the original volume before the next layer is laid.

d. Where clean stone fill is specified, it shall consist of clean selected stone metal of 40mm nominal size. It shall be laid in layers not exceeding 200mm and lightly tamped before the next layer is laid. No compaction shall be required for this type of stone filling.

E.1 **Dressing**

After filling, the top surface shall be dressed by light rolling.

8.7.0 Planking and strutting

A. When the depth of trench in soft/loose soil exceeds 2 metres, stepping, sloping and/ or planking and strutting of sides shall be done. In case of loose and slushy soils, the depths at which these precautions are to be taken shall be determined by the Engineer-in-Charge according to the nature of soil.

Planking and strutting shall be 'close' or 'open' depending on the nature of soil and the depth of trench. The type of planking and strutting shall be determined by the Engineer-in-Charge. It shall be the responsibility of the Bidder to take all necessary steps to prevent the sides of trenches from collapse. Engineer-in-Charge should take guidance from IS: 3764 for designing the shoring and strutting arrangements and specifying the profile of excavation.

B. **Close Planking and Strutting**

Close planking and strutting shall be done by completely covering the sides of the trench generally with short upright, members called 'poling boards'. These shall be 250x38 mm in section or as directed by the Engineer-in-Charge.

The boards shall generally be placed in position vertically in pairs**.** One boards on either side of cutting. These shall be kept apart by horizontal wallings of strong wood at a maximum spacing of 1.2 meters cross strutted with ballies, or as directed by Engineer-in-Charge. The length and diameter of the ballies strut shall depend upon the width of the trench. Typical sketch of close timbering is given below.

Where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical 'wallings' which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the sides shall be taken in the ground for a minimum depth of 75 mm. No portion of the vertical side of the trench shall remain exposed.

The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried, unless required by the Engineer-in-Charge to be left permanently in position.

C. **Open Planking and Strutting**

In case of open planking and strutting, the entire surface of the side of the trench is not required to be covered. The vertical boards 250 mm wide & 38 mm thick shall be spaced sufficiency apart to leave unsupported strips of 50 cm average width. The detailed arrangement, sizes of the timber and the distance apart shall be subject to the approval of the Engineer-in-Charge. In all other respect, specifications for close planking and strutting shall apply to open planking and strutting.

8.8.0 Anti-termite treatment

A. General

Sub-terranean termites are responsible for most of the termite damage in buildings. Typically, they form nests or colonies underground in the soil near ground level in a stump or other suitable piece of timber in a conical or dome shaped mound. The termites find access to the super-structure of the building either through the timber buried in the ground or by means of mud shelter tubes constructed over unprotected foundations.

Termite control in existing as well as new building structures is very important as the damage likely to be caused by the termites to wooden members of building and other household article like furniture, clothing, stationery etc. is considerable. Anti-termite treatment can be either during the time of construction i.e. pre-constructional chemical treatment or after the building has been constructed i.e. treatment for existing building.

Prevention of the termite from reaching the super-structure of the building and its contents can be achieved by creating a chemical barrier between the ground, from where the termites come and other contents of the building which may form food for the termites. This is achieved by treating the soil beneath the building and around the foundation with a suitable insecticide.

All work shall in general be executed as specified in IS: 6313 Part II-1981 and as per specification. All necessary work to ensure uniform distribution and proper penetration of treatment of treating solution shall be done according to the instruction of the Owner/Consultant/Engineer. Soil treatment shall not be done when it is raining or when the soil is wet with rain or subsoil water. Once formed, the treated soil barrier shall not be disturbed.

B. **Materials**

i. **Chemicals:** Any one of the following chemicals in water emulsion to achieve the percentage concentration specified against each chemical shall be used:

a. Chlorphriphos emulsifiable concentrate of 20%
b. Lindane emulsifiable concentrate of 20%

Anti-termite treatment chemical is available in concentrated form in the market and concentration is indicated on the sealed containers. To achieve the specified percentage of concentration, Chemical should be diluted with water in required quantity before it is used. Graduated containers shall be used for dilution of chemical with water in the required proportion to achieve the desired percentage of concentration. For example, to dilute chemical of 20% concentration, 19 parts of water shall be added to one part of chemical for achieving 1% concentration. Bidder shall procure the chemical of required concentration in sealed original containers directly from the reputed and authorized dealers. Chemical shall be kept in Bidder's custody or his authorized representatives and issued for use to meet the day's requirements. Empty containers after washing and concentrated chemical left unused at the end of the day's work shall be disposed immediately.

ii. **Safety Precautions**

Chemical used for anti-termite treatment are insecticides with a persistent action and are highly poisonous. This chemical can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed. The containers having emulsifiable concentrates shall be clearly labelled and kept securely closed in stores. Storage and mixing of concentrates shall not be done near any fire source or flame. Persons using these chemical shall be warned that absorption though skin is the most likely source of accidental poisoning. Particular care shall be taken to prevent skin contact with concentrates and prolonged exposure to dilute emulsion shall also be avoided. After handling the concentrates or dilute emulsion, workers shall wash themselves with soap and water and wear clean clothing, especially before eating. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemical has splashed into the eyes, they shall be flushed with plenty of soap and water and immediate medical attention shall be sought. Care should be taken in the application of chemicals to see that they are not allowed to contaminate wells or springs which serve as source of drinking water.

iii. **Anti-Termite Treatment: Constructional Measures**

The construction measures specified below should be adopted for protection against subterranean termites originating both internally from within the plinth and externally from the area surrounding the building.

a. Earth free from roots, dead leaves, or other organic matter shall be placed and compacted in successive horizontal layers of loose material not more than 200 mm thick. Dry brick shall be inserted atleast 50 mm in brick masonry for providing apron floor around the periphery.

b. Brick on edge masonry in cement mortar shall be laid on the plinth wall. Dry brick shall be placed on the inner side of plinth wall for getting anticipated offset space for coarse sand and on the other side for installing anti-termite masonry groove. In the case of intermediate walls, dry bricks are placed on either side of the brick on edge masonry for getting offset space for coarse sand layer.

c. The dry brick for the anti-termite groove shall be taken out and dense cement concrete 1:3:6 (1 cement: 3 sand: 6 coarse aggregate by volume) sub-floor carpet shall be laid casting the anti-termite groove in position. In case of internal partition walls, the cement concrete sub-floor shall be laid on either side over the dry bricks to sufficient extent for getting staggered vertical joints over the joint of plinth wall and earth filling.

d. Superstructure masonry shall be raised over the dense cement concrete sub floor carpet and over-head jobs completed.

e. The dry brick for coarse sand layer shall be removed and graded sand (of size 3 to 5 mm) layer at least 100 mm thick shall be compacted over the earth filling and underneath the partially laid dense cement concrete sub-floor carpet

f. Dense cement concrete (1:3:6 mix.) sub-floor at least 75 mm thick shall be laid over the sand filling. Necessary finish may be provided to the cement concrete sub-floor carpet.

g. Dry brick provided for apron floor shall be taken out and 600 mm wide formation of earth in 1:30 slope shall be made. Over the formation, 75 mm thick lime concrete 1:3:6 (1 lime:3 sand: 6 coarse aggregate, by volume) shall be laid.

h. Over the 75 mm thick like concrete bed at least 25 mm thick cement concrete topping 1:2:4(1 cement: 2 sand: 4 fine aggregate, by volume) shall be laid and 12 mm thick cement plaster shall be applied on foundation and plinth. The final recommendations incorporating the constructional details given above (i to viii).

C. **Anti-Termite Treatment : Treatment for Existing Building: Post Construction Treatment**

i. **Material**

a. **Chemicals**: Any one of the following chemicals conforming to relevant Indian Standards in water emulsion may be used for soil treatment in order to protect a building from termite attack.

Chemicals	Code	Concentration by Weight, Percentage
Chlorpyrifos Emulsifiable	IS:8944 - 1978	1
Heptachlor Emulsifiable Concentrate	IS: 6439 - 1978	0.5
Chlordane Emulsifiable Concentrate	IS: 2682 - 1984	1

Bidder shall procure the chemical of required concentration in sealed original containers directly from the reputed and authorized representative. Chemical shall be kept in the custody of the Bidder or his authorized representatives and issued for use to meet the day's requirements. Empty containers after washing and concentrated chemical left unused at the end of the day's work shall be returned to the Engineer-in-charge or his authorized representative.

ii. **Safety Precautions:** Chemical used for anti-termite treatment is insecticides with a persistent action and are highly poisonous. This chemical can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed. The containers having emulsifiable concentrates shall be clearly labelled and kept securely closed in stores so that children or pet cannot get at them. Storage and mixing of concentrates shall not be done near any fire source or flame. Persons carrying out chemical soil treatments should familiarize themselves and exercise due care when handling the chemicals whether in concentrated or in diluted form. After handling the concentrates or dilute emulsion, worker shall wash themselves with soap and water and wear clean clothing especially before eating and smoking. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemical has splashed into the eyes, they shall be flushed with plenty of soap and water and immediate medical attention shall be sought. The use of chemical shall be avoided where there is any risk of wells or other water supplies becoming contaminated.

iii. **Treatment**

a. Once the termites have ingress into the building, they keep on multiplying and destroy the wooden and cellulosic materials, and as such it becomes essential to take measures for protection against termites. Anti-termite measures described below are necessary for the eradication and control of termites in existing building. To facilitate proper penetrations of chemical in to the surface to be treated, hand operated pressure pump shall be used. To have proper check for uniform penetration of chemical, graduated containers shall be used. Proper check should be kept so that the specified quantity of chemical is used for the required area during the operation. Chemical treatment for the eradication and control of subterranean termites in existing building shall be done as per IS: 6313 (Part III). Treatment shall be got done only from the approved specialized agencies using the chemical procured directly by the Engineer-in-Charge from reputed and authorized dealers.

b. **Treatment along outside of foundations:** The soil in contact with the external wall of the building shall be treated with chemical emulsion at the rate of 7.5 litres per square metre of vertical surface of the sub-structure to a depth of 300 mm. To facilitate this treatment, a shallow channel shall be excavated along and close to the wall face. The chemical emulsion shall be directed towards the wall at 1.75 litres per running metre of the channel. Rodding with 12 mm diameter mild steel rods at 150 mm apart shall be done in the channel. If necessary, for uniform dispersal of the chemical to 300 mm depth from the ground level. The balance chemical of 0.5 litre per running metre shall then be used to treat the backfill earth as it is returned to the channel directing the spray towards the wall surface.

If there is a concrete or masonry apron around the building, approximately 12 mm diameter holes shall be drilled as close as possible to the plinth wall about 300 mm apart, deep enough to reach the soil below and the chemical emulsion pumped into these holes to soak the soil below at the rate of 2.25 litres per linear metre.

In soils which do not allow percolation of chemicals to desired depth, the uniform disposal of the chemical to a depth of 300 mm shall be obtained by suitably modifying the mode of treatment depending on site condition.

In case of RCC foundations the soil (backfill) in contact with the column sides and plinth beams along with external perimeter of the building shall be treated with chemical emulsion at the rate of 7.5 litres/Sq.m. of the vertical surface of the structure. To facilitate this treatment, trenches shall be excavated equal to the width of the shovel exposing the sides of the column and plinth beams upto a depth of 300 mm or upto the bottom of the plinth beams, if this level is less than 300 mm. The chemical emulsion shall be sprayed on the backfill earth as it is returned into the trench directing the spray against the concrete surface of the beam or column as the case may be.

c. **Treatment of Voids in Masonry:** The movement of termites through the masonry wall may be arrested by drilling holes in masonry wall at plinth level and squirting chemical emulsions into the holes to soak the masonry. The holes shall be drilled at an angle of 45 degree from both sides of the plinth wall at 300 mm intervals and emulsion squirted through these holes to soak the masonry using a hand operated pump. This treatment shall also be extended to internal walls having foundations in the soil. Holes shall also be drilled at wall corners and where door and window frames are embedded in the masonry or floor at ground. Emulsion shall be squirted through the holes till refusal or to a maximum of one litre per hole. Care shall be taken to seal the holes after the treatment.

8.9.0 Mortar

A. List of applicable code

S.NO	IS CODE.NO	SUBJECT
1	IS:383	Specification for coarse and fine aggregate from natural source for concrete
2	IS:455	Specification for Portland slag cement
3	IS:460 (Part I)	Specification for test sieves: wire cloth test sieves.
4	IS:650	Specification for standard sand for testing of cement
5	IS:1269	Specification for 53 grade ordinary Portland cement
6	IS:1344	Specification for calcined clay Pozzolano
7	IS:1542	Specification for sand for plaster
8	IS:1727	Methods of Test for Pozzolanic materials
9	IS:2116	Specification for sand for masonry mortar
10	IS:2250	Code of practice for preparation and use of masonry Mortar
11	IS:2386 (Pt-I)	Method of test for aggregate for concrete (Particle size and shape)
12	IS:2386 (Pt-II)	-Do- Estimation of deleterious materials and organic impurities
13	IS:2386 (Pt-III)	-Do- Specific gravity, density, voids, absorption and bulking
14	IS:3025	Method of sampling and test for water
15	IS:3406	Specification for masonry cement
16	IS:3812 (Part I)	Specification for fly ash for use as pozzolano in cement mortar and concrete
17	IS:3812 (Part II)	Specification for fly ash for use as admixture in cement mortar and concrete

S.NO	IS CODE.NO	SUBJECT
18	IS:4031 (Part I) to (Part XIII)	Method of Physical test for hydraulic cement
19	IS:4032	Method of chemical analysis of Hydraulic cement
20	IS:8042	Specification for white cement
21	IS:8112	Specification for 43 grade ordinary Portland cement
22	IS:11652	Woven HDPE sacks for packing cement
23	IS:11653	Woven polypropylene sacks for packing cement
24	IS:12174	Jute synthetic union bags for packing cement
25	IS:269	Ordinary and low heat Portland cement

B. **MANDATORY TESTS Notes:**

i. The mandatory tests shall be carried out when the quantity of materials to incorporate in the work exceeds the minimum quantity specified.

ii. Optional tests specified or any other tests, shall be carried out in case of specialised works or important structures as per direction of the Engineer-in-charge/Owner/Consultant.

iii. Testing charges, including incidental charges and cost of sample for testing shall be borne by the Bidder for all mandatory tests.

iv. In case of non-IS materials, it shall be the responsibility of the Bidder to establish the conformity of material with relevant IS specification by carrying out necessary tests. Testing charges including incidental charge and cost of sample for testing shall be borne by the Bidder for such tests.

The mandatory tests shall be as follows:

Material	Test	Field / Laboratory Test	Test Procedure	Minimum quantity of material / work for carrying out	Frequency of testing
Water for Construction Purposes	Ph. Value Limits of Acidity limits of Alkality Percentage of solids Chlorides Suspended matter Sulphates Inorganic solids organic solids	Lub	IS:3025	Water from Each source	Before commencement of work & thereafter: Mandatory – Once in one year from each source; Optional: once in 3 months from each source; Municipal Supply - optional
MORTAR					
Sand	Buckling of sand	Field		20 cu.m	Every 20 cu.m or part thereof or more frequently decided by Engineer – in-charge
	Silt content	Field	IS:383	20 cu.m	Every 20 cu.m or part thereof or more frequently decided by Engineer-incharge/

Material	Test	Field / Laboratory Test	Test Procedure	Minimum quantity of material / work for carrying out	Frequency of testing
					Owner/Consul Tant
	Particle size and distribution	field laboratory decided by engineer-in - charge	IS:383	40 cu.m	Every 40 cu.m of fine aggregate/ sand required in RCC work only
	Organic impurities	Field	IS:383	20 cu.m	Every 20 cu.m or part of thereof or more frequently decided by engineer in charge
	Chloride sulphate content		Optional		Once in three months
Cement	Test requirement	Finenesss (m^2/kg)	IS:4031 (Part II)	Each fresh lot	Every 50 MT or part thereof
		Normal consistency	IS:4031 (Part IV)		
		Setting time minutes 1.Initial 2. Final	IS:4031 (Part V)		
		Soundness a)Le-chat expansion b) Autoclave (%)	IS:4031(part .III)		
		Compressive Strength (mpa) a)72+/-1 hr b)168+/-2hr	IS:4031 (part.IV)		
				50:35001 to 50000	3
				20:for every addl. 50000 or part of thereof if <20000, as per decision of EIC	4

C. General

Desirable properties of mortars for use in masonry are:

i. Workability
ii. Water retentivity
iii. Rate of stiffing
iv. Strength
v. Resistance to rain penetration
vi. Durability

D. Materials

i. Water

a. Water used for mixing and curing shall be clean and sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is

generally considered satisfactory for mixing concrete. As a guide the following concentrations represent the maximum permissible values:

1) To neutralize 100 ml sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml of 0.02 normal NaOH. The details of test are given in 8.1 of IS: 3025 (Part 22).

2) To neutralize 100 ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 normal H_2O_4 the details of 'test shall be as given in 8 of IS: 3025 (Part 23).

3) Permissible limits for solids shall be as given in Table 2 below.

Table 2 Permissible Limit for solids

S.No.	Description	Code	Permissible Limit
1	Organic	IS:3025 (Part 18)	200 mg/l
2	Inorganic	IS:3025 (Part 18)	3000 mg/l
3	Sulphates	IS:3025 (Part 24)	400 mg/l
4	Chlorides	IS:3025 (Part	2000 mg/l for concrete not containing embedded steel and 500 mg/l for reinforced concrete work
5	Suspended matter	IS:3025 (Part 17)	2000 mg/l

b. 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 specified below.

1) The sample of water taken for testing shall represent the water proposed to be used for concreting, due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.

2) Average 28 days compressive strength of at least three 150 mm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS: 516.

3) 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 min and shall not differ by& 30min 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 the requirements of IS: 4031 (Part 5).

c. The pH value of water shall be not less than 6.

d. Water found satisfactory for mixing is also suitable for curing concrete. However, water used for curing should not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or iron compounds is objectionable.

ii. **Cement**

If HSRC is used, the following are the specification.

A. Sulphate resisting Portland cement

I. Chemical requirements.

When tested in accordance with the methods given in IS: 4032-1985, sulphate resisting Portland cement shall comply with the chemical requirements given in Table below:

S.No.	Characteristic	Requirement
1	Ratio of percentage or lime to percentage of silica, alumina and iron oxide; when calculated by the formula: (Cao-0.7S3)/ (2.8S2O3+1.2Al2O3 +0.65Fe2O3)	200 mg/l
2	Insoluble residue, percent by mass	Not more than 4
3	Magnesia., percent by mass	Not more than 6
4	Total sulphur content calculated as sulphuric anhydride (SO2), percent by mass	Not more than 2.5
5	Tricalcium aluminate (C3A). percent by mass	Not more than 5
6	Tetra calcium alumino ferrite phase plus twice the tricalcium aluminate (C3AF + 2C3A), percent by mass	Not more than 25
7	Total lose on ignition, percent by mass	Not more than 5

II. Physical requirements.

a. Fineness

When tested for fineness by Blaine's air permeability method as given in IS: 4031 (Part 2)-1988, the specific surface of cement shall be not be less than 225 m^2/kg.

b. Soundness

When tested by Le Chatelier method and autoclave test described in IS: 4031 (Part 3) 1988 unaerated sulphate resisting Portland cement shall not have an expansion of more than 10 mm and 0·8 percent, respectively.

In the event of cement failing to comply with anyone or both the requirements further tests in respect of each failure shall be made as described in IS : 4031 (Part 3) - 1988 from another portion of the same sample after aeration. The aeration hall be done by spreading out the sample to a depth of 75 mm at a relative humidity of 50 to 80 percent for a total period of 7 days. The expansion of cements so aerated shall not be more than 5 mm and 0.6 percent when tested by Le Chatelier method and autoclave test respectively.

c. Setting Time

The setting time of sulphate resisting Portland cement, when tested by the Vicat apparatus method described in IS: 4031 (Part 5)-1988 shall conform to the following requirement

1. Initial setting time in minutes, not less than 30, and
2. Final setting time in minutes, not more than 600.

If cement exhibits false set, the ratio of final penetration measured after 5 minutes of completion of mixing period to the initial penetration measured exactly alter 20 seconds of completion of mixing period, expressed as percent, shall not be less than 50. In the event of cement exhibiting false set, the initial and final setting time of cement when tested by the method described in IS: 4031 (Part 5)-1980.

d. Sulphate Expansion

The sulphate expansion of the sulphate resisting Portland cement when tested shall not be more than 0.045 percent at 11 days. This test is optional and shall be carried out by agreement between the purchaser and the manufacturer at the time of placing order.

For this test a mixture of sulphate resisting Portland cement and gypsum should be prepared in such proportions that the total SO3 content is 70 percent by mass. The gypsum used shall be natural gypsum 100 percent passing 150 µm IS Sieve, at least 90 percent passing 75µm IS Sieve and at least 90 percent passing 45 µm IS Sieve. Mortar should have proportion of (cement + gypsum): sand as 1: 2.75 and water :(cement + gypsum) as 0.485. The sand used shall conform to IS: 650-1966. The dimension of mortar bars shall be 25 x 25 X 250 mm, after remoulding, the bars shall be stored horizontally in water.

The average expansion of three specimens after 14 days shall be reported.

III. Compressive strength

The average compressive strength of at least three mortar cubes (area of face 50 cm^2) composed of one part of cement, three parts of standard sand (conforming to IS: 650-1966) by mass and P/4 + 3.0 percent (of combined mass of cement plus sand) water and prepared, stored and tested in the manner described in IS: 4031 (Part 6)-1988 shall be as follows:

a . 72 ± 1 h, not less than 10 MPa
b . 168 ± 2 h, not less than 16 MPa
c . 672 ± 4 h, not less than 33 MPa

By arrangement between the purchaser and the manufactures, transverse strength test of plastic mortar in accordance with the method described in IS:4031 (Part 8)-1988: may be specified. The permissible values of the transverse strength shall be mutually agreed to between the purchaser and the supplier at the time of placing order.
Not withstanding the strength requirements specified, sulphate resisting Portland cement shall show a progressive increase in strength (loom the strength at 72 h.

IV. TESTS

The sample or samples of cement for test shall be taken as described the code and shall be tested in the manner described in the relevant clauses.

a. Temperature for Testing

The temperature range within which physical tests may be carried out shall, as far as possible, be 27 ± 2℃. The actual temperature during the testing shall be recorded.

b. Consistency of standard cement paste

The quantity of water required to produce a paste of standard consistency , to be used for the determination of the water content of mortar for the compressive strength tests and for the determination of soundness and setting time, shall be obtained by the method described in IS : 4031 (Part 4)-1988.

V. REJECTION

Cement may be rejected if it does not comply with any of the requirements specified above.

Cement remaining in bulk storage at the mill, prior to shipment, for more than six months, or cement in bags in local storage in the hands of a vendor for more than 3 months after completion of tests, may be retested before use and may be rejected if it fails to conform to any of the requirements specified.

iii. Fine Aggregate

Aggregate most of which passes 4.75-mm IS Sieve and contains only so much coarser material as permitted below. The grading of fine aggregates, when determined as described in IS: 2386 (Part I)-1963 shall be within the limits given in Table below and shall be described as fine aggregates, Grading Zones I, II, III and IV: Where* the grading falls outside the limits of any particular grading zone of sieves other than 600-micron IS Sieve by a total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600-micron IS Sieve or to percentage passing any other sieve size on the coarse limit of Grading Zone I or the finer limit of Grading Zone IV.

IS Sieve Designation	Percentage passing for			
	Grading Zone – I	Grading Zone – II	Grading Zone – III	Grading Zone - IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	May-20	Aug-30	Dec-40	15-50
150 micron	0-10	0-10	0-10	0-15

Note 1- For crushed stone sands, the permissible limit on 150-micron IS Sieve is increased to 20 percent. This does not affect the 5 percent allowance permitted applying to other sieve sizes.

Note 2 - Fine aggregate complying with the requirements of any grading zone in this table is suitable for concrete but the quality of concrete produced will depend upon a number of factors including proportions.

Note 3 - Where concrete of high strength and good durability is required, fine aggregate conforming to any one of the four grading zones may be used, but the concrete mix should be properly designed. As the fine aggregate grading becomes progressively finer, that is, from Grading Zones I to IV, the ratio of fine aggregate to coarse aggregate should be progressively reduced. The most suitable fine to

coarse ratio to be used for any particular mix will, however, depend upon the actual grading, particle shape and surface texture of both fine and coarse aggregates.

Note 4- It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

a. Natural Sand - Fine aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies.
b. Crushed Stone Sand - Fine aggregate produced by crushing hard stone.
c. Crushed Gravel Sand - line aggregate produced by crushing natural gravel.

APPENDIX — A

TEST FOR ORGANIC IMPURITIES

The aggregate must also be checked for organic impurities such as decayed vegetation humus, coal dust etc.

What is called the colour test is reliable indicator of the presence of harmful organic matter in aggregate, except in the area where there are deposits of lignite.

Fill a 350 ml clear glass medicine bottle up to 70 ml mark with a 3% solution of caustic soda or sodium hydroxide. The sand is next added gradually until the volume measured by the sandy layer is 125 ml. The volume is then made up to 200 ml by addition of more of solution. The bottle is then stoppered and shaken vigorously and allowed to stand for 24 hours. At the end of this period, the colour of the liquid will indicate whether the sand contains a dangerous amount of matter. A colourless liquid indicates clean sand free from organic matter. A straw colored solution indicates some organic matter but not enough to be seriously objectionable. Darker colour means that the sand contains injurious amounts and should not be used unless it is washed, and a reset shows that it is satisfactory.

Add a 2.5 ml of two percent solution of tannic acid in 10 percent alcohol, to 9.75 ml of three percent sodium hydroxide solution. Place in a 350 ml bottle, fix the stopper, shake vigorously and allow to stand for 24 hours before comparison with solution above the sand.

NOTE: A three percent solution of caustic soda is made by dissolving 3g of sodium hydroxide in100 ml of water, preferably distilled. The solution should be kept in a glass of bottle tightly closed with a rubber stopper. Handling sodium hydroxide with moist hands may result in serious burns. Care should be taken not to spill the solution for it is highly injurious to clothing, leather, and other materials.

APPENDIX — B

TEST FOR PARTICLE SIZE (SIEVE ANALYSIS)

Apparatus:

Perforated plate sieves of designation 10 mm, 4.75 mm and fine mesh sieve of designation 2.36 mm, 1.18 mm, 600 micron and 150 micron should be used. The balance or scale shall be such that it is readable and accurate to 0.1 percent to the weight of the test sample.

SAMPLE:

The Weight of sample available should not be less than the weight given in the table below. The sample of sieving shall be prepared from the larger sample either by quartering or means of a sample divider.

TABLE-3 SHOWING MINIMUM WEIGHTS FOR SAMPLING

Maximum size present in substantial proportions (mm)	Minimum weight of sample for sieving (kg)
10	0.5
4.75	0.2
2.36	0.1

TEST PROCEDURE:

The sample shall be brought to an air- dry condition before weighing and sieving. This may be achieved either by drying at room temperature or by heating at a temperature of 100 degree to 110 degree centigrade. The air dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use.

Each sieve shall be shaken separately over a clean tray until more than trace passes, but in any case for a period of not less than two minutes. The shaking shall be done with a varied motion, backwards and forwards, left to right, circular clockwise and anti- clockwise, and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions. Materials shall not be forced through the sieve by hand pressure, but on sieves coarser than 20 mm, placing of particles is permitted, lumps of the fine material, if present may be broken by gentle pressure with fingers against the side if the sieve. Light brushing of underside of the sieve with a soft brush may be used to clear the sieve openings.

Light brushing with the fine camel hair brush may be used on the 150 micron is sieve to prevent segregation of powder and blinding of apertures, stiff or worn out brushes shall not be used for this purpose and pressure shall not be applied to the surface of the sieve to force particles through the mesh.

On completion of sieve the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.

REPORTING OF RESULTS:

The results shall be calculated and reported as:

i. The cumulative percentage by weight of the total sample passing each of the sieves, to the nearest whole number.

(Or)

ii. The percentage by weight of the total sample passing one sieve and retained on the next smaller sieve, to the nearest 0.1 percent.

APPENDIX-C

TEST FOR SILT CONTENT

The sand shall not contain more than 8% of silt as determined by field test with measuring cylinder. The method of determining silt contents by field test is given below.

A sample of sand to be tested shall be placed without drying in a 200 ml measuring cylinder. The volume of the sample shall be such that it fills the cylinder upto 100 ml mark.

Clean water shall be added upto 150 ml mark. Dissolve a little salt in the water in the proportion one tea spoon to half a litre. The mixture shall be shaken be vigorously, the last few shakes being sidewise direction to level off the sand and the contents allowed to settle for three hours.

The height of the silt visible as settled layer above the sand shall be expressed as a percentage of the height of sand below. The sand containing more than the above allowable percentage of silt, shall be washed so as to bring the silt contents within allowable limits.

APPENDIX 'D'

BULKING OF FINE AGGREGATES/SAND (FIELD METHODS)

Two methods are suggested for determining the bulking of sand/fine aggregate. The procedure may be suitably varied, if necessary. Both depend on the fact that the volume of inundated sand/fine aggregate is the same if the sand/fine aggregate were dry.

Method -1:
Put sufficient quantity of sand loosely into a container until it is about two-third full. Level off the top of the sand and push a steel rule vertically down through the sand at the middle to bottom, measure the height. Suppose this is 'X' cm.

Empty the sand out of the container into another container where none of it is lost. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6 mm in diameter, so that its volume is reduced to a minimum. Then add the remainder and level the top surface of the inundated sand. Measure its depth at the middle with the steel rule. Suppose this is 'Y' cm.

The percentage of bulking of the sand due to moisture shall be calculated from the formula.
Percentage bulking = (X/Y -1) X 100

Method-2:
In a 250 ml measuring cylinder, pour the damp sand, consolidate it by staking until it reached the 200 ml mark.

Then fill the cylinder with the water and stir the sand well (the water shall be sufficient to submerge the sand completely). It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of Y ml, the percentage of bulking of sand due to moisture shall be calculated from the formula.

Percentage bulking= (200/Y – 1) x 100

8.10.0 Concrete Work

A. List of applicable code

S.No	IS Code. No	Subject
1	IS:383	Specification for coarse and fine aggregate from natural sources for concrete
2	IS:456	Plain and reinforced concrete - Code of practice
3	IS:516	Method of test for strength of concrete
4	IS:1199	Method of sampling and analysis of concrete
5	IS:1200 (Part II)	Method of measurement of building and civil engineering work (concrete work)
6	IS:1322	Specification for bitumen felt for water proofing and damp proofing
7	IS:1791	General requirements for batch type concrete mixers
8	IS:2386	Method of test for aggregates for concrete
		(a) Part I - Particle size and shape
		(b) Part II - Estimation of deleterious materials and organic impurities

S.No	IS Code. No	Subject
		(c) Part III - Specific gravity, density, voids absorption and bulking
		(d) Part IV - Mechanical properties
		(e) Part V – Soundness
9	IS:2505	General requirements for concrete vibrators -
10	IS:2506	General requirements for concrete vibrators - screed board concrete vibrators
11	ISL2645	Specification for integral water proofing compounds for cement mortar and concrete
12	IS:3068	Specification for broken brick (burnt clay) coarse aggregate for use in concrete
13	IS:3812	Specification for fly ash for use as pozzolano and admixture in cement mortar and concrete
14	IS:4656	Specification for form vibrators for concrete.
16	IS:7861 (Part– II)	Code of practice for extreme weather concreting
17	IS:9103	Specification for concrete admixtures

B. **Mandatory tests**

NOTES:

a. The mandatory tests shall be carried out when the quantity of materials to incorporate in the work exceeds the minimum quantity specified.
b. Optional tests specified or any other tests, shall be carried out in case of specialised works or important structures as per direction of the Engineer-in-charge/ Owner/Consultant.
c. Testing charges, including incidental charges and cost of sample for testing shall be borne by the Bidder for all mandatory tests.
d. Testing charges for optional tests shall be reimbursed by the Department. However, the incidental charges and cost of sample for testing shall be borne by the Bidder.
e. In case of non-IS materials, it shall be the responsibility of the Bidder to establish the conformity of material with relevant IS specification by carrying out necessary tests. Testing charges including incidental charge and cost of sample for testing shall be borne by the Bidder for such tests.

The mandatory tests shall be as follows:

Material	Test	Field / Laboratory test	Test procedure	Minimum quantity of material/ work for carrying out	Frequency of testing
Stone aggregate	Percentage of soft or deleterious material	Field or Laboratory-Test as required	IS:2386-Part II	As required by Engineer-in-charge	For all quantities
	Particle size	Field / Lab	Appendix 'A' of this clause	45 cum	For every 45cum or part thereof for RCC Work only. For rest of items as decided by Engineer-in-charge

Material	Test	Field / Laboratory test	Test procedure	Minimum quantity of material/ work for carrying out	Frequency of testing
	Estimation of organic impurities	Field / Lab	IS:2386-Part II	10 cum	For every 40 cum or part thereof
	Surface Moisture	Field / Lab	IS:2386	10 cum	For every 40 cum or part thereof
	Determination of 10% fine value	Field / Lab	IS:2386	10 cum	For every 40 cum or part thereof
	Specific gravity	Field / Lab	IS:2386	10 cum	For every 40 cum or part thereof
	Bulk density	Field / Lab	IS:2386	10 cum	For every 40 cum or part thereof
	Aggregate crushing strength	Field / Lab	IS:2386	10 cum	For every 40 cum or part thereof
	Aggregate impact value	Field / Lab	IS:2386	10 cum	For every 40 cum or part thereof
Concrete	Slump test	Field	Appendix 'D' of this clause 14.0	10 cum	15 cum or part thereof

C. **Material**

Water, cement, fine aggregate or sand has been specified in Mortar.

A.1 Coarse Aggregates

Aggregate most of which is retained on 4.75 mm IS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

NOTE:
Coarse aggregate may be described as:
a. uncrushed gravel or stone which results from natural disintegration of rock,
b. crushed gravel or stone when it results from crushing of gravel or hard stone, and
c. Partially crushed gravel or stone when it is a product of the blending of (a) and (b).

Coarse aggregate shall be specified as stone aggregate, gravel or brick aggregate and it shall be obtained from approved/ authorized sources.

i. **Stone Aggregate:**

It shall consist of naturally occurring (uncrushed, crushed or broken) stones. It shall be hard, strong, dense, durable and clean. It shall be free from veins, adherent coating and injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. It shall be roughly cubical in shape. Flaky and elongated pieces shall be avoided. It shall conform to IS: 383 unless otherwise specified.

ii. **Gravel:**

It shall consist of naturally occurring (uncrushed, crushed or broken) river bed shingle or pit gravel. It shall be sound, hard and clean. It shall be free from flat particles of shale or similar laminated material, powdered clay, silt, loam, adherent coating, alkali, vegetable matter and other deleterious substances. Pit gravel shall be washed if it contains soil materials adhering to it. These shall conform to IS: 383 unless otherwise specified.

iii. **Brick Aggregate:**

Brick aggregate shall be obtained by breaking well burnt or over burnt dense brick/brick bats. They shall be homogeneous in texture, roughly cubical in shape and clean. They shall be free from unburnt clay particles. Soluble salt, silt, adherent coating of soil, vegetable matter and other deleterious substances. Such aggregate should not contain more than one percent of sulphates and should not absorb more than 10% of their own mass of water, when used in cement concrete. It shall conform to IS:306 unless otherwise specified.

iv. Light weight aggregate such as sintered fly ash aggregate may also be used provided the Engineer-in-Charge is satisfied with the data on the proportion of concrete made with them.

B.1 Deleterious Materials

Aggregates shall not contain any harmful material, such as pyrites, coal, lignite, mica, shale or similar laminated material, clay, alkali, soft fragments, sea shells and organic impurities in such quantity as to affect the strength or durability of the concrete. Aggregates to be used for reinforced concrete shall not contain any material liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkalies of cement are harmful as cracking of concrete may take place.

Note - Aggregates petrographically similar to known reactive types or aggregates which, on the basis of service history or laboratory experiments, are suspected to have reactive tendency should be avoided or used only with cements of low alkalies [not more than 0.6 percent as sodium oxide (Na_2O)] after detailed laboratory studies. Use of pozzolanic cement and certain pozzolanic admixtures may be helpful in controlling alkali aggregate reaction.

C.1 Limits of Deleterious Materials

The maximum quantity of deleterious materials shall not exceed the limits specified in Table 4 when tested in accordance with IS: 2386-1963. However, the Engineer-in-charge at his discretion may relax some of the limits as a result of some further tests and evidence of satisfactory performance of the aggregates.

Table 4 Limits of Deleterious Materials

Sl. No.	Deleterious Substance	Method of Test	Fine Aggregate % by Weight Uncrushed	Fine Aggregate % by Weight Crushed	Coarse Aggregate % by Weight Uncrushed	Coarse Aggregate % by Weight Crushed
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Coal and lignite	IS:2386 (Part II)	1.00	1.00	1.00	1.00
	Clay lumps	-do-	1.00	1.00	1.00	1.00
	Materials	IS:2386	3.00	15.00	3.00	3.00

Sl. No.	Deleterious Substance	Method of Test	Fine Aggregate % by Weight Uncrushed	Fine Aggregate % by Weight Crushed	Coarse Aggregate % by Weight Uncrushed	Coarse Aggregate % by Weight Crushed
	fine than 75µ IS sieve	(Part I)				
	Soft fragments	IS:2386 (Part II)	-	-	3.00	-
	Shale	-do-	1.00	-	-	-
	Total of percentage of all deleterious material (except mica) including S. No. i to v for column (4), (6) & (7) and S. No. i & ii for column (5) only	-	5.00	2.00	5.00	5.00

Note 1 - The presence of mica in the fine aggregate has been found to red considerably the durability and compressive strength of concrete and further investigations are underway to determine the extent of the deleterious effect of mica. It is advisable, therefore, to investigate the mica content of fine aggregate and in suitable allowances for the possible reduction in the strength of concrete or mortar.

Note 2- The aggregate shall not contain harmful organic impurities (tested in accordance with IS: 2386(Part II) - I963] in sufficient quantities to affect adverse the strength or durability of concrete. A fine aggregate which fails in the test of organic impurities may be used, provided that, when tested for the effect of organic impurities on the strength of mortar, the relative strength at 7 and 28 days, reported in accordance with 7 of IS : 2386 (Part VI)-1963 is not less than 95 percent.

D.1 Size and Grading

Stone aggregate and gravel: It shall be either graded or single sized as specified. Nominal size and grading shall be as under:-

i. Nominal sizes of graded stone aggregate or gravel shall be 40, 20, 16, or 12.5 mm as specified. For any one of the nominal sizes, the proportion of other sizes as determined by the method prescribed in Appendix 'A' of this clause shall be in accordance with Table 6.

ii. Nominal sizes of single sized stone aggregate or gravel shall be 63, 40, 20, 16, 12.5 or 10 mm as specified. For any one of the nominal size, the proportion of other sizes as determined by the method prescribed in Appendix 'A' of this clause shall be in accordance with Table 5.

Table 5 Single Sized (Ungraded) Stone Aggregate or Gravel

IS sieve designation	Percentage passing for single sized aggregate of nominal size					
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)
80 mm	100	-	-	-	-	-
63 mm	85 to	100	-	-	-	-
100						
40 mm	0 to 30	85 to	100	-	-	-
20 mm	0 to 5	0 to 20	85 to	100	-	-
16 mm	-	-	-	85 to	100	-
12.5 mm	-	-	-	-	85 to	100
10 mm	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to
4.75 mm	-	-	0 to 5	0 to 5	0 to 10	0 to 20
2.36 m	-	-	-	-	-	0 to 5

Table 6 Graded Stone Aggregate or Gravel

IS Sieve Designation	Percentage Passing For Graded Aggregate Of Nominal Size			
	40 mm	20 mm	16 mm	12.5 mm
(1)	(2)	(3)	(4)	(5)
80 mm	100	-	-	-
63 mm	-	-	-	-
40 mm	95 to		-	-
100	100			
20 mm	30 to 70	95 to 100	100	100
16 mm	-	-	90 to 100	-
12.5 mm	-	-	-	90 to 100
10 mm	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	0 to 5	0 to 10	0 to 10	0 to 10
2.36 m -		-	-	-

E.1 Testing:

Coarse aggregate shall be sampled from current production in accordance with IS: 2386 (part 1 to 8). Three [20 mm, 10 mm and 5 mm] nominal maximum size (NMS) aggregates shall be sampled and tested as follows:-

i. IS: 2386(part 1) : Methods of test for aggregates for cement- Particle size and shape
ii. IS:2386(part 2) : Methods of test for aggregates for concrete- Estimation of deleterious materials and organic impurities (Amendment 1)
iii. IS:2386(part 3) : Methods of test for aggregates for concrete- Specific gravity, density, voids, absorption and bulking

iv. IS:2386(part 4) : Methods of test for aggregates for concrete- Mechanical properties
v. IS:2386(part 5) : Methods of test for aggregates for concrete- Soundness
vi. IS:2386(part 6) : Methods of test for aggregates for concrete- Measuring mortar making properties of fine aggregates
vii. IS:2386(part 7) : Methods of test for aggregates for concrete-Alkali aggregate reactivity
viii. IS:2386(part 8) : Methods of test for aggregates for concrete- Petrographic examination

Aggregates when subjected to the tests defined in items above, unless otherwise approved by the purchaser shall meet the requirements of IS: 383 and IS: 456.

Testing is to be carried out at the following intervals:

S. No	Type	Coarse Aggregate	Fine Aggregates
1	Grading	Daily	Daily
2	Specific gravity	7 days	7 days
3	Magnesium sulphate soundness	30 days	-
4	Clay, silt and dust content	Daily	Daily
5	Shape (elongation and flakiness)	3.5 days	-
6	Los Angeles abrasion	Initial stage only	Initial stage only
7	Moisture content	2 days	2 days
8	Drying shrinkage	Initial stage only	Initial stage only
9	Organic impurities	30 days	30 days
10	10% fines value for concrete	7 days	-

Note: Combined grading also on a daily basis.

F.1 Chemical Admixtures

When required, admixtures of approved quality shall be mixed with concrete, as specified. The admixtures shall conform to IS: 9103 and as specified in next clause of "R.C.C".

a. Admixtures may be any one of the following classes for use in concrete:-

i. Water Reducing Admixtures
ii. Retarding Admixtures
iii. Accelerating Admixtures.
iv. Water Reducing and Retarding Admixtures.
v. Water Reducing and Accelerating Admixtures.
vi. Permeability reducing (water proofing) Admixtures.

b. **Liquid Admixtures:** Admixtures introduced into the concrete as liquids generally fall into the following categories.
i. Air Entraining
ii. Water Reducing
iii. Water Reducing Retarders
iv. Retarders
v. Water Reducing Accelerators
vi. Accelerators

c. Dosage of these admixtures may vary according to manufacturer's specification.

d. Two or more admixtures may not be compatible in the same solution. It is therefore mandatory that when two admixtures manufactured by the same manufacturers is being used simultaneously, the manufacturer shall certify their compatibility. In case the two or more admixtures are produces by different manufacturers, then, before their use in concrete, test shall be performed by the manufacturer to establish their compatibility, all such test reports shall be furnished to the Engineer-in-Charge for his approval before their use in concrete.

e. Some admixture may be in the form of powder, particle or high concentration liquids which may require mixing with water prior to dosing. Under these conditions water in solution shall be considered as part of total water content in the batch in order to maintain the water-cement ratio.

f. Admixture manufacturer's recommendation shall be carefully followed so as to ensure complete solution of the product or to prepare a standard solution of uniform strength for easier use.

g. Certain admixtures may contain significant amounts of finely divided insoluble materials or active ingredients which may or may not be readily soluble. It is essential for such admixtures that precautions be taken to ensure that these constituents be kept in a state of uniform suspension before actual batching. When relatively small amounts of powered admixtures are to be used directly, these shall be pre-blended with cement.

h. Admixtures are sold under various trade names and may be in the form of liquids or powders. The proprietary name and the net quantity of content shall be clearly indicated in each package or container of admixtures. The admixtures shall be uniform within each batch and uniform between all batches.

i. No admixtures shall be accepted for use in concrete unless these are tested in accordance with IS: 9103 and the test results are approved by the Engineer-in-Charge.

D. Cement concrete

1) Grades of Cement Concrete

The concrete shall be in grade designated as under:

Table 7 Grades of concrete

Group	Grade Designation	Specified Characteristic Compressive Strength Of 150mm Cube At 28 Days In N/mm2
Ordinary concrete	M10	10
	M15	15
	M20	20
Standard concrete	M25	25
	M30	30
	M35	35

NOTES

1) In the designation of concrete mix M refers to the mix and the number to the specified compressive strength of 150 mm size cube at 28 days, expressed in N/mm^2.

2) The characteristic strength is defined as the strength of material below which not more than 5 percent of the test results are expected to fall.

Table 8 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal; Maximum

Sl. No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum cement content kg/m³	Maximum Free Water Cement Ratio	Minimum Grade of concrete	Minimum cement content kg/m³	Maximum Free water cement ratio	Minimum Grade of concrete
1.	Mild	220	0.60	-	300	0.55	M20
2.	Moderate	240	0.60	M15	300	0.50	M25
3.	Severe	250	0.50	M20	320	0.45	M30
4.	Very severe	260	0.45	M20	340	0.45	M35
5.	Extreme	280	0.40	M25	360	0.40	M40

NOTES

i. Cement content prescribed in this table is irrespective of the grades of cement. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolano and slag specified in IS: 1489 (Part I) and IS: 455 respectively.
ii. Minimum grade for plain concrete under mild exposure condition is not specified.

3) **Workability of Concrete**

i. The concrete mix proportion chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested ranges of workability of concrete measured in accordance with IS:1199 are given below:
ii. In the 'very low' category of workability where strict control is necessary, for example, pavement quality concrete, measurement of workability be determination of compacting factor will be more appropriate than slump (see IS:1199) and a value of compacting factor of 0.75 to 0.80 is suggested.
iii. In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS: 9103).

4) **Concrete Mix Proportioning**

a. The determination of the proportion of cement, aggregate and water to attain the required strength shall be made as follows:
   i. By designing the concrete mix: such concrete shall be called 'Design mix concrete', for details reference may be made to RCC Chapter.
   ii. By adopting nominal concrete mix: such concrete shall be called 'Nominal mix concrete'. Design mix concrete is preferred to nominal mix. If design mix concrete cannot be used for any reason on the work for grades of M20

or lower, nominal mixes may be used with the permission of Engineer-in-Charge, which, however, is likely to involve higher cement content.

b. **Nominal Mix Concrete:** Nominal Mix Concrete may be used for concrete of M20 or lower. The proportions of materials for nominal mix concrete shall be in accordance with Table 9. The cement content of the mix specified in Table 9 for any nominal mix shall be proportionately increased if the quantity of water in the mix has to be increased to overcome the difficulty or placement and compaction, so that the water cement ratio as specified is not exceeded.

Table 9 Proportions for Nominal Mix-Concrete

Grade of Concrete	Total Quantity Of Dry Aggregate By Mass Per 50 Kg Of Cement, To Be Taken As The Sum Of The Individual Masses Of Fine And Coarse Aggregate, Kg	Proportion Of Fine Aggregate To Coarse Aggregate (By Mass)	Quantity Of Water Per 50 Kg Of Cement, Max (Litre)
M5	800	Generally 1:2 but subjected to an upper limit of 1: 1 1/2 and a lower limit of 1: 21/2	60
M7.5	625	Generally 1:2 but subjected to an upper limit of 1: 1 1/2 and a lower limit of 1: 21/2	45
M10	480	Generally 1:2 but subjected to an upper limit of 1: 1 1/2 and a lower limit of 1: 21/2	34
M15	330	Generally 1:2 but subjected to an upper limit of 1: 1 1/2 and a lower limit of 1: 21/2	32
M20	250	Generally 1:2 but subjected to an upper limit of 1: 1 1/2 and a lower limit of 1: 21/2	30

Note-The proportion of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of fine aggregates becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregate shall be used.

Example

For an average grading of fine aggregate (that is. Zone II of Table 4 of IS:383), the proportions shall be 1:1 ½, 1:2 and 1: 2 ½ for maximum size of aggregates 10 mm, 20 mm and 40 mm respectively.

5) **Batching**

To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixed on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass; admixture, if solid, by mass: liquid admixture may however be measured in volume or mass: water shall be weighed or measured by volume in a calibrated tank (see also IS: 4925).

Ready-mixed concrete supplied by ready-mixed concrete plant shall be preferred. For large and medium project sites, the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants (see IS: 4926).

a. Except where it can be shown to the satisfaction of the Engineer-in-Charge that supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock-piles. The material should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job being determined by the Engineer- in-Charge to ensure that the specified grading is maintained.

b. The accuracy of the measuring equipment shall be within + 2 percent of the quantity of cement being measured and within + 3 percent of the quantity of aggregate, admixtures and water being measured.

c. Proportion/Type and grading of aggregates shall be made by trial in such a way so as to obtain densest possible concrete. All ingredients of the concrete should be used by mass only.

d. Volume batching may be allowed only where weigh-batching is not practicable and provided accurate used in concrete have earlier been established. Allowance for bilking shall be made in accordance with IS: 2386 (Part 3). The mass volume relationship should be checked as frequently as necessary, the frequency for the given job being determined by Engineer-in-Charge to ensure that the specified grading is maintained.

e. It is important to maintain the water cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge according to weather conditions. The amount of the added water shall be adjusted to compensate for any observed variations in the moisture contents. For the determination of moisture content in the aggregates, IS: 2386 (Part 3) may be referred to. To allow for the variation in mass for aggregate due to variations in their moisture content, suitable adjustments in the masses of aggregates shall be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table 10.

Table 10 Surface Water Carried by Aggregate

S. No	Aggregate	Approximate Quantity Of Surface Water	
		Percent By Mass	l/m3
1	Very wet sand	7.5	120
2	Moderately wet sand	5	80
3	Moist sand	2.5	40
4	Moist gravel or crushed	1.25-2.5	20-40

Note: Coarser the aggregate, lesser the water it will carry.

f. No substitutions in materials used on the work or alteration in the established proportions, except as permitted in 14.3.7.5.4 and 14.3.7.5.5 shall be made without additional tests to show that the quality and strength of concrete are satisfactory.

6) **Mixing**

Concrete shall be mixed in mechanical batch type concrete mixers conforming to IS: 1791 having two blades and fitted with power loader (lifting hopper type). Half bag mixers and mixers without lifting hoppers shall not be used for mixing concrete. In exceptional circumstances, such as mechanical breakdown of mixer, work in remote areas or power breakdown and when the quantity of concrete work is very small, hand mixing may be done with the specific prior permission of the Engineer-in- Charge in writing subject to adding 10% extra cement. When hand mixing is permitted, it shall be carried out on a water tight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency. Before mixing the brick aggregate shall be well soaked with water for a minimum period of two hours and stone aggregate or gravel shall be washed with water to remove, dirt, dust and other foreign materials. For guidance, the mixing time may be 1½ to 2 minutes, for hydrophobic cement it may be taken as 2 ½ to 3 minutes.

a. **Power Loader:** Mixer will be fitted with a power loader complying with the following requirements.

i. The hopper shall be of adequate capacity to receive and discharge the maximum nominal batch of unmixed materials without spillage under normal operating conditions on a level site.

Note: In such a case the volume of the maximum nominal batch of mixed material is 50% greater than the nominal mixed batch capacity.

ii. The minimum inside width of the feeding edge of the hopper shall be as specified below in Table

Nominal size of mixer (T, NT or R) litre	Minimum inside width of hopper feeding edge
140	1.0
200	1.1
280	1.2
375	1.4
500	1.5
1000	2.0

Note: T- Tilting NT – Non-tilting R-Reverse

iii. The design of the loader shall be such that it allows the loading hopper to be elevated to such a height that the centre line of the chute plate of the hopper when in discharge position, is at an angle of not less than 50º to the horizontal. A mechanical device to aid discharge of the contents as quickly as possible from the hopper to the drum may also be provided. Even when a mechanical device is provided, it is recommended that the angle of centre line of the chute plate of the hopper when in discharge position, should be as large as practicable, preferably not less than 40º to horizontal.

iv. When the means of raising and lowering the loading hopper includes flexible wire ropes winding on to a drum or drums, the method of fastening the wire to rope to the drums shall be such as to avoid, as far as possible any tendency to cut the strands of the ropes and the fastening should preferably be positioned clear of the barrel of the drum for example, outside the drums flange. When the loading hopper is lowered to its normal loading position, these should be at least one and a half drums of rope on the drum.

v. Clutch brake and hydraulic control lever shall be designed so as to prevent displacement by liberation or by accidental contact with any person.

vi. The clutch and brake control arrangements shall also be so designed that the operator can control the falling speed of the loader.

vii. Safety device shall be provided to secure the hopper in raised position when not in use.

b. **Mixing Efficiency:** The mixer shall be tested under normal working conditions in accordance with the method specified in IS: 4643 with a view to check its ability to mix the ingredients to obtain concrete having uniformity within the prescribed limits. The uniformity of mixed concrete shall be evaluated by finding the percentage variation in quantity (mass in water) of cement, fine aggregate and coarse aggregate in a freshly mixed batch of concrete.

The percentage variation between the quantities of cement, fine aggregate and coarse aggregates (as found by weighing in water) in the two halves of a batch and average of the two halve of the batch shall not be more than the following limits:

i. Cement 8%
ii. Fine aggregate 6%
iii. Coarse aggregate 5%

c. **Machine Mixing:** The mixer drum shall be flushed clean with water. Measured quantity of coarse aggregate shall be placed first in the hopper. This shall be followed with measured quantity of fine aggregate and then cement. In case fine aggregate is damp, half the required quantity of coarse aggregate shall be placed in the hopper, followed by fine aggregate and cement. Finally the balance quantity of coarse aggregate shall be fed in the hopper, & then the dry materials are slipped into the drum by raising the hopper. The dry material shall be mixed for atleast four turns of the drum. While the drum is rotating, water shall be added gradually to achieve the water cement ratio as specified or as required by the Engineer-in-Charge. After adding water, the mixing shall be continued until concrete of uniform colour, uniformly distributed material and consistency is obtained. Mixing shall be done for atleast two minutes after adding water. If there is segregation after unloading from the mixer, the concrete should be remixed. The drum shall be emptied before recharging. When the mixer is closed down for the day or at any time exceeding 20 minutes, the drum shall be flushed cleaned with water.

d. **Hand Mixing:** When hand mixing has been specifically permitted in exceptional circumstances by the Engineer-in-Charge in writing, subject to adding 10% extra cement, it shall be carried out on a smooth, clean and water tight platform of suitable size. Measured quantity of sand shall be spread evenly on the platform and the cement shall be dumped on the sand and distributed evenly. Sand and cement shall be mixed intimately with spade until mixture is of even colour throughout. Measured quantity of coarse aggregate shall be spread on top of cement sand mixture and mixing done by shovelling and turning till the coarse aggregate gets evenly distributed the cement sand mixture. Three quarters of the total quantity of water required shall be added in a hollow made in the middle of the mixed pile and the material is turned towards the middle of pile with spade. The whole mixture is turned slowly over and again and the remaining quantity of water is added gradually. The mixing shall be continued until concrete of uniform colour and consistency is obtained. The mixing platform shall be washed and cleaned at the end of the day.

7) **Transportation and Handling:** Concrete shall be transported from the mixer to the place of laying as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients and maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers, other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

8) **Placing**

The concrete shall be deposited as nearly as practicable in its final position to avoid rehandling. The concrete shall be placed and compacted before initial setting of concrete commences and should not be subsequently disturbed. Methods of placing should be such as to preclude segregation. Care should be taken to avoid displacement of reinforcement or movement of formwork. As a general guidance, the maximum permissible free fall of concrete may be taken as 1.5 m.

9) **Compaction**

Concrete shall be thoroughly compacted and fully worked around embedded fixtures and into corners of the form work.

Concrete shall be compacted using mechanical vibrators complying with IS: 2505, IS: 2506, IS: 2514 and IS: 4656. Over vibration and under vibration of concrete are harmful and should be avoided. Vibration of very wet mixes should also be avoided.

Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators should receive special consideration to ensure efficient compaction and to avoid surface blemishes.

10) **Concreting under special conditions**

i. Work in Extreme Weather Conditions

During hot or cold weather, the concreting should be done as per the procedure set out in IS:7861 (Part 1) or IS: 7861 (Part 2).

ii. Under-Water Concreting

a. When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to and approved by the engineer-in-charge before the work is started.
b. Under-water concrete should have a slump recommended in 7.1 of IS: 456, the water- cement ratio shall not exceed 0.6 and may need to be smaller, depending on the grade of concrete or the type of chemical attack. For aggregates of 40 mm maximum particle size, the cement content shall be at least 350 kg/m^3 of concrete.

iii. Concrete in Sea-water

Concrete in sea-water or exposed directly along the sea-coast shall be at least M 20 Grade in the case of plain concrete and M 30 in case of reinforced concrete. The use of slag or pozzolano cement is advantageous under such conditions.

a. Special attention shall be given to the design of the mix to obtain the densest possible concrete; slag, broken brick, soft limestone, soft sandstone, or other porous or weak aggregates shall not be used.
b. As far as possible, preference shall be given to precast members unreinforced, well- cured and hardened, without sharp comers, and having trowel- smooth finished surfaces free from crazing, cracks or other defects; plastering should be avoided.
c. No construction joints shall be allowed within 600 mm below low water-level or within 600 mm of the upper and lower planes of wave action. Where unusually severe conditions or abrasion are anticipated, such parts of the work shall be protected by bituminous or silica-fluoride coatings or stone facing bedded with bitumen.
d. In reinforced concrete structures, care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage, fabrication and use. It may be achieved by treating the surface of reinforcement with cement wash or by suitable methods.

11) Curing

Curing is the process of preventing the loss of moisture from the concrete whilst maintaining a satisfactory temperature regime. The prevention of moisture loss from the concrete is particularly important if the water-cement ratio is low, if the cement has a high rate of strength development, if the concrete contains granulated blast furnace slag or pulverised fuel ash. The curing regime should also prevent the development of high temperature gradients within the concrete. The rate of strength development at early ages of concrete made with supersulphated cement is significantly reduced at lower temperatures. Supersulphated cement concrete is seriously affected by inadequate curing and the surface has to be kept moist for at least seven days.

a. **Moist Curing:** Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by making pond or by covering with a layer of sacking, canvas, Hessian or similar materials and kept constantly wet for at least 7 days from the date of placing concrete in case of ordinary Portland cement and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather conditions. In the case of concrete where mineral admixtures or blended cements are used, it is recommended that above minimum periods may be extended to 14 days.

b. **Membrane Curing:** Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. Impermeable membrane such as polythene sheet covering the concrete surface may also be used to provide effective barrier against the evaporation

c. For the concrete containing Portland pozzolano cement, Portland slag cement or mineral admixture, period of curing may be increased.

d. Freshly laid concrete shall be protected from rain by suitable covering.

e. Over the foundation concrete, the masonry work may be started after 48 hours of its compaction but the curing of exposed surfaces of cement concrete shall be continued along with the masonry work for atleast 7 days. And where cement concrete is used as base concrete for flooring, the flooring may be commenced before the curing period of base concrete is over but the curing of base concrete shall be continued along with top layer of flooring for a minimum period of 7 days.

12) **Testing of Concrete**

Testing of concrete shall be done as described in chapter of R.C.C.

13) **Form Work**

Form work shall be as specified in "R.C.C." clause and shall be paid for separately unless otherwise specified.

14) **Finishes**

Plastering and special finishes other than those, obtained through form work shall be specified and paid for separately unless otherwise specified.

15) **Durability of Concrete**

A durable concrete is one that performs satisfactorily in the working environment during its anticipated exposure conditions during service. The materials and mix proportions shall be such as to maintain its integrity and, if applicable, to protect reinforcement from corrosion.

The factors influencing durability include:

i. The environment;
ii. The cover to embedded steel;
iii. The type and quality of constituent materials;
iv. The cement content and water/ cement ratio of the concrete;
v. Workmanship, to obtain full compaction and efficient curing; and vi. The shape and size of the member.

Requirements for Durability

a. General Environment:

The general environment to which the concrete will be exposed during its working life is classified into five levels of severity, that is, mild, moderate, severe, very severe and extreme as described in Table 11.

Table 11 Environmental Exposure Conditions

S.No	Environment	Exposure Condition
1	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal areas
2	Moderate	Concrete surfaces 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 areas.

S.No	Environment	Exposure Condition
3	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in sea water. Concrete exposed to coastal environment.
4	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing condition whilst wet. Concrete in contact with or buried under aggressive sub-soil / ground water
5	Extreme	Surface of members in tidal zone Member in direct contact with liquid/solid aggressive chemicals

b. Freezing and thawing

Where freezing and thawing actions under wet conditions exist, enhanced durability can be obtained by the use of suitable air entraining admixtures. When concrete lower than grade M 50 is used under these conditions, the mean total air content by volume of the fresh concrete at the time of delivery into the construction should be:

Nominal Maximum Size Aggregate (mm)	Entrained Air Percentage
20	5±1
40	5±1

Since air entrainment reduces the strength, suitable adjustments may be made in the mix design for achieving required strength.

c. Exposure to sulphate attack

Table 4 of IS:456 gives 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 of 6 to 9.

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.

d. Chlorides in concrete

Whenever there is chloride in concrete there is an increased risk of corrosion of embedded metal. The higher the chloride content, or if subsequently exposed to warm moist conditions, the greater the risk of corrosion. All constituents may contain chlorides and concrete may be contaminated by chlorides from the external environment. To minimize the chances of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete coming from concrete materials, that is, cement, aggregates water and admixtures, as well as by diffusion from the environment should be limited. The total amount of chloride content in the concrete at the time of placing shall be as given in Table 12.

The total acid soluble chloride content should be calculated from the mix proportions and the measured chloride contents of each of the constituents. Wherever possible, the total chloride content of the concrete should be determined.

Table 12 Limits of chloride content of concrete

S. No.	Type Or Use Of Concrete	Maximum Total Acid Soluble Chloride Content Expressed As Kg/m3 Of Concrete
1	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete	0.4
2	Reinforced concrete or plain concrete containing embedded metal	0.6
3	Concrete not containing embedded metal or any material requiring protection from chloride	3

e. Sulphates in concrete

Sulphates are present in most cements and in some aggregates; excessive amounts of water-soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO_3, should not exceed 4 percent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix.

The 4 percent limit does not apply to concrete made with Super sulphated cement complying with IS: 6909.

8.11.0 Damp Proof Course

A. Cement Concrete Layer

This shall consist of cement concrete of specified proportions and thickness. The surface of brick or stone masonry work shall be levelled and prepared before laying the cement concrete. Edge of damp proof course shall be straight, even and vertical. Side shuttering shall consist of steel forms and shall be strong and properly fixed so that it does not get disturbed during compaction and the mortar does not leak through. The concrete mix shall be of workable consistency and shall be tamped thoroughly to make a dense mass. When the sides are removed, the surface should come out smooth without honeycombing.

Continuity shall be maintained while laying the cement concrete layer and laying shall be terminated only at the predetermined location where damp proof course is to be discontinued. There shall be no construction joints in the Damp Proof Course.

B. Curing

Damp proof course shall be cured for at least seven days, after which it shall be allowed to dry.

C. Application of Hot Bitumen

Where so directed, hot bitumen in specified quantity shall be applied over the dried up surface of cement concrete properly cleaned with brushes and finally with a piece of cloth soaked in kerosene oil.

Bitumen of penetration A 90 or equivalent where used shall be heated to a temperature of 160º ± 5ºC.

The hot bitumen shall be applied uniformly all over, so that no blank spaces are left anywhere.

D. Water Proofing Materials

Where so specified, water proofing material of approved quality shall be added to the concrete mixture in accordance with the manufacturer's specification stating the quantity of water proofing material in litres or kg per 50 kg or cement and will be paid for separately.

APPENDIX A

DETERMINATION OF PARTICLE SIZE

The apparatus, sample size and test procedure shall be same as specified in sub-head 'MORTARS'. In order that the sieves shall not be overloaded, care must be taken to ensure that the maximum sieve loads shown in Table 13 (below) are not exceeded at the completion of sieving.

TABLE 13

Maximum Weight For		
I.S. Sieve Designation	**45 Cm Dia Sieve**	**30 Cm Dia Sieve**
	Kg	**Kg**
45 mm	10	4.5
40 mm	8	3.5
31.5 mm or 22.1 mm	6	2.5
20 mm	4	2
16 mm or 12.5 mm	3	1.5
10 mm	2	1
5.6 mm	1.5	0.75
4.75 mm	1	0.5
3.35 mm	-	0.3

The sample weight taken will thus normally require several operations on each sieve. Each sieve should be taken separately over a clean tray or receiver until no more than a trace passes, but in any case for not less than two minutes. Materials should not be forced through the apertures but hand placing is permitted. A light brush should be used with fine sieves. The cumulative weight passing each sieve should be calculated as percentage of the total sample weight to the nearest whole number.

APPENDIX B

TEST FOR SURFACE MOISTURE

Take a sample of wet aggregate and weigh it (A). Then place it in a frying pan and gently apply heat, meanwhile stirring with a glass rod until the surface moisture disappears. This is apparent when the aggregate losses its shining wet appearance and becomes dull, or when it just attains a free funning condition. The saturated surface dry material is then weighed (B). Continue the heating thereafter until the moisture is evaporated and weigh the dry sample (C). The surface moisture is then calculated as follows:

Surface moisture = 100 x A-B/C
It is expressed as a percentage of dry aggregate.

APPENDIX — C

DETERMINATION OF TEN PERCENT FINE VALUE

Apparatus - The apparatus for the standard test shall consist of the following:

a. A 15-cm diameter open-ended steel cylinder, with plunger and base-plate, of the general form and dimensions shall be used. The surfaces in contact with the aggregate shall be machined and case-hardened or otherwise treated so as to have a diamond (VI-I) pyramid hardness number of not less than 650 VH.
b. A straight metal tamping rod of circular cross-section 16 mm in diameter and 45 to 60 cm long, rounded at one end.
c. A balance of capacity 3 kg, readable and accurate to one gram.
d. IS Sieves of sizes 12.5,10 and 2.36 mm.
e. A compression testing machine capable of applying a load of 50 tonnes and which can be operated to give a uniform rate of loading so that the maximum load is reached in 10 minutes. This load may vary from 0.5 to 50 tones
f. For measuring the sample, cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions:

Diameter	11.5 cm
Height	8.0 cm

g. Means of measuring the reduction in the distance between the plates of the testing machine to the nearest one millimetre during the test (for example, dial gauge).

TEST SAMPLE: Material for the test shall consists of aggregate passing a 12.5-mm IS Sieve and retained on a 10 mm I.S Sieve. The aggregate shall be tested in a surface-dry condition. If dries by heating, the period of drying shall not exceed four hours, the temperature shall be 100 to 110℃ and the aggregate shall be cooled to room temperature before testing.

The quantity of aggregate shall be such that the depth of material in the cylinder, after tamping as described in this specification, shall be 10 cm.

The weight of material comprising the test sample shall be determined (Weight A) and the same weight of sample shall be taken for the repeat test.

NOTE: About 6.5 kg of natural aggregate id required to provide the two test samples. Less of light weight aggregate is required.

The measuring cylinder is filled in three layers of approximately equal depth with aggregate passing a 12.5 mm. I.S sieve and retained on 10 mm. I.S. Sieve .each layer is subjected to 25 strokes from the tamping rod (16 mm dia and 45 to 60 cm long) rounded to one end, care being taken in case of weak materials not to break the particles. The surface of the aggregates shall be carefully leveled and the plunger inserted so that is rests horizontally on this surface.

TEST PROCEDURE: The apparatus, with the test sample and plunger in position, shall then be placed in the compression testing machine. The load shall be applied at a uniform rate so as to cause a total penetration of a plunger in 10 minutes of about: 15.0mm for rounded or partially rounded aggregates (for example uncrushed gravel) 20 mm for nominal crushed aggregates & 24 mm for honey combed aggregate (for example expanded shale's and slag's) these figures may be varied according to the extent of the rounding or honey combing.

After reaching the required maximum penetration, the load shall be released and the whole' of the material removed from the cylinder and sieved on a 2.36-mm IS Sieve. The fines passing the sieve shall be weighed, and this weight expressed as a percentage of the weight of the test sample. Normally, this percentage will fall within the range 7.5 to 12.5, but if it does not, a further test shall be made at a load adjusted as seems appropriate to bring the percentage fines within the range of 7.5 to 12.5.

A repeat test shall be made at the load that gives a percentage fines within the range 7.3 to 12.5.

Calculations - The mean percentage fines from the two tests at this load shall be used in the following formula to calculate the load required to give 10 percent fines:

$$\text{Load required for 10 percent fines} = \frac{14xX}{Y+4}$$

Where x = load in tonnes, and

y = mean percentage fines from two tests at x tonnes load.

REPORTING THE RESULTS:

The load required to produce 10 percent fines shall be reported to the nearest whole number for loads of 10 tonnes or more, the nearest 0-5 tonne for loads of less than 10 tonnes.

The value expressed to the nearest 0.5 tone should be as follows:

(a) For normal concrete, not less than 5 tones.
(b) For wearing surfaces, not less than 10 tones.
(c) For granolithic concrete, not less than 15 tones.

APPENDIX-D

SLUMP TEST

Apparatus: Mould shall consist of a metal frustum of cone having the following internal dimensions:

Bottom diameter.....20 cm
Top diameter.....10 cm
Height.....30 cm

The mould shall be of a metal other than brass and aluminium of at least 1.6 mm (or 16 BG) thickness. The top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction as required by the test. A mould provided with a suitable guide attachment may be used.

Tamping rod shall be of steel or other suitable material 16 mm in diameter 60 mm long and rounded at one end.

Procedure:

The internal surface of the mould shall be thoroughly cleaned and freeform superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth horizontal, rigid and non-absorbent surface viz. levelled metal plate. The operator shall hold the mould firmly in place while it is being filled with test specimen of concrete. The mould shall be filled in four layers, each approximately one quarter of height of mould. Each layer shall be tamped with twenty five strikes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and for the second and subsequent layers shall penetrate into the underlying layer. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded, the concrete shall be struck off out level trowel or the tamping rod, so that the mould is exactly filled. Any mortar which shall leak out between the mould and the base plate shall be cleaned away. The mould shall be removed from the concrete immediately after filling by raising it slowly and carefully in a vertical direction. The moulded concrete shall then be allowed to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of specimen.

The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

Result:

The slump shall be recorded in terms of millimetres of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally give incorrect result. If this occurs, the test shall be repeated with another sample.

The slump test shall not be used for very dry mixes as the results obtained are not accurate.

8.12.0 Reinforced cement concrete work

A. List of applicable code

S. No.	IS Code. No	Subject
1	IS:226	Structural Steel
2	IS:432 (Part I)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement part-I mild steel and medium tensile steel bars
3	IS:432 (Part II)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement – Part-II hard drawn steel wire
4	IS:456	Code of Practices for plain and Reinforced concrete
5	IS:516	Method of test for strength of concrete
6	IS:716	Specification for pentachlorophenol
7	IS:1199	Method of sampling and analysis of concrete
8	IS:1200 (Part II)	Method of measurement of building and civil engineering work -concrete work
9	IS:1200 (Part V)	Method of measurement of building and civil engineering work - concrete work (Part 5- Form work)
10	IS:1566	Specification for hard drawn steel wire fabric for concrete requirement
11	IS:1599	Method for bend test
12	IS:1343	Code of Practice for Prestressed Concrete
13	IS:1608	Method for tensile testing of steel products
14	IS:1786	Specification for high strength deformed steel and wires for concrete reinforcement.
15	IS:1791	Specification for batch type concrete mixes
16	IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement
17	IS:2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
18	IS:4925	Batch plants specification for concrete batching and mixing plant
19	IS:4926	Ready – Mixed Concrete
20	IS:6523	Specification for precast reinforced concrete door, window frames
21	IS:10262	Recommended guidelines for concrete mix design
22	IS:13311 (Part I)	Indian standard for non-destructive testing of concrete. Method of test for ultrasonic pulse velocity
23	IS:13311 (Part II)	Indian standard for non-destructive testing of concrete. Method of testing by rebound hammer

S. No.	IS Code. No	Subject
24	IS:432	Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement
25	IS:516	Methods of test for strength of concrete
26	IS:1199	Methods of sampling and analysis of concrete
27	IS:1566	Hard drawn steel wire fabric for concrete reinforcement
28	IS:1786	High strength deformed steel bars and wires for concrete reinforcement
29	IS:1834	Hot applied sealing compounds for joints in concrete
30	IS:3414	Code of practice for design and installation of joints in buildings
31	IS:4948	Welded steel wire fabrics for general use
32	IS:6452	High alumina cement for structural use
33	IS:7320	Concrete slump test apparatus
34	IS:13290	Ductile detailing of RCC structure subjected to seismic loads
35	IS:2950	Code of practice for design and construction of raft foundations

B. Mandatory tests

Notes:

i. The mandatory tests shall be carried out when the quantity of materials to incorporate in the work exceeds the minimum quantity specified.
ii. Optional tests specified or any other tests, shall be carried out in case of specialised works or important structures as per direction of the Engineer-in-charge/Owner/Consultant.
iii. Testing charges, including incidental charges and cost of sample for testing shall be borne by the Bidder for all mandatory tests.
iv. In case of non-IS materials, it shall be the responsibility of the Bidder to establish the conformity of material with relevant IS specification by carrying out necessary tests. Testing charges including incidental charge and cost of sample for testing shall be borne by the Bidder for such tests.

The mandatory tests shall be as follows:

Material	Test	Field / Laboratory Test	Test Procedure	Minimum Quantity of Material/ Work For Carrying Out Test	Frequency of Testing
Reinforced cement concrete (Nominal mix)	Slump test	Field/Lab	Appendix D of Concrete Work	5 cu.m in case of column	Every 5 cu.m or part thereof
				20 cu.m for slabs, beams and connected columns	Every 20 cu.m or part thereof
	Cube test	Lab	Appendix A of this clause	5 cu.m in case of column	Every 5 cu.m or part thereof

Material	Test	Field / Laboratory Test	Test Procedure	Minimum Quantity of Material/ Work For Carrying Out Test	Frequency of Testing
				20 cu.m for slabs, beams and connected columns	Every 20 cu.m or part thereof
				20 cu.m for other R.C.C work for all other small items and where R.C.C done in a day is less than 5 cu.m test may be carried out as required by Engineer-in-charge	Every 20 cu.m or part thereof
Reinforced cement concrete (Design mix)					
Coarse aggregates				50 cu.m or part thereof & also on each change of source	
Fine aggregates				50 cu.m or part thereof & also on each change of source	
Cement				50 MT or on each change of source	
Fresh concrete	Slump test	Field/Lab	Appendix D of Concrete Work	10 cu.m	50 cu.m for R.C.C work including in all other small location. R.C.C. done in a day is less than 50 cu.m test may be carried out as required by Engineer-in-charge
	Cube test	Lab	Appendix A of this clause	10 cu.m or part thereof	50 cu.m or 10 batches of 5-7 cu.m each for R.C.C work in all location-taken together. R.C.C. done in a day is less than 50 cu.m test may be carried out as required by Engineer-in-charge

Material	Test	Field / Laboratory Test	Test Procedure	Minimum Quantity of Material/ Work For Carrying Out Test	Frequency of Testing
Steel for Reinforced Cement concrete	Physical test and chemical test			(a) for consignment below 100 tonnes	(b) for consignment above 100 tonnes
				i. Under 10mm dia, one sample for each 25 tonnes and part thereof	i. Under 10mm dia, one sample for each 40 tonnes and part thereof
				ii. 10mm to 16mm dia, one sample for each 35 tonnes and part thereof	ii. 10mm to 16mm dia, one sample for each 45 tonnes and part thereof
				iii. Over 16mm dia, one sample for each 45 tonnes and part thereof	iii. Over 16mm dia, one sample for each 50 tonnes and part thereof

C. **MATERIALS**

a. Water, cement, fine and coarse aggregate shall be as specified under respective clauses of mortars and concrete works as applicable.

b. Fly Ash admixed cement concrete (FACC) and fly ash Blended cements in Cement Concrete (PPCC) in RCC structures.

1) Fly ash Blended Cements conforming to IS:1489 (Part I) may be used in RCC structures as per guidelines given below :

2) **General**

a. IS:456- 2000 Code of Practice for Plain and Reinforced Concrete (as amended up to date) shall be followed in regard to Concrete Mix Proportion and its production as under:

i. The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause-9 of IS: 456 mentioned above.

ii. Concrete shall be manufactured in accordance with clause 10 of above mentioned IS:456 covering quality assurance measures both technical and organizational, which shall also necessarily require a qualified Concrete Technologist to be available during manufacture of concrete for certification of quality of concrete.

b. Minimum M-25 grade of concrete shall be used in all structural elements made with RCC both in load bearing and framed structure.

c. The mechanical properties such as modulus of elasticity, tensile strength, creep and shrinkage of fly ash mixed concrete or concrete using fly ash blended cements (PPCs) are not likely to be significantly different and their values are to be taken same as those used for concrete made with OPC.

d. To control higher rate of carbonation in early ages of concrete both in fly ash admixed as well as PPC based concrete, water/binder ratio shall be kept as low as possible, which shall be closely monitored during concrete manufacture.

   If necessitated due to low water/binder ratio, required workability shall be achieved by use of chloride free chemical admixtures conforming to IS: 9103. The compatibility of chemical admixtures and super plasticizers with each set OPC, fly ash and /or PPC received from different sources shall be ensured by trials.

e. In environment subjected to aggressive chloride or sulphate attach in particular, use of fly ash admixed or PPC based concrete is recommended. In cases, where structural concrete is exposed to excessive magnesium sulphate, fly ash substitution/content shall be limited to 18% by weight. Special type of cement with low C3A content may also be alternatively used. Durability criteria like minimum binder content and maximum water /binder ratio also need to be given due consideration in such environment.

f. Wet curing period shall be enhanced to a minimum of 10 days or its equivalent. In hot & arid regions, the minimum curing period shall be 14 days or its equivalent.

3) **Use of Fly ash Admixed Cement Concrete (FACC) in RCC structures**

There shall be no bar on use of FACC in RCC structures subject to following additional conditions.

a. Fly ash shall have its chemical characteristics and physical requirements etc. conforming to IS: 3812 (part I & II) and shall be duly certified.

b. To ensure uniform blending of fly ash with cement in conformity with IS: 456, a specific facility needs to be created at site with complete computerized automated process control to achieve design quality or with similar facility from Ready Mix Concrete (RMC) plants.

c. As per IS: 1489 (Part-I) maximum 35% of OPC by mass is permitted to be substituted with fly ash conforming to IS: 3812 (Part –I) and same is reiterated.

d. Separate storage for dry fly ash shall be provided. Storage bins or silos shall be weather proof and permit a free flow and efficient discharge of fly ash. The filter or dust control system provided in the bins or silos shall be of sufficient size to allow delivery of fly ash maintained at specified pressure to prevent undue emission of fly ash dust, which may interfere weighing accuracy.

4) **Use of Fly Ash Blended Cements in Cement Concrete (PPCC) in RCC Structures**

a. Subject to General Guidelines detailed out as above, PPC manufactured conforming to IS: 1489 (Part-I) shall be treated at par with OPC for manufacture of Design Mix concrete for structural use in RCC.

b. Till the time, BIS makes it mandatory to print the %age of fly ash on each bag of cement, the certificate from the PPC manufacture indicating the same shall be insisted upon before allowing use of such cements in works.

c. While using PPC for structural concrete work, no further admixing of fly ash shall be permitted.

d. **Steel for Reinforcement**

The reinforcement shall be any of the following:

a. Mild steel and medium tensile steel bars conforming to IS: 432 (Part I).
b. High strength deformed steel bars conforming to IS: 1786.
c. Hard-drawn steel wire fabric conforming to IS: 1566.
d. Structural steel conforming to Grade A of IS: 2062.

i. All reinforcement shall be free from loose mill scales, loose rust and coats of paints, oil, mud or any other substances which may destroy or reduce bond. Sand blasting or other treatment is recommended to clean reinforcement.
ii. Special precautions like coating (If reinforcement may be required for reinforced concrete elements in exceptional cases and for rehabilitation of structures. Specialist literature may he referred to in such cases.
iii. The modulus of elasticity of steel shall be taken as 200 KN/mm^2. The characteristic yield strength of different steel shall be assumed as the minimum yield stress/0.2 percent proof stress specified in the relevant Indian Standard.

iv. **Tolerances on dimensions and nominal mass**

a. **Specified Lengths**

If bars/wires are specified to be cut to certain lengths, each bar/wire shall be cut within deviations of +75 mm /-25 mm on the specified length, but if minimum lengths are specified, the deviations shall be +50 mm /-0 mm.

b. **Nominal Mass**

For the purpose of checking the nominal mass, the density of steel shall be taken as 0.007 85 kg/ mm^2 of the cross-sectional area per metre run. Unless otherwise agreed to between the manufacturer and the purchaser, the tolerances on nominal mass shall be as in Table 14. For bars/wires, the nominal mass per metre run shall correspond to the gross mass and the deviations in Table 14 shall apply to the nominal mass.

Table 14 Tolerance on nominal mass

S. No.	Nominal size	Tolerance on the Nominal Mass, Percent		
		Batch	Individual sample	Individual sample for coils only
1	Upto and including 10	±7	-8	±8
2	Over 10 and upto and including 16	±5	-6	±6
3	Over 16	±3	-4	±4

Note:

For individual sample plus tolerance is not specified. A single sample taken from a batch as defined in clause 3.1 of IS: 1786 shall not be considered as individual sample. For coils batch tolerance is not specified.

c. Physical properties

Mechanical properties

Mechanical properties for all sizes of deformed bars/wires determined on effective cross-sectional area and in accordance with tensile test shall be as specified in table 15.

Table 15 Mechanical properties of High strength deformed bars and wires

S. No.	Property	Fe 415	Fe 415 D	Fe 500	Fe 500 D	Fe 550	Fe 550 D	Fe 600
i.	0.2 percent proof stress/yield stress, Min, N/mm2	415.0	415.0	500.0	500.0	550.0	550.0	600.0
ii.	Elongation percent, Min on gauge length 5.65 A, where A is the cross sectional area of the test piece	14.5	18.0	12.0	16.0	10.0	14.5	10.0
iii.	Tensile strength, Min	10 percent more than the actual 0.2 percent proof stress/ yield stress but not less than 485 N/mm2	12 percent more than the actual 0.2 percent proof stress/ yield stress but not less than 500 N/mm2	8 percent more than the actual 0.2 percent proof stress/ yield stress but not less than 545 N/mm2	10 percent more than the actual 0.2 percent proof stress/ yield stress but not less than 565 N/mm2	6 percent more than the actual 0.2 percent proof stress/ yield stress but not less than 585 N/mm2	8 percent more than the actual 0.2 percent proof stress/ yield stress but not less than 600 N/mm2	6 percent more than the actual 0.2 percent proof stress/ yield stress but not less than 660 N/mm2
iv.	Total elongation at maximum force, percent, Min or gauge length 5.65 A, where A is the cross sectional area of the test piece	-	5	-	5	-	5	-

d. **TESTS**

I. Selection and Preparation of Test Sample

Unless otherwise specified in this standard, the requirements of IS: 226 shall apply.

1. All test pieces shall be selected by the purchaser or his authorized representative, either:
   a. From the cuttings of bars/wires; or
   b. If, he so desires, from any bar/wire after it has been cut to the required or specified size and the test piece taken from any part of it. In neither case, the test piece shall be detached from the bar/wire except in the presence of the purchaser or his authorized representative.

2. The test pieces obtained in accordance with above shall be full sections of the bars/wires and shall be subjected to physical tests without any further modifications. No reduction in size by machining or otherwise shall be permissible, except in case of bars of size 28 mm and above. No test piece shall be annealed or otherwise subjected to heat treatment. Any straightening which a test piece may require shall be done cold.

   For the purpose of carrying out tests for tensile strength, proof stress and percentage elongation for bars 28 mm in diameter and above, deformations of the bars only may be machined. For such bars, the physical properties shall be calculated using the actual area obtained after machining.

3. Notwithstanding the provisions given above, test pieces may be subjected to artificial ageing at a temperature not exceeding 100℃ and for a period not exceeding 2 hours.

4. Before the test pieces are selected, the manufacturer or supplier shall furnish the purchaser or his authorized representative with copies of the mill records giving the mass of bars/wires in each bundle/cast with sizes as well as the identification marks, whereby the bars/wires from that cast can be identified.

II. Tensile test

0.2% proof stress and percentage elongation - This shall be done as per IS: 1608, read in conjunction with IS: 226.

III. Bend test

This shall be done as per IS: 1786.

IV. Re-Bend test

This shall be done as per IS: 1786.

V. Retest

This shall be done as per IS: 1786.

e. **Chemical composition**

The ladle analysis of steel for various grades, when made as per relevant parts of IS:228 shall have maximum permissible percentage of constituents as follows:

Constituent	Percent, Maximum						
	Fe 415	Fe 415 D	Fe 500	Fe 500 D	Fe 550	Fe 550 D	Fe 600
Carbon	0.300	0.250	0.300	0.250	0.300	0.250	0.300
Sulphur	0.060	0.045	0.055	0.040	0.055	0.040	0.040
Phosphorus	0.060	0.045	0.055	0.040	0.055	0.040	0.040
Sulphur and Phosphorus	0.110	0.085	0.105	0.075	0.100	0.075	0.075

D. **Formwork (centering& shuttering)**

I. The formwork shall be designed and constructed so as to remain sufficiently rigid during placing and compaction of concrete, and shall be such as to prevent loss of slurry from the concrete. For further details regarding design, detailing, etc., reference may be made to IS:14687.The tolerances on the shapes, lines and dimensions shown in the drawing shall be within the limits given below:

Deviation from specified dimension of cross section of columns and beams	+12 mm
	-6mm
Deviation from dimensions of footings	
i. Dimension in Plan	+ 50 mm
	-12mm
ii. Eccentricity in plan	0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
iii. Thickness	± 0.05 times the specified thickness

Note: These tolerances apply to concrete dimensions only, and not to positioning of vertical reinforcing steel or dowels.

II. **Shuttering**

a. General

i. All shuttering, formwork, supports and staging shall be designed by the Bidder and be subject to approval by the Engineer. The Bidder shall submit drawings and calculations to the Engineer for scrutiny when called upon to do so. The Bidder shall be responsible for the correctness and strength of the form-work including its supports and centering and approval by the Engineer will not relieve him of responsibilities.

ii. The staging and supports may be of round or sawn timber or tubular or other shapes in steel. Round timber shall preferably extend over the full height in one piece. These shall be securely jointed or otherwise fastened and spaced at suitable intervals as the design may warrant and shall be suitably braced at regular intervals horizontally and diagonally.

iv. The formwork shall be of steel plate on steel frame, wooden boards with steel sheet lining, or plywood or seasoned timber board. For ornamental and curved surfaces, the material shall be very good seasoned timber or plywood.

iv. The shuttering shall conform to the shapes, lines, levels and dimensions shown in the drawing. It shall be fixed in perfect alignment and securely braced so as to be able to withstand, without appreciable displacement, deflection or movement of any kind, the weight of all construction, movement of persons and plant. It shall be so constructed as to remain rigid during the placing and compacting of

concrete without shifting or yielding and shall be sufficiently water tight to prevent loss of slurry from the concrete.

v. All props shall be supported on sole plates and double wedges. At the time of removing props these wedges shall be gently eased and not knocked out. The formwork shall be so designed that the sides are independent of the soffits and the side forms can be removed easily without any damage or shock to the concrete.

vi. Wrought shuttering shall be such as to produce a first class fair face on the concrete free from board marks or any other disfigurements. This shall be used for exposed surfaces where specified or directed by the Engineer. It may be made of heavy quality plywood or steel sheets having smooth, plain surface.

vii. The joints in shuttering shall be arranged in a regular pattern approved by the Engineer. Wrought shuttering shall be aligned within a tolerance of 3mm.

viii. Rough shuttering shall be used for all surface of concrete walls, footings etc., which are not exposed in the finished work or which are to receive plaster and as directed by the Engineer. It may be made of timber, ordinary plywood or steel sheets.

ix. Before any concreting is commenced the shuttering shall be carefully examined for dimensional accuracy and safety of construction. The space to be occupied by concrete shall be thoroughly cleaned out to remove rubbish, debris, shavings and saw dust. The surface in contact with concrete shall be coated with an approved substance such as mould oil or other non-staining mineral oil to prevent adhesion. Where necessary the surface shall be wetted to pre-vent absorption of moisture from concrete. Care shall be taken to avoid the reinforcements coming in contact with shutter oil.

b. Removal of Forms

i. Removal of forms shall never be started until the concrete has thoroughly set and aged to attain sufficient strength to carry twice its own weight plus the live load that is likely to come over it during construction. Shuttering shall be removed without shock or vibration and shall be eased off carefully in order to allow the structure to take up its load gradually and also without disfiguring the concrete surface.

ii. Time period for shuttering removal shall be as follows:

i.	Walls, columns & vertical faces	24 to 48 hours as may be directed by the Engineer.
ii.	Bottom of slab up to 4.5m span	7 days
iii.	Bottom of slab above 4.5m span and bottom of beam and arch, rise up to 6m span	14 days
iv.	Bottom of beam and arch rise over 6m span	21 days

Note 1: For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. Generally If Portland pozzolano or low heat cement or OPC with direct addition of fly ash has been used for concrete; the stripping time will be 10/7 of the period stated for OPC 43 grade cement above.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Note 3: For rapid hardening cement, 3/7 of above periods for OPC 33 grade will be sufficient in all cases except for vertical side of slabs, beams and columns which should be retained for atleast 24 hours.

Note 4: In case of cantilever slabs and beams, the centering shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength.

Note 5: Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement in cold weather and accordingly stripping time shall be increased.

Note 6: Work damaged through premature or careless removal of forms shall be reconstructed within 24 hrs.

c. Surface Treatment

1. **Oiling the Surface:** Shuttering gives much longer service life if the surfaces are coated with suitable mould oil which acts both as a parting agent and also gives surface protections. Typical mould oil is heavy mineral oil or purified cylinder oil containing not less than 5% pentachlorophenol conforming to IS: 716 well mixed to a viscosity of 70-80 centipoises. After 3-4 uses and also in cases when shuttering has been stored for a long time, it should be recoated with mould oil before the next use.

   The second categories of shuttering oils / leavening agents are Polymer based water soluble Compounds. They are available as concentrates and when used diluted with water in the ratio of 1:20 or as per manufacturer specifications. The diluted solution is applied by brush applications on the shuttering both of steel as well as ply wood. The solution is applied after every use.

2. The design of form work shall conform to sound Engineering practices and relevant IS codes.

d. Inspection of Form Work

The completed form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discoloration of concrete etc. Proper and accurate alignment and profile of finished concrete surface will be ensured by proper designing and erection of form work which will be approved by Engineer-in-Charge.

Shuttering surface before concreting should be free from any defect/ deposits and full cleaned so as to give perfectly straight smooth concrete surface. Shuttering surface should be therefore checked for any damage to its surface and excessive roughness before use.

e. **Erection of Form Work (Centering and shuttering):** Following points shall be borne in mind while checking during erection.

   i. Any member which is to remain in position after the general dismantling is done, should be clearly marked.
   ii. Material used should be checked to ensure that, wrong items/ rejects are not used.

iii. If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.
   a. The bearing soil must be sound and well prepared and the sole plates shall bear well on the ground.
   b. Sole plates shall be properly seated on their bearing pads or sleepers.
   c. The bearing plates of steel props shall not be distorted.
   d. The steel parts on the bearing members shall have adequate bearing areas.

iv. Safety measures to prevent impact of traffic, scour due to water etc. should be taken.

Adequate precautionary measures shall be taken to prevent accidental impacts etc. Bracing, struts and ties shall be installed along with the progress of form work to ensure strength and stability of form work at intermediate stage. Steel sections (especially deep sections) shall be adequately restrained against tilting, overturning and form work should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.

v. The stacked materials shall be placed as catered for, in the design.
   a. When adjustable steel props are used. They should:
   b. Be undamaged and not visibly bent.
   c. Have the steel pins provided by the manufacturers for use.
   d. Be restrained laterally near each end.
   e. Have means for centralizing beams placed in the fork-heads.

vi. Screw adjustment of adjustable props shall not be over extended.

vii. Double wedges shall be provided for adjustment of the form to the required position wherever any settlement/ elastic shorting of props occur. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightened/ clamped down after adjustment to prevent shifting.

viii. No member shall be eccentric upon vertical member.

ix. The number of nuts and bolts shall be adequate.

x. All provisions of the design and/or drawings shall be complied with. xii. Cantilever supports shall be adequate.

xi. Props shall be directly under one another in multistage constructions as far as possible.

xii. Guy ropes or stays shall be tensioned properly.

xiii. There shall be adequate provision for the movements and operation of vibrators and other construction plant and equipment.

xiv. Required camber shall be provided over long spans.

xv. Supports shall be adequate, and in plumb within the specified tolerances.

E. Reinforcements

I. General Requirements

Steel for reinforcement shall be clear and free from loose mill scales, dust, loose rust, coats of paints, oil or other coating which may destroy or reduce bond. It shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. Prior to assembly of reinforcement on no account any oily substance shall be used for removing the rust.

II. Assembly of Reinforcement:

Bars shall be bent correctly and accurately to the size and shape as shown in the detailed drawing or as directed by Engineer-in-Charge. Preferably bars of full length shall be used. Necessary cutting and straightening is also included. Overlapping of bars, where necessary shall be done as directed by the Engineer-in-Charge. The overlapping bars shall not touch each other and these shall be kept apart with concrete between them by 25mm or 11/4 times the maximum size of the coarse

aggregate whichever is greater. But where this is not possible, the overlapping bars shall be bound together at intervals not exceeding twice the dia. of such bars with two strands annealed steel wire of 0.90 mm to 1.6 mm twisted tight. The overlaps/ splices shall be staggered as per directions of the Engineer-in-Charge. But in no case the overlapping shall be provided in more than 50% of cross sectional area at one section.

III. **Bonds and Hooks Forming End Anchorages:**

Reinforcement shall be bent and fixed in accordance with procedure specified in IS: 2502, code of practice of bending and fixing of bars for concrete reinforcement. The details of bends and hooks are shown below for guidance.

i. **U-Type Hook**

In case of mild steel plain bars standard U type hook shall be provided by bending ends of rod into semi-circular hooks having clear diameter equal to four times the diameter of the bar.

Note: In case of work in seismic zone, the size of hooks at the end of the rod shall be eight times the diameter of bar or as given in the structural drawings.

ii. **Bends**

Bend forming anchorage to a M.S. plain bar shall be bent with and internal radius equal to two times the diameter of the bar with a minimum length beyond the bend equal to four times the diameter of the bar.

iii. **Anchoring Bars in Tension:**

Deformed bars may be used without end anchorages provided, development length equipment is satisfied. Hooks should normally be provided for plain bars in tension. Development length of bars will be determined as per IS: 456.

iv. **Anchoring Bars in Compression:**

The anchorage length of straight bar in compression shall be equal to the 'Development length' of bars in compression as specified in IS: 456. The projected length of hooks, bend and straight lengths beyond bend, if provided for a bar in compression, shall be considered for development length.

v. **Binders, stirrups, links etc.:**

In case of binders, stirrups, links etc. the straight portion beyond the curve at the end shall be not less than eight times and nominal size of bar.

vi. **Welding of Bars**

Wherever facility for electric arc welding or gas pressure welding is available, welding of bars shall be done in lieu of overlap. The location and type of welding shall be got approved by the Owner/Engineer-in-Charge. Welding shall be as per IS: 2751 and IS: 9417.

vii. **Placing in Position**

1) Fabricated reinforcement bars shall be placed in position as shown in the drawings or as directed by the Engineer-in-charge. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.9 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during deposition of concrete. Tack welding in crossing bars shall also be permitted in lieu of binding with steel wire if approved by Engineer-in-Charge.

2) The bars shall be kept in correct position by the following methods:
   i. In case of beam and slab construction pre-cast cover blocks in cement mortar 1:2 (1 cement : 2coarse sand) about 4x4 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcements.
   ii. In case of cantilevered and doubly reinforced beams of slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0mere or at shorter spacing to avoid sagging.
   iii. In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them: or with clock of cement mortar 1:2 (1 cement: 2 coarse sand) of required size suitable tied to the reinforcement to ensure that they are in correct position during concreting.
   iv. In case of other R.C.C. structure such as arches, domes, shells, storage tanks etc. a combination of cover blocks, spacers and templates shall be used as directed by Engineer-in-Charge.

3) **Tolerance on Placing of Reinforcement:** Unless otherwise specified by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances:

Tolerance in spacing

a. For effective depth, 200 mm or less +10 mms
b. For effective depth, more than 200 mm + 15 mm

4) **Bending at Construction Joints:** Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position care should be taken to ensure that at no time the radius of the bend is less than 4 bar diameters for plain mild steel or 6 bar diameter for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bar is not damaged.

5) **Cover:**
Nominal cover is the design depth of concrete cover to all steel reinforcements, including links. It is the dimension used in design and indicated in the drawings. It shall be not less than the diameter of the bar.

i. Nominal Cover to Meet Durability Requirement

a. Minimum values for the nominal cover of normal weight aggregate concrete which should be provided to all reinforcement, including links depending on the condition of exposure described shall be as given in Table 16.
b. However for a longitudinal reinforcing bar in a column nominal cover shall in any case not be less than 40 mm, or less than the diameter of such bar. In the case of columns of minimum dimension of 200mmor under, whose reinforcing bars do not exceed 12mm, a nominal cover of 25 mm may be used.
c. For footings minimum cover shall be 50 mm.

ii. Nominal Cover to Meet Specified Period of Fire Resistance
Minimum values of nominal cover of normal-weight aggregate concrete to be provided to all reinforcement including links to meet specified period of fire resistance shall be given in Table 16A of IS: 456.

Table 16 Nominal Cover to Meet Durability Requirements

Exposure	Nominal concrete cover in mm not less
Mild	20
Moderate	30

Exposure	Nominal concrete cover in mm not less
Severe	45
Very severe	50
Extreme	75

NOTES

i. For main reinforcement upto 12mm diameter bar for mild exposure the nominal cover may be reduced by 5mm.
ii. Unless specified otherwise, actual concrete cover should not deviate from the required nominal cover by + I0 mm
iii. For exposure condition 'severe' and 'very severe', reduction of 5mm may be made, where concrete grade is M35 and above.

F. Concreting

The concrete shall be as specified under “concrete work”. The proportion by volume or by the weight of ingredients shall be as specified.

(a) Consistency

The concrete which will flow sluggishly into the forms and around the reinforcement without any segregation of coarse aggregate from the mortar shall be used. The consistency shall depend on whether the concrete is vibrated on or hand tamped, it shall be determined by slump test as prescribed in sub-head “concrete” under workability requirement.

(b) Placing of Concrete

i. Concreting shall be commenced only after Engineer-in-Charge has inspected the centering, shuttering and reinforcement as placed and passed the same. Shuttering shall be clean and free from all shavings, saw dust, pieces of wood, or other foreign material and surfaces shall be treated as prescribed.
ii. In case of concreting of slab and beams, wooden plank or cat walks of chequered MS plated or bamboo chalies or any other suitable material supported directly on the centering by means of wooden blocks or lugs shall be provided to convey the concrete to the place of deposition without disturbing the reinforcement in any way. Labour shall not be allowed to walk over the reinforcement.
iii. In case of columns and wall, it is desirable to place concrete without construction joints. The progress of concreting in the vertical direction, shall be restricted to one metre per hour.
iv. The concrete shall be deposited in its final position in a manner to preclude segregation of ingredients. In deep trenches and footings concrete shall be placed through chutes or as directed by the Engineer-in-Charge. In case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 metres at a time.
v. During cold weather, concreting shall not be done when the temperature falls below 4.50℃. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone.
vi. During hot weather precaution shall be taken to see that the temperature of wet concrete does not exceed 38ºC. No concrete shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge.
vii. It is necessary that the time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with.

(c) **Compaction**

It shall be as specified in sub-head of Concrete Work of this specification.

i. Concrete shall be compacted into dense mass immediately after placing by means of mechanical vibrators designed for continuous operations complying with IS:2505, IS:2506, IS:2514 and IS:4656. The Engineer-in-Charge may however relax this condition at his discretion for certain items depending on the thickness of the members and feasibility of vibrating the same and permit hand compaction instead. Hand compaction shall be done with the help of tamping rods so that concrete is thoroughly compacted and completely worked around the reinforcement, embedded fixtures, and into corners of the form. The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. The vibrators shall maintain the whole of concrete under treatment in an adequate state of agitation; such that de-aeration and effective compaction is attained at a rate commensurate with the supply of concrete from the mixers. The vibration shall continue during the whole period occupied by placing of concrete, the vibrators being adjusted so that the centre of vibrations approximates to the centre of the mass being compacted at the time of placing.

ii. Concrete shall be judged to be properly compacted, when the mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface. When this condition has been attained, the vibrator shall be stopped in case of vibrating tables and external vibrators. Needle vibrators shall be withdrawn slowly so as to prevent formation of loose pockets in case of internal vibration. In case both internal and external vibrators are being used, the internal vibrator shall be first withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions of the makers of the particular type of vibrator used shall be strictly complied with. Shaking of reinforcement for the purpose of compaction should be avoided. Compaction shall be completed before the initial setting starts, i.e. with 30 minutes of addition of water to the dry mixture.

(d) **Construction joints**

i. Concreting shall be carried out continuously upto the construction joints, the position and details of which shall be as shown in structural drawing or as directed by Engineer-in-Charge. Number of such joints shall be kept to minimum. The joints shall be kept at places where the shear force is the minimum. These shall be straight and shall be at right angles to the direction of main reinforcement. Construction joints should comply with IS: 11817.

ii. In case of columns the joints shall be horizontal and 10 to 15 cm below the bottom of the beam running into the column head. The portion of the column between the stepping off level and the top of the slab shall be concreted with the beam.

iii. When stopping the concrete on a vertical plane in slabs and beams, and approved stop board shall be placed with necessary slots for reinforcement bars or any other obstruction to pass the bars freely without bending. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop-board. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stop-board shall be removed soon after the initial set. When concrete is stopped on a horizontal plane, the surface shall be roughened and cleaned after the initial set.

iv. When the work has to be resumed, the joint shall be thoroughly cleaned with wire brush and loose particles removed. A coat of neat cement slurry at the rate of 2.75 kg of cement per square metre shall then be applied on the roughened surface before fresh concrete is laid.

(e) **Expansion Joints**

Expansion joints shall be provided as shown in the structural drawings or as directed by Engineer-in-Charge, for the purpose of general guidance. However it is recommended that structures exceeding 45 m in length shall be divided by one or more expansion joints. The filling of these joints with bitumen filler, bitumen felt or any such material and provision of copper plate, etc. shall be paid for separately in running metre.

(f) **Curing**

After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected from quick drying by covering with moist gunny bags, sand, canvass Hessian or any other material approved by the Engineer-in-Charge. After 24 hours of laying of concrete, the surface shall be cured by making pond with water for a minimum period of 7 days from the date of placing of concrete in case of OPC and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather condition.

(g) **Finishing**

1) In case of roof slabs the top surface shall be finished even and smooth with wooden trowel, before the concrete begins to set. Sprinkling of dry cement while finishing shall not be resorted to.

2) Immediately on removal of forms, the R.C.C. work shall be examined by the Engineer-in-Charge, before any defects are made good.

a. The work that has sagged or contains honey combing to an extent detrimental to structural safety or architectural concept shall be rejected for visual inspection test.
b. Surface defects of minor nature may be accepted. On acceptance of such a work by the Engineer-in-Charge, the same shall be rectified as follows:
   i. Surface defects which require repair when forms are removed, usually consist of bulged due to movement of forms, ridges at form joints, honey-combed areas, damage resulting from the stripping of forms and bolt holes, bulges and ridges are removed by careful chipping or tooling and the surface is then rubbed with a grinding stone. Honey- combed and other defective areas must be chipped out, the edges being cut as straight as possible and perpendicularly to the surface, or preferably slightly under cut to provide a key at the edge of the patch.
   ii. Shallow patches are first treated with a coat of thin grout composed of one part of cement and one part of fine sand and then filled with mortar similar to that used in the concrete. The mortar is placed in layers not more than 10mm thick and each layer is given a scratch finish to secure bond with the succeeding layer. The last layer is finished to match the surrounding concrete by floating, rubbing or tooling on formed surfaces by pressing the form material against the patch while the mortar is still plastic.
   iii. Large and deep patches require filling up with concrete held in place by forms. Such patches are reinforced and carefully dowelled to the hardened concrete.
   iv. Holes left by bolts are filled with mortar carefully packed into places in small amounts. The mortar is mixed as dry as possible, with just enough water so that it will be tightly compacted when forced into place.
   v. Tiered holes extending right through the concrete may be filled with mortar with a pressure gun similar to the gun used for greasing motor cars.
   vi. Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where

uniform surface colour is important, this defect shall be remedied by adding 10 to 20 percent of white Portland cement to the patching mortar, the exact quantity being determined by trial.

vii. The same amount of care to cure the materials in the patches should be taken as with the whole structure. Curing must be started as soon as possible, after the patch is finished to prevent early drying. Damp Hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound in these cases will be most convenient.

c. The exposed surface of R.C.C. work shall be plastered with cement mortar 1:3 (1 cement : 3 fine sand) of thickness not exceeding 6 mm to give smooth and even surface true to line and form. Any RCC surface which remains permanently exposed to view in the completed structure shall be considered exposed surfaced for the purpose of this specification. Where such exposed surface exceeding 0.5 Sq.m, in each location is not plastered with cement mortar 1:3 (1cement: 3 fine sand) 6 mm thick, necessary deduction shall be made for plastering not done.

d. The surface which is to receive plaster or where it is to be joined with brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give bond between concrete and plaster. RCC work shall be done carefully so that the thickness of plaster required for finishing the surface is not more than
6 mm.

e. The surface of RCC slab on which the cement concrete or mosaic floor is to be laid shall be roughened with brushes while the concrete is green. This shall be done without disturbing the concrete.

(h) **Strength of Concrete**

The compressive strength on the work tests for different mixed shall be as given in Table below:-

Concrete Mix (Nominal Mix on Volume basis)	Compressive Strength in (Kg/ sq.cm)	
	7 days	28 days
1:1:2	210	315
1:1.5:3	175	265
1:2:4	140	210

(i) **Testing of Concrete**

i. Regular mandatory tests on the workability of the fresh concrete shall be done to achieve the specified compressive strength of concrete. These will be of two types

a. Mandatory Lab, Test
b. Mandatory Field Test

Results of Mandatory Field Test will prevail over mandatory Lab Test.

ii. **Cube Test for Compressive Strength of Concrete - Mandatory Lab Test :**

Mandatory tests shall be carried out as prescribed in Appendix A of this clause.

iii. **Additional Test:**

Additional test, if required, shall be carried out as prescribed in Appendix B of this clause.

iv. **Slump Test:**

This test shall be carried out as prescribed in the clause of concrete.

v. **Visual Inspection Test:**

The concrete will be inspected after removal of the form work as described in this specification. The question of carrying out mandatory test or other tests described in Appendix A and B of this clause will arise only after satisfactory report of visual inspection.

The concrete is liable to be rejected if:
a. It is porous or honeycombed.
b. Its placing has been interrupted without providing a proper construction joint.
c. The reinforcement has been displaced beyond tolerance specified or construction tolerances have not been met.

However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-Charge at the risk and cost of the Bidder.

(j) **Standard of Acceptance – for Nominal Mix**

i. **Mandatory Lab Test:** For concrete sampled and tested as prescribed in Appendix A of this clause, the following requirement shall apply.

ii. Out of six sample cubes, three cubes shall be tested at 7 days and remaining three cubes at 28 days.

iii. **7 days Tests**

Sampling: The average of the strength of three specimen shall be accepted as the compressive strength of the concrete provided the variation in strength of individual specimen is not more than + 15% of the average. Difference between the maximum and minimum strength should not exceed 30% of average strength of three specimen. If the difference between maximum and minimum strength exceeds 30% of the average strength, then 28 days' test shall have to be carried out.

Strength: If the actual average strength of sample accepted in para 'sampling' above is equal to or higher than specified strength upto +15% then strength of the concrete shall be considered in order.

In case the actual average strength of sample accepted above is lower than the specified or higher by more than 15% then 28 days' test shall have to be carried out to determine the compressive strength of concrete cubes.

Iv **28 days Test**

a. The average of the strength of three specimen be accepted as the compressive strength of the concrete provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.

b. If the actual average strength of accepted sample exceeds specified strength by more than 30% the Engineer-in-Charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of specified strength, it will be restricted to 130% only for computation of strength.
c. If the actual average strength of accepted sample is equal to or higher than specified strength upto 30% then strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.
d. If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Engineer-in- Charge.
e. If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-Charge shall reject the defective portion of work represented by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken at the risk and cost of Bidder. If, however the Engineer-in- Charge so desires, he may order additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the Bidder.

v. **Acceptance Criteria of Field Test (Additional Test – Not Mandatory)**

1. Preparation of Standard Test Cubes for calibration of Rebound Hammer at site

a. In the beginning the standard test cubes of the specified mix shall be prepared by field units before undertaking any concrete work in each project.
b. At least 18 standard cubes necessary for formation of one specimen of specified mix, shall be cast by site staff well in advance. From these 18 cubes any 3 cubes may be selected at random to be tested for crushing strength of 7 days. The crushing strength obtained should satisfy the specified strength for the mix as per specification or agreement. If the strength is satisfactory then the remaining cube will form the standard samples for calibration of rebound hammer. In case of failure, the site staff should totally reject the samples and remove them also and then make another set of samples by fresh mixing or alternatively, out of the remaining 15 cubes, 3 cubes will be tested on 28 days. If the 28 days' tests are found satisfactory then remaining 12 cubes will form the standard sample for calibration at 28 days' strength otherwise all samples shall be rejected and whole procedure repeated to form a fresh specimen. All the results shall be recorded in a register.
c. No concreting will be allowed unless the standard specimen cubes are obtained.
The criteria for acceptance and calibration of hammer will be 28 days' strength. The 7 days' strength is only to facilitate the work to start.
d. No work (for the concrete cast between 8th and 28th day) shall be allowed to be paid unless 28 days' cube strength is obtained. For the concrete cast between 8th and 28th day, the decision to make the payment may be taken by the Engineer-in-charge on the basis of existing criteria. Concrete work will be rejected if 28 days' strength falls short as per acceptance criteria. No further work will be allowed till the acceptable standard cubes are obtained.
e. Frequency: it will be once in each quarter or as per the direction and discretion of Engineer-in-Charge. Whenever the acceptance criteria is changed or concrete mix or type of cement is changed or Engineer-in- Charge feels it necessary for recorded reasons with the approval of the authority according to technical sanction, fresh specimen shall be prepared.

2. Calibration of Hammer

a. Simultaneously, same three cubes to be tested on 28 days as referred in para A (b) above shall be used to correlate the compressive strength of their concrete

with rebound number as per procedure described in para 5.2 of the IS: 13311 (Part 2) "Indian standard for non-destructive testing of concrete Method of test by rebound hammer which is given below. The average of values of the rebound number (minimum readings) obtained in respect of same three cubes passing on 28 days work test shall form the datum reference for remaining cubes for the strength of cubes.

b. The concrete cubes specimens are held in a compression testing machine under a fixed load, measurements of rebound hammer taken and then compressive strength determined as per IS:516. The fixed load required is of the order of 7 N/mm^2 when the impact energy of the hammer is about 2.2 NM.
   If the specimen are wet cured, they should be removed from wet storage & kept in the laboratory atmosphere for about 24 hours before testing.
   Only the vertical faces of the cubes as cast should be tested for rebound number. At least nine readings should be taken on each of the three vertical faces accessible in the compression testing machine when using rebound hammers. The points of impact in the specimen must not be nearer than 20 mm from the edge & should not be less than 20 mm from each other. The same points must not be impacted more than once.
c. The rebound number of hammer will be determined on each of the remaining (18-3-3=12) cubes. Whenever the rebound number of hammer of any individual cube varies by more than +25% from the datum readings, that cube will be excluded and will not be considered for standard specimen cubes for calibration. It must be ensured that at least 8 cubes out of 12 that is 66.67% are within the permissible range of variation of rebound number i.e. +25% or otherwise whole procedure shall have to be repeated and fresh specimen prepared.
   These 8 cubes will form one standard sample in the beginning before commencement of work and shall be kept carefully for the visiting officers who will calibrate their hammers on these cubes.
d. This calibration will be done by field staff with their hammer and then chart of calibration giving the details of the average readings, date & month of casting, mix of the concrete etc. shall be prepared and signed by Engineer-in-Charge and will be duly preserved for future reference as and when required.

3. Preservation of Cubes at site

Standard sample cubes cast shall be carefully preserved at site under the safe custody of Engineer in-charge at site or his representative for making them available together with the charts, to the officers of QCTA/CTE or any other senior departmental officer, during their inspection of the work. They will calibrate their hammer on these cubes if required.

4. Testing at Site

a. Testing Equipments

b. Testing will be done generally by non-destructive methods like rebound hammers etc.
   Each field Division/ Sub Division/ Unit will purchase rebound hammers and keep them in working order at work site. The testing will be done only by hammers which are duly calibrated.
c. The relative strength of actual field work will be tested with reference to strength of these standard cubes and calibration charts of a hammer for determining the rebound number on the field work. The hammer will be used as per manufacturer's guidelines at various locations chosen at random. The number of location/reading on each wall, beam or column etc. shall not be less than 12. All the readings should be within the +25% range of values prescribed in calibration chart normally. However, reading indicating good strength will be when it is at per with calibrated value or between 100% & 125% and very good if more than 125% any value between 100% & 75% of calibrated value shall be considered

satisfactory. Values from 75% to 50% shall be considered for payment at rates reduced on prorate basis. The concrete indicating rebound number less than 50% of calibrated value shall be rejected and not paid for.

5. Acceptance of Field Tests and Strength

If the relative strength of actual field work is found satisfactory considering the calibration charts with reference to the standard cube test kept at site, the representative work will be considered satisfactory. If the work is considered below satisfactory, the same will be dealt as stated above.

6. 7 days Strength in Rare Cases only

Normally cube crushing strength on 28 days test shall form the basis of acceptance. However in rare cases of time bound projects/ urgent repairs 7 days cube test strength criteria may be adopted on similar lines using 7 days standard test cubes and calibration graphs/ curves/ charts for 7 days in lieu of 28 days and testing work done at 7 days.

7. Precautions

a. The testing shall be done generally as per guidelines of manufacture of the apparatus and strictly in accordance with the procedure laid down in clause 6 of IS:13311 (Part 2): Indian Standard for Non-Destructive Testing of Concrete - Method of Test by Rebound Hammer.

b. The rebound hammers are influenced by number of factor like type of cement aggregate, surface conditions, moisture content, age of concrete & extent of calibration of concrete etc. hence care shall be taken to compare the cement, aggregate etc. and tested under the similar surface conditions having more or less same moisture content and age. However effect of age can be ignored for concrete between 3 days & 3 months old.

G. **Mix Design**

I. General

i. At the commencement of the contract the Bidder shall make preliminary tests to determine the proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce required grades of concrete. The mix proportions shall be selected to ensure that workability of the fresh concrete is suitable for the conditions of handling, placing and finishing as well as it develops the required strength, durability and surface finish upon hardening. The Bidder shall get approval of Engineer to proportions before he starts concreting. Such approval shall not relieve the Bidder of his responsibility to produce concrete having the required compressive strengths.

ii. No departure from the approved proportions will be permitted unless the Engineer in-charge gives written permission for any change in proportion. The Engineer shall have authority at any time to check whether the mixing of concrete is carried out according to the approved proportions. The design of mixes shall be made by the Bidder at his own cost, for each grade of concrete as well as for various workability requirements. The cement content for various grades of concrete shall be based on design mix. However, irrespective of requirement of cement found out from design mix, cement content of concrete shall not be less than the quantities specified hereunder except for the cases specifically approved by the Engineer.

Grade of concrete	Minimum cement content/cu.m of finished concrete
M-15	300 kg
M-20	340 kg
M-25	375 kg
M-30	400 kg

iii. The minimum cement content stipulated above shall be adopted irrespective of whether required strength is achieved with lesser quantity of cement. The quoted rates for concrete shall provide for the above eventuality and nothing shall become payable extra on this account.

iv. The strength requirements of the concrete mixes ascertained on 150mm cubes as per IS: 516 shall comply with the requirements of IS: 456.

II. Water Cement Ratio

Where a particular water cement ratio is stipulated in the design or drawing along with the characteristic grade of concrete, the design of mix shall be carried out by adjusting the other variable factors to obtain the characteristic strength of concrete with stipulated water cement ratio. In the structures where the impermeability and shrinkage of concrete have an important bearing on the durability and serviceability of the structures, the water cement ratio shall be kept low and preferably not exceeding 0.45. The water cement ratio, as achieved in the Mix Design or as specified in the drawings shall be adhered to strictly and shall not be varied without the permission of the Engineer.

III. Workability

i. The workability of fresh concrete shall be such that the concrete is just suitable for the conditions of handling & placing so that after compaction it be-comes completely consistent and homogeneously surrounds all the reinforcement and completely fills the formwork.

ii. The workability of fresh concrete at the place of batching/mixing shall be measured by compaction factor test and at the place of disposition by means of slump test. During the finalization of Trial Mixes, the relationship between compaction factor and slump test shall be established for each grade of concrete as well as for various levels of workability. The workability tests shall be carried out in accordance with IS: 1199.

iii. Normally, in the condition of low water cement ratio as well as for medium/high workability, the workability shall be achieved by increasing the cement content, in consistent with added water.

iv. In cases where the cement content is to be limited to reduce the heat of hydration, and the water cement ratio is also to be kept low to reduce the permeability or due to other requirements the desired workability may be achieved with use of limited doses of plasticiser or air entraining agent. In such cases the method of mixing and dosage of the plasticiser/air entraining agent shall be according to the manufacturer's specification and with the approval of the Engineer.

v. 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.

IV. Trial Mixes

i. After approval of the mix design by the Engineer, the Bidder shall make in presence of Engineer the Trial Mixes for each grade of concrete as well as for required workability.
ii. Before starting the trial mixes, necessary preparatory works like sieve analysis of the aggregates, determination of densities of different ingredients and moisture contents, in the aggregates, shall be completed according to the I.S. Codes 383 and 2386. Each trial mix shall be handled and compacted by method which the Bidder proposes to use for that mix in the works and the mixes shall not show tendency of inadequate compaction by the method proposed.
iii. The compacting factor and the slump of each trial mix shall be determined immediately after mixing and the values shall not exceed the maximum value obtained by the mix design.
iv. Six numbers of 150mm test cubes shall be made from each trial mix. These shall be cured and tested in accordance with relevant I.S. Codes. In order to have the specified characteristic strength in the field, the concrete mix as de-signed in the Design Mix shall have higher average compressive strength de-pending on the degree of quality control at site. If the size and special requirement of the work so warrants, the trial may be extended to cover larger ranges of mix proportions as well as other variables such as alternative source of aggregates, maximum size and grading of aggregates and different type and brands of cement.
v. Before commencement of the concreting works of particular grade of concrete, the Bidder must complete the work of trial mixes and subsequent testing of test cubes obtained there from the design of the approved Mix for that particular grade of concrete. The entire cost of all the trial mixes including all the preparatory works for trial mixes, preparation of test cubes and their testing shall be borne by the Bidder.

V. Batching of Concrete a. Cement

Cement shall always be batched by weight. A separate weighing device shall be provided for weighing cement. Where the weight of cement is determined by accepting the weight per bag, number of bags shall be weighed separately to determine the average net weight of cement per bag and the same shall be checked regularly

b. Aggregates

i. For both Design Mix concrete and Nominal Mix concrete the aggregates (coarse and fine) shall be batched by weight.
ii. In particular cases, or where weigh-batching is not possible proportioning by volume batching may be allowed by the Engineer, provided the Bidder guarantees the uniformity of aggregates throughout the period of construction. For this purpose, the Bidder shall submit to the Engineer sufficient data indicating the weight/volume relationship of aggregates for different types of concrete and after such approval, periodic checks on the weight/volume relationship of the aggregates shall be made by the Bidder to the satisfaction of the Engineer.
iii. Where aggregates are moist and volume batching is adopted, allowance shall be made for bulking in accordance with IS: 2386 (Part-III).
iv. Suitable adjustments shall be made for the variation in the weight of aggregates due to variation in moisture contents.

c. Water

Water may be measured either by weight or by volume. It is very important to maintain the water cement ratio constant at its correct value. For the correct determination of amount of water to be added in the concrete mix, to maintain the

water cement ratio constant, the amount of moisture content in both coarse and fine aggregates shall be taken into consideration, be as frequently as possible. Determination of moisture content in the aggregates shall be according to I.S. 2386 (Part-III).

VI. Mixing & Transportation of Concrete

The mixing, placing, compacting, curing and finishing of concrete shall be done according to IS: 456 "Code of Practice for Plain and Reinforced Concrete".

i. Mixing of Concrete

a. Concrete shall always be mixed in adequate capacity batching plant. Water shall not, normally be added into the drum of the mixer until all other ingredients have been already mixed in the drum for at least one minute. Mixing shall be continued until there is uniform distribution of materials and the mass is uniform in colour and consistency. The mixing time from the time of adding water shall be in accordance with IS: 1791.

b. Where hand mixing is permitted by the Engineer it shall be carried out on a watertight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency for minor works only. In case of hand mixing 10% extra cement shall be added to each batch at no extra cost to the Owner.

ii. Transportation of Concrete

Concrete shall be transported from the place of mixing to the place of placing concrete as rapidly as practicable by means that will prevent the segregation or loss of any of the ingredients and maintain the required workability through transit mixer/agitator car. No water shall be mixed with the concrete after it has left the mixer.

iii. Placing and Compaction of Concrete

a. Before placement of concrete, the Bidder shall get all the form works, reinforcements, inserts, conduits, openings, surface preparation etc., checked and approved by the Engineer in-charge. To facilitate such checking, the Bidder shall complete all his works according to the drawings and specifications well in advance before placement of concrete at least 36 hours for all major/ important/ complicated works and 24 hours for all normal works. The checks are purely in the interest of the work and to draw the Bidder's attention to his contractual obligations to execute the works according to the drawings/specification and do not relieve the Bidder from his responsibility in getting the end results for the quality & strength of concrete and for maintaining the shape, level & dimensions of the finished concrete, as well as the inserts, openings, other features within the tolerance limits.

b. All concrete works shall normally be placed at or below soil level and where in touch with soil with a levelling layer of lean concrete M15. In such cases the earth shall be rammed and consolidated as directed by the Engineer such that it does not crumble and get mixed with the lean concrete during or after placement. If the foundation is quite wet, the same shall be kept dry and then sufficiently consolidated; if necessary, wet soil/ unsuitable soil shall be re-moved and replaced by sand or other suitable materials as directed by the Engineer at no extra cost to the Owner. Utmost care shall also be taken that earth from the sides also does not get mixed with the concrete, during or after placement, before it has sufficiently set and hardened.

c. The concrete shall be placed and compacted before setting commences & should not be subsequently disturbed. No water shall be mixed with the concrete after it has left the mixer. Method of placing should be such as to preclude segregation. Approved mechanical vibrator shall be used for compacting concrete, and concrete

shall not be over vibrated or under vibrated. No concrete shall be placed until the place of deposit has been thoroughly inspected and approved by the Engineer. All inserts and embedment properly secured in position and checked and forms properly oiled. No concrete shall be placed in the absence of the Engineer. Concrete shall be placed on a clean surface free of all debris and other objectionable materials. Concreting shall not be done during rains unless all precautions have been taken by the Bidder and permission has been given by the Engineer.

d. Concrete shall not be dropped from a height of more than 2m except through a chute, the design and type of which shall be subject to approval of the Engineer. The concrete shall be placed, spread and compacted by approved mechanical vibrator. Vibrators shall not be used for pushing concrete to adjoining areas. For members involving vertical placing of concrete (e.g. columns, walls etc.,) each lift shall be deposited in horizontal layer extending the full width between shuttering and of such depth that each layer can be easily and effectively vibrated and incorporated with the layer below by means of compaction. For member involving horizontal placing of concrete (e.g. slabs, beams etc.,) the concrete shall be placed along the line of starting point in such quantities as will allow members to be cast to their full depth along the full width between side shuttering and then gradually brought towards the finishing point along its entire front parallel to the starting line. Vibration and surface finish shall follow behind the placement as closely as possible. Utmost care shall be taken to avoid the displacement of reinforcements/ embedded parts or movement of formwork or damage to faces of the formwork or transmission of any harmful vibration/shocks to the concrete, which has not yet hardened sufficiently.

e. All members shall be concreted at such a rate that no cold joint is formed and fresh concrete is placed always against green concrete, which is still plastic and workable. Should any unforeseen occurrence results in a stoppage of concreting for one hour or such other time as might allow the concrete, already placed, to begin to set before the next batches can be placed, the Bidder shall make at his own cost, suitable tongue and groove construction joint, as approved by the Engineer. Any additional reinforcement required as directed by the Engineer shall also be provided at no extra cost to Owner. Before placement of new batches of concrete over that construction joint, the surface preparation according to this specification, stipulated earlier, shall be done by the Bidder. The concrete shall be worked well up against whatever surface it adjoins and compacted to such a degree that it reaches its maximum density as a homogeneous mass, free from air and water holes and penetrates to all corners of moulds and shuttering and completely surround the reinforcement. All measures shall be taken to make the shape, size, and location of the finished concrete including its embedment's, holes, openings etc., well within the accepted tolerance limit.

iv. **Construction Joints**

a. The construction joints shall be constructed as per locations and details indicated on the drawings. Where the location of the joint is not specified in the drawings, it shall be in accordance with best Engineering practice/ decision of the Engineer-in-charge.

b. In the case of water retaining structures and structures under the influence of ground water, approved water bars of suitable size shall be provided to make the joint completely water tight.

c. For nominally reinforced slab the area of pour shall not exceed 40 Sq.m and the maximum panel dimension shall not exceed 8m. In all construction joints the reinforcements shall pass through as per drawings and the same shall not be disturbed in any way. The vertical construction joints shall be provided by insertion of board keeping provision for passage of reinforcement/ fixtures/embedment. All construction joints shall be made to form a tongue and groove joint.

d. In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not rise in-spite of extensive vibration, a tongue and groove joint shall be made by removing some of the older concrete and the joint shall be left to harden at least for 12-24 hours. It will then be treated as regular construction joint and the surface prepared before placement of concrete.

e. Placing of concrete in lifts exceeding 2m in columns and walls is considered a deep lift. Before commencement of work, the Bidder shall submit for the approval of the Engineer, the details of the methods he proposes to adopt for concreting. The placement of concrete shall preferably be by tremie, chute or any other approved method. In structures of heavy/complicated reinforcement or in complicated form works, the Bidder shall provide sufficient number of windows in the form works as directed by the Engineer to check the placement and compaction of concrete in different stages. Such windows shall be closed as soon as the concreting reaches the bottom level of the same.

f. When it is necessary to deposit concrete under water, the special requirements, over and above those of this specification shall be in accordance with IS: 456.

g. When concreting in very hot weather the Bidder shall take all precautions as stipulated in IS:7861 (Part-I) and stagger the work to cooler parts of the day to ensure that the temperature of wet concrete used, especially in massive structure, does not exceed 23°C.

h. During windy weather, efficient protection is to be provided to prevent the cement from being blown away during the process of apportioning and mixing. All special care shall be taken to protect new concrete from the harmful effects of drying winds. During wet weather, the concrete shall be adequately protected as soon as it is in position. No concreting shall be carried out during periods of continuous heavy rain unless it is completely covered during mixing, transporting and placing.

v. **Mass Concreting**

The aim of controlling the concreting in large pours is to reduce cracking caused by shrinkage due to heat of hydration. The Bidder shall submit detailed proposal to the Engineer for approval about the method of pouring and the measures to reduce heat of hydration, which he proposes to adopt. The maximum height of lifts will depend on the type of cement used. The use of cement having low heat of hydration, could allow greater lifts.

vi. **Programme of Works**

At the beginning of every fortnight, the Bidder shall give his detailed concreting programme for that fortnight to the Engineer. Such programmes, shall specify all information such as the locations where concrete is to be poured., type/grade of concrete, volume of concrete to be poured, number and type of Vibrators proposed to be used as well as proposed to keep as standby, number of skilled technicians and supervisors proposed to be engaged, the pro-posed time and period of pouring etc.

vii. **Curing of Concrete**

a. The purpose of curing is to prevent loss of moisture from the concrete itself so that the cement inside the concrete is sufficiently hydrated which of course is slow and prolonged process. As soon as the concrete has hardened sufficiently the

curing shall be started. To cure the concrete properly and sufficiently is also the sole responsibility of the Bidder.

b. Any one of the following methods may be used for curing as approved by the Engineer:

1. Curing by direct water.
2. Curing by covering the concrete with absorbent material and kept damp.
3. Curing by providing protective membrane.

1. Curing by Direct Water

This is done either by ponding or spraying water. Ponding is widely used for curing slab and pavements. Small earth bunds are formed over the edges of the slab and water is pumped or poured into them and the same is replenished at interval to make up for the loss of evaporation. As this type of curing is one of the best methods, 7 days of curing after final setting is sufficient. Curing is done by spraying water by suitable means at approved time/ interval. While spraying, it shall be ensured that the complete area is covered. In order to avoid cracking, cold water shall not be applied to massive members immediately after striking the formwork, while the concrete is still warm. Al-ternate wetting and over drying shall be avoided. Curing by spraying water shall be continued for at least 10 days after final setting.

2. Curing of Concrete with Absorbent Material Kept Damp

The entire concrete surface is covered either with Hessian, canvas or similar material and kept wet continuously for at least 10 days after final setting.

3. Curing by Providing Protective Membrane by Applying a Curing Compound

This is achieved by applying a membrane-forming compound (curing com-pound) over the concrete surface. Generally these are available in emulsion form and shall be applied as per manufacturer's instructions. The curing compound membrane forms a continuous adhesive membrane over the concrete surface. Such membrane serves as a physical barrier to pre-vent the loss of moisture from the concrete itself.

viii. **Testing of Concrete**

1. General

a. The Bidder shall carry out, entirely at his own cost, all sampling and testing in accordance with the relevant I.S. standards and as supplemented herein. The Bidder shall get all tests done at his site laboratory and/ or an approved external laboratory as per the instructions of the Engineer-in-charge and submit to the Engineer the test result in triplicate.
b. At the place of both mixer and pouring concrete, slump tests shall be carried out by the Bidder in accordance with I.S. 1199 as directed by the Engineer-in-charge.
c. The results of the slump tests/ tests shall be recorded in a register for reference duly signed by both the Bidder and the Engineer. That register shall be considered as the property of the owner and shall be kept by the Bidder at site in safe custody.
d. For any particular batch of concrete, if the results do not conform to the requirements as specified or do not conform to any requirement of this specification, the Engineer has the right to reject that batch and the Bidder shall remove the same immediately from the site, at no cost to the owner.

2. Strength Test of Concrete

a. While placing concrete the Bidder shall make 6 nos. of 15 cm test cubes from particular batches of concrete as desired by the Engineer. The frequency of taking test cubes shall be according to IS: 456 or as directed by the Engineer.
b. The cubes shall be prepared, cured and tested according to IS: 516. Out of the 6 nos. of test cubes 3 shall be tested for compressive strength at 7 days after casting and the remaining 3 at 28 days after casting.
C A register shall be maintained at site by the Bidder with the following details entered for the cubes and signed both the Bidder and the Engineer. That register shall be considered as the property of the Owner.
d. Following details shall be available for the cubes having reference to the specific structural member:
   (i) Mark on cubes
   (ii) The grade of concrete
   (iii) The mix of concrete
   (iv) Date and time of casting
   (v) Crushing strength at 7 days
   (vi) Crushing strength at 28 days
   (vii) Any other information directed by the Engineer.
e. The acceptance criteria of concrete on strength requirement shall be in accordance with the stipulations under IS: 456.

3. Non-Destructive Tests on Hardened Concrete

If there is doubt about the strength or quality of a particular work or the test results do not comply with the acceptance criteria as stipulated under IS: 456, non-destructive tests on hardened concrete like core test and/or load tests or other type of non-destructive tests like ultrasonic impulse test etc. shall be carried out, as may be directed by the Engineer, by the Bidder at entirely his cost. The core tests and load tests shall comply with the requirements of IS: 456. In case of other types of special tests like ultrasonic impulse tests etc., the relevant stipulation of clauses of IS: 456 shall be applicable.

4. Concrete below Specified Strength

In case of failure of test cubes to meet the specified requirements the Engineer may take one of the following actions:

i. Instruct the Bidder to carryout additional test and/or works to ensure the soundness of the structure at Bidder's expense.

ii. Reject the work and instruct that section of the works to which the failed cubes relate shall be cut out and replaced at Bidder's expense and the resultant structures affected due to such rejection shall be made good at Bidder's expense.

iii. Modification/remedial measures if approved by the engineer to be carried out at Bidder's expense.

5. Concrete Failed in Non-Destruction Tests

In case the test results of the core tests or load tests in a particular work do not comply with the requirements of clauses for load tests of IS: 456 the whole or part of the work concerned shall be dismantled and replaced by the Bidder as may be directed by the Engineer at no extra cost to the Owner and to the satisfaction of the Engineer. No payment for the dismantled concrete including relevant formwork, reinforcement, embedded fixtures etc. shall be made. In the course of dismantling if any damage occurs to the adjacent structure or embedded item, the same shall be made good, free of charge by the Bidder, to the satisfaction of the Engineer.

6. Steel Reinforcement

All steel for reinforcement shall be free from loose scales, rust coatings, oil, grease, paint or other harmful matters immediately before placing the concrete. To ensure this, reinforcements shall be cleaned thoroughly before bending and placement of the same.

7. Storage

Steel reinforcement shall be stored in such a manner that they are not in direct contact with ground. Bars of different classifications and sizes shall be stored separately. Reinforcement shall be stacked at least 15 cm above ground level and a coat of cement wash given at no extra cost to prevent scaling and rusting.

8. Bending and Placing

Bending and placing of bars shall be in conformity with IS: 2502 "Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement" and IS: 456 "Code of Practice for Plain and Reinforced Concrete".

9. Lapping / Welding of Reinforcement

i. Normally the lapping of reinforcement bars shall be by mechanical means satisfying the requirements of IS: 456. However, in case of congestion of reinforcement the welding of reinforcement may be adopted with special approval of Engineer.

ii. Welding of mild steel reinforcement bars conforming to IS: 432 (Part-I) and shall be done in accordance with IS: 2751"Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete construction".

iii. All reinforcements shall be accurately fixed and maintained in positions as shown on the drawings and by adequate means like mild steel chairs and/or concrete spacer blocks as required. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by 20G annealed soft steel wire or by tack welding in case of bars larger than 25mm 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 layer 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. The binding wires shall be soft annealed black wire.

iv. Necessary templates, jigs, fixtures, supports shall be used as may be specified or required or directed by the Engineer. Templates shall invariably be supported such that the same is not disturbed due to vibration, movement of labourers, materials, shuttering works, reinforcement etc. while concreting. Bidder will have to suitably bend, cut or otherwise adjust the reinforcement in concrete at location of inserts as directed by Engineer.

H. **Mixing**

a. **Washing out Water**: Before loading concrete materials or mixed concrete into either a stationary mixer or truck mixer any water retained in the mixing drum for washing out purposes shall be completely discharged.

b. **Stationary or Central Mixers**: Stationary mixers shall not be loaded in excess of the manufacturer's rated capacity. The mixing time shall be measured from the time all the materials required for the batch, including water, are in the drum of

the mixer. The mixing time shall not be less than that recommended by the manufacturer. Where a continuous mixing plant is used, the complete mixing time shall be sufficient to ensure that the concrete is of the required uniformity.

c. **Truck Mixers:** When a truck mixer is used for the partial or complete mixing of concrete, mixing shall be considered to commence from the moment when all the materials required for the batch, including water, are in the rotating drum of the mixer.

Truck or agitators shall not be loaded in excess of the manufacturer's rated capacity. In order to produce a satisfactory mix, and where there is no data available to establish different period and speed of revolutions, mixing shall continue for not less than 60 revolutions of the truck mixer drum at a rate of not less than 7 revolutions/min. All completely truck mixed concrete shall be visually inspected for uniformity prior to leaving the plant.

When a truck mixer or agitator is used for transporting concrete which has been mixed before leaving the plant, the concrete shall be agitated during transit and remixed at the site for at least 2 min so that the concrete is of the required uniformity.

Where water is added to the concrete in the truck mixer through the truck mixer water meter and when such water is being accounted for in the total water within the mix, it shall be ensured that the truck mixer water meter is in operational condition and properly calibrated. Where a water meter is not available, water must be measured in a suitable container before being added to the truck mixer.

d. **Condition of Mixers** : Stationary and truck mixers shall be maintained in an efficient and clean condition with no appreciable build-up of hardened concrete or cement in the mixing drum, on the mixing blades, or on the loading hopper or discharge chutes.

l. **Quality Control**

Quality control of ready-mixed concrete may be divided into three components, forward control, immediate control and retrospective control.

a. **Forward control:**

Forward control and consequent corrective action are essential aspects of quality control. Forward control includes the following.

i. Control of purchased material Quality
ii. Control of Materials storage
iii. Mix design and mix design modification
iv. Transfer and Weighing Equipment: The producer shall be able to demonstrate that a documented calibration procedure is in place. The use of electro-mechanical weighing and metering systems, that is, load cells, flow meters, magmeters, etc., is preferable over purely mechanical system, that is, knife edge and lever systems.
v. Plant mixers where present and truck mixers used shall be in an operational condition.

b. **Immediate Control:**

Immediate control is concerned with instant action to control the quality of the concrete being produced or that of deliveries closely following. It includes the production control and product control.

(1) Production Control:

The production of concrete at each plant shall be systematically controlled. This is to ensure that all the concrete supplied shall be in accordance with these requirements and with the specifications that has formed the basis of the agreement between the producer and purchaser. Each load of mixed concrete shall be inspected before dispatch and prior to discharge. The workability of the concrete shall be controlled on a continuous basis during production and any corrective action necessary taken.

For each load, written, printed or graphical records shall be made of the mass of the materials batched, the estimated slump, the total amount of water added to the load, the delivery ticket number for that load, and the time the concrete was loaded into the truck. Regular routine inspections shall be carried out on the condition of plant and equipment including delivery vehicles.

(2) Product Control:

Concrete mixes shall be randomly sampled and tested for workability and where appropriate, plastic density, temperature and air content. Where significant variations from target values are detected, corrective action shall be taken.

It is important to maintain the water cement ratio constant at its correct value. The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in the aggregates. Suitable adjustments should also be made in masses of the aggregates due to this variation (refer IS: 456). Any change in water content due to change in aggregate grading shall be taken care of by forward control by suitable modifications to mix design.

(3) Retrospective Control: Retrospective control is concerned with those factors that influence the control of production. Retrospective control may cover any property of materials or concrete, such as aggregate grading, slump, or air content, but is particularly associated with 28-day cube strength because by its very nature it is not property which can be measured ahead of, or at the time of, manufacture.

(4) Mix Performance: The producer shall be responsible for ensuring that suitable control procedures are in place ensure the following.

(i) Design Mixes :

A quality control system shall be operated to control the strength of design mixes to the levels required as per IS: 456 and shall be based on random tests of mixes which form the major proportion of production. The system shall include continuous analysis of results from cube tests to compare actual with target values together with procedures for modifying mix proportions to correct for observed differences. Compressive strength testing shall be carried out using a machine that meets the requirements of IS: 14858.

(ii) Prescribed Mixes :

Periodic and systematic checks shall be made to ensure that the cementitious material contents of prescribed mixes comply with their mix descriptions.

J. **Records**

Records shall be maintained by the producer to provide confirmation of the quality and quantity and quantity of concrete produced. The records shall be retained for the purposes of these requirements for a period of at least one year. They shall cover the following aspect:

i. Production and delivery:
   a. Batching instruction

b. Batching Records
c. Delivery tickets, and
d. Equipment calibration and plant maintenance.

ii. Materials and production control:
a. Concrete production and materials purchase, usage and stocks, and
b. Certificates or test results for materials.

iii. Production quality Control: Control test results.

K. PLACING CONCRETE BY PUMPING

i General

Concrete conveyed by pressure through either rigid pipes or flexible hoses and discharged directly into the desired area is termed as pumped concrete.

Method of applying pressure to concrete is by pumps. Pumps to be used shall be either of the two types as mentioned below:-

i. Piston type pumps
ii. Squeeze pressure type pumps.

Compressed air pressure pumps shall not be used in the works.

ii. Pumping Equipments

i. **Piston Pumps**:

Piston pump to be used in the works shall consist of a receiving hopper for mixed concrete, an inlet valve, an outlet valve, and the pump shall be a twin-piston pump. The two pistons shall be so arranged that one piston retracts when the other is moving forward and pushing concrete into the pipe line to maintain a reasonably steady flow of concrete. Single piston pumps shall not be acceptable.

Inlet and outlet valve shall be any one of the following types:-

1. Rotating plug type
2. Sliding plate type
3. Guided plunger type
4. Swing type
5. Flapper type
6. Or any combination of the above.

The pistons shall be mechanically driven using a crank or chain or hydraulically driven using oil or water.

The receiving hopper shall have a minimum capacity of 1.0 cum and the hopper shall be fitted with remixing rotating blades capable of maintaining consistency and uniformity of concrete.

The primary power for pumps may be supplied by gasoline, diesel, or electric motors. The primary power unit and the pump unit may be truck, trailer or skid mounted.

ii. **Squeeze Pressure Pumps:** Squeeze pressure pumps shall consist of a receiving hopper fitted with re-mixing blades. Re-mixing blades shall be such that these can push the concrete into the flexible hose connected at the bottom of the hopper.

The flexible hose shall pass through a metal drum around the inside periphery of the drum and come out through the top part of the drum.

The drum shall be maintained under a very high degree of a vacuum during operation. The drum shall be so fitted with hydraulically operation metal rollers., which when rotating, create a squeeze pressure on the flexible hose carrying concrete and forces the concrete out into the pipe line.

iii. **Effective Range and Discharge of Pumps:** Effective range of pumps to be used in the work shall be decided after studying the site conditions. However, the minimum horizontal range shall not be less than 150 metres and minimum vertical range shall not be less than 50 metres. Selection of pumps bases on discharge capacity shall be decided after studying the requirements for the project. Discharge capacity shall be worked out by the Bidders and approval obtained from the Engineer-in-Charge. As a guide line figure the Bidder may assume a discharge capacity of 15 cubic meter/hour/pump.

iv. **Pipe Lines:** All concrete carrying pipe lines shall generally be rigid pipe lines. Flexible pipe lines may only be used at bend curves in lines or at discharge ends if required. Placements of flexible units shall be done judiciously and connected to the pipe lines only when it meets the approval of the Engineer-in-Charge.

1. **Rigid Line/ Hard Line/ Slick line:** Such lines shall be made either of steel or plastic. Aluminium alloy pipes shall not be used.

   Minimum pipeline diameter shall be 100 millimeters and shall have normal maximum length of 3 meter in each section connected through couplers.

2. **Flexible Pipe Line**: Flexible lines shall be made out of rubber or spiral wound flexible metal or plastic. The pipe shall again be such that they are in sections of 3 metre length each and connected through couplers. These pipes shall be such that they are interchangeable with rigid lines. While installing flexible units, care shall be taken that there are no links in the pipeline, which is a normal tendency with these pipes having diameter 100 mm and above.

v. **Couplers:**

Couplers to be used for connecting pipe line sections (either hard or flexible) shall have adequate strength to withstand stresses due to handling, misalignments, poor support to pipe lines etc.

For horizontal runs of pipes and for vertical run upto 30 meter height the couplers shall be rated for a minimum pressure of 35 kg/ cm square. Couplers used for rising runs between 30 meter and 50 meter heights shall have a minimum pressure rating of 50 kg/cm square. Couplers shall be designed to allow for replacement of any pipe section without displacing other sections. These shall provide for the full internal cross section. These shall provide for the full internal cross section with no constructions or service, which may disrupt the smooth flow of concrete. For pipelines of size 150mm and above, double togged type coupler with a thick rubber gasket and secondary wedge-take-up is recommended. Types of couplers that may be used shall be any of the following:-

- Grooved end coupler
- One piece extended lever swing type couplers
- And full flow oil line type couplers.

vi. **Other Accessories:** Other accessories which shall be catered for, are as under:-

a) Back up pump of rigid and flexible pipes of varying lengths of similar rating/specifications
b) Curved sections of rigid pipes
c) Swivel joints and rotary distributors

d) Pin and gate valves to prevent back flow in pipe lines
e) Switch valves to direct the flow into another pipe line
f) Connection devices to fill forms from the bottom up
g) Splints, rollers, and other devices for protection of conduit over rock concrete Reinforcing steel and form and to provide lifting and lashing points in the pipe line.
h) Transitions for connecting different sizes of pipe sections
i) Air vents for downward pumping.
j) Clean out equipment.

For concreting of columns, walls and scattered small placement, recommendation is made for special cranes or power controlled booms carrying pipe lines with a pendant type concrete delivery hose.

vii. **Lubricating of Pipe Line**

Before pumping concrete into the pipeline, the line shall be lubricated with a properly designed mortar/grout lubricant. This shall be ensured by starting the pumping operation with a properly designed mortar, or with a batch of regular concrete with the coarse aggregate omitted. The quantity of mortar required as lubricant is dependent on the smoothness and cleanliness of the pipelines. As a guide line, for a 100 mm diameter pipe line of 100 meter length, 0.08 cum to 0.10 cum of mortar should normally be adequate, but this shall not be taken as specified, and the Bidder shall establish his requirements.

The quantity of mortar that comes out of the delivery end of the pipeline shall not be used in place of the concrete work. However, with the approval of Engineer-in-Charge, this mortar may be used as bedding mortar against construction joints. The rest of the mortar shall be wasted.

Lubrication shall be maintained as long as the pumping of concrete continues.

L. **GUIDELINES FOR FIELD PRACTICE**

i. **General Precautions**

a. Proper planning of concrete supply, pump locations, line layout, placing sequence and the entire pumping operation will result in savings of time and expense.
b. The pump shall be placed as near the placement area as practicable. The surrounding area of the pump shall be free of obstructions to allow for movement of concrete delivery trucks. The surface must be strong enough to withstand the loaded trucks operating on it. If the surface is a suspended slab, the truck route shall be adequately supported in consultation with the Engineer-in-Charge.
c. Pipe lines from the pump to the placing area shall be laid with minimum number of bend. For large placement areas, alternate lines shall be installed for rapid connection when required. A flexible pipe at the discharge end will permit placing over a large area directly without re-handling of pipelines. The pipeline shall be firmly supported.
d. If more than one size of pipe must be used, the smaller diameter pipe shall be placed at the pump end and the larger diameter at the discharge end.
e. When pumping downwards, an air release valve shall be provided at the middle of the top bend to prevent vacuum or air build-up. Similarly, while pumping upwards, a no- return valve shall be provided near the pump to prevent the reverse flow of concrete.
f. It is essential that direct radio/telecommunication be maintained between the pump operator and the concrete placing crew. Good communication between the pump operator and the batching plant is also essential. The placing rate shall be

estimated by the pump operator so that concrete can be ordered at an appropriate delivery rate.

g. The pump shall be started for a check run and operated without concrete to ensure that all moving parts are in operation properly. Before placing concrete, the pump shall be run with some grout/mortar for lubricating the line.

h. When concrete is received in the hopper, the pump shall be run slowly until the lines are completely full and the concrete is steadily moving. A continuous pumping must be ensured, because, if the pump is stopped, concrete in the line may be difficult to move again.

i. When a delay occurs because of concrete delivery or some form repair works or for any other reason, the pump shall be slowed down to maintain some movement of concrete in the pipe line. For longer delays, concrete in the receiving hopper shall be made to last as long as possible by moving the concrete in the lines occasionally with intermittent strokes of the pump. It is sometimes essential to run a return line back to the pump so that concrete can be re-circulated during long delays.

j. If after a long delay, concrete cannot be moved in the line, it may be necessary to clean out the entire line. However, quite often only a small section of pipe line may be plugged and requires cleaning. The pump operator who knows such details as the length of line, age of concrete in the line etc., should be depended upon to aid in deciding the appropriate section to be cleaned.

k. 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” inserted at the appropriate time so that concrete ahead of the go-devil shall be forced completion of the work.

The go-devil shall be forced through the pipeline to clean it out. Use of water pressure is a safer method. The go-devil shall be stopped at the discharge end to ensure that water does not spill on the placement area, if air pressure is used, extreme care shall be taken and the pressure must be carefully regulated. A trap shall be installed at the end of the line to prevent the go-devil being ejected as a dangerous projectile. An air release valve shall also be installed in the line to prevent air pressure build up.

l. It is essential to clean the line after concrete placing operation is complete. Cleaning shall be done in the reverse direction from the form work end to the pump-end where the concrete in the line can be dumped in bucket. After removal of all concrete, all pipe lines and other equipments shall be cleaned thoroughly and made ready for the next use.

ii. **Submittals**

Along with their bid the Bidders shall be required to submit the following information regarding the equipments proposed to be used by them:-

a. Type, number, capacity, range, mounting, nature of primary power used and the operating weight of pump and mounting.

b. Manufacturer’s specifications for pipe lines giving pressure ratings, sizes and material for straight and curved sections.

c. Manufacturer’s certificates.

iii. **Sampling and Testing (Materials)**

1) **Aggregates**

(a) Supplier of aggregates shall furnish the following information before the material is delivered to site:-

- Precise location of source from where the material is to be supplied.
- Trade group of principal rock type as per table below :
- Presence or reactive minerals

Trade group name of Aggregates to be used for concrete	Granite, Gabbro, Dolerite, Rhyolite, Basalt, Quartzite, Gneiss

The supplier shall also furnish reports on test results giving the following information for approval to Engineer-in-Charge before delivery of material at site:-

(i) Specific gravity
(ii) Bulk density
(iii) Moisture content
(iv) Absorption Value
(v) Aggregate crushing strength
(vi) Aggregate impact value
(vii) Abrasion value (viii) Flakiness index
(ix) Elongation index
(x) Limits of deleterious substances in the aggregate
(xi) Soundness of aggregate
(xii) Potential reactivity of aggregates.

All tests shall be conducted in accordance with IS: 2386 (Part-I to VIII).

(c) Change in quality of aggregate as per trade group name shall not be acceptable in the work. Change in source of aggregates shall also not be acceptable under normal circumstances, even if the aggregate belong to the same trade group. Engineer-in-Charge may with his discretion allow a change in the source. But, in that case, all test mentioned in above shall have to be repeated for the aggregates form the changed source and the test results submitted to Engineer- in-Charge for his approval before the delivery of material at site.

(d) In addition to above, the following tests have to be performed on representative samples from every lot of aggregate after delivery at site. These test results are to be submitted to the Engineer-in-Charge for his approval. Acceptance criteria for aggregates shall be based on the results of this set of tests only. If in the opinion of the Engineer-in-Charge, the test results are not within permissible limits, the lot of aggregates from which the samples have been obtained for testing shall stand rejected and the material shall be removed from the site.

Mandatory tests on Aggregates at site

Tests	Nos. of Test on Each 50 Cum of Material or Part Thereof
Specific gravity	3
Bulk density	3
Aggregate crushing strength	3
Limits of deleterious substances	3
Aggregate impact value	3

Mean value of the results from above test shall be taken as the representative value and the acceptance criteria shall be based on these. All test procedures and computations for test results shall be as per IS: 2386.

(e) All other tests in para iv being in compliance with requirements set in specifications, if only the limits of deleterious substances do not meet the requirements, and attempt may be made to wash the aggregate to bring the limits within permissible values. Under such circumstances, moisture content check shall be made and allowance made before batching.

(f) Apart from mandatory tests specified above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. Sampling, procedure and computations for such test shall be done in accordance with IS: 2430 and IS: 2386 as applicable.

2) **Cement**:

Supplier of cement shall furnish the following documents before the cement is delivered to site:-

i. Certificate confirming that chemical composition and physical characteristics are within the stipulated values for types of cement supplied as per relevant codes.
ii. Certificate confirming that the chloride content in the cement is not in excess of 0.05 percent of mass of cement.
iii. If during subsequent testing of cement supplied in lots any of the properties are found to be outside the acceptable limits, the lot of cement shall be rejected.
iv. Each 1000 bags or part thereof the cement or each wagon load of cement shall constitute one lot of cement for the purpose of conducting tests at site before cement is accepted.
v. Samples for testing at site shall be taken at random from 2% of the total quantity supplied in one lot. For cement supplied in bags, samples shall be drawn from minimum of 5 bags and the 2% value shall be rounded off to the next higher integer.
For bulk cement, sampling shall be done with the help of slotted sampler to be as per IS: 3535.
vi. Results of test conducted on samples drawn shall be submitted to the Engineer- in-Charge for his approval. If in the opinion of the Engineer-in-Charge, the test results are not within permissible limits, the lot of cement from which samples have been obtained from testing shall stand rejected and the material shall be removed from site.

vii. Following tests shall be conducted at site on each lot of cement delivered:

Mandatory tests	Number of test per
Consistency of standard cement paste	5
Initial and final setting time	5 each
Compressive strength test	10

Mean values of the results from the above results shall be taken as the representative value and the acceptance criteria shall be based on these test. All test procedures and computation of test results shall be as per I.S. 4031.

viii. Apart from mandatory tests specified above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. All such tests shall be done on representative samples taken from each lot and testing and computation of test results shall be done as per IS: 4031.

3) **Water**

i. Water to be used in manufacturing and curing of concrete shall be tested before use. All such test results shall be submitted to the Engineer-in-Charge for his approval before water is used.
ii. Manufacturer/ Bidder responsible for curing concrete shall identify and inform the Engineer-in-Charge, precisely the location of source of water intended to be used. Each such source of water shall be separately tested. In the event of a change in the source of water all tests specified herein shall have to be repeated.
iii. In the event water is drawn from tube wells or open-wells, water samples shall be tested for seasonal fluctuations in water table or at intervals to be directed by the Engineer-in-charge.

iv. Water sample from each source shall be tested as under:-

Test	Number of test for each source
Acidity	3
Alkalinity	3
Presence of solids	3

Mean values of the above test shall be taken as the representative value and the acceptance criteria shall be based on these test results. All testing procedure and computation of test results shall conform to IS: 3025.

4) **Admixtures**

i. Suppliers of Admixtures for concrete shall supply the following before any admixtures is approved by the Engineer-in-Charge for their used:-
Certificate confirming that the use of a particular brand of admixture shall not be harmful to concrete in any way.
Certificate confirming the exact dosage of admixture of a particular brand.
Certificate stating the specific purpose for which the admixture is to be used. Special precautionary measures to be taken in the manufacturer of concrete when using the particular brand of admixture.
Certificate confirming that the admixture conforms to specifications of IS: 9103.
ii. Engineer-in-Charge at his discretion may require tests to be performed to reconfirm the characteristic properties of any admixture. All such tests shall be done in accordance with IS: 9103.
iii. All tests described above shall be done at the site laboratory or at a laboratory to be identified by the Engineer-in-Charge depending on the test to be conducted.
iv. All tests shall be done in the presence of a representative nominated by the Engineer-in-Charge and a representative of the concrete Manufacturer/ Bidder when tests are performed at the site laboratory. All observation and reports of test shall be jointly signed by the two representatives before the test results are submitted to the Engineer-in-Charge.
v. Expenses for all materials used for testing, sampling procedures and testing including preparing reports shall be borne by the concrete Manufacturer/ Bidder.
vi. Rate of concrete is inclusive of cost of admixtures. The Bidder shall not be paid anything extra for admixtures required for achieving direct workability without any change in specified water cement ration for RCC/CC work.

iv. **Sampling and Testing for Quality Control of Fresh Concrete**

Fresh concrete shall be tested for
a) Slump
b) Compacting Factor/ Workability
c) Consistency
d) Weight per cubic metre, cement factor and air content

a) Slump

1. For concrete totally mixed in a central plant, slump shall be checked at:-
(A) Immediately during loading of trucks
(B) Point of discharge from the delivery truck
(C) Final placement location
(D) At placement location the slump measured shall conform to the design slump. Manufacturer of concrete shall adjust for loss of slump in transit and establish the requirements of design mix. All slump measurements shall be done within a period of 20 minutes from the time cement is added to the mixer. Placement Bidder shall transport concrete from truck discharge point to actual placement location within 10 minutes of delivery, before the final slump reading is taken at placement location.

2. For concrete entirely mixed in transit or for shrink mix concrete, slump reading shall be taken at:-
   (A) Point of discharge from delivery trucks
   (B) Final placement location

   In this case also, the slump measured at the final placement location shall conform to the design slump. The placement Bidder shall be responsible for transporting concrete from delivery truck discharge point to final placement location within 10 minutes. However, in this case, the truck shall discharge the concrete within 1 hour and 30 minutes from the time cement is added in the mixer and slump measured at point of discharge immediately on delivery. Manufacturer of concrete shall ensure that the final slump measurement corresponds to the ordered slump.
3. For measuring concrete slump at point of discharge from delivery trucks, samples shall be taken from concrete omitting the first and the last 15% of the load. For concrete delivery of placed by pumping, sampling shall be similar to those specified for delivery trucks.
4. Slump measurements of ready mix concrete transported by buckets shall be at locations specified in this specification with same limits on time. Sampling from buckets shall be such that the buckets containing discharge from mixer for the last 15% are omitted.
5. At placement locations, samples for checking slump shall be collected from every 20 cum of concrete or part thereof placed at location for each type to concrete.
6. For all slump checks in the field at least two recordings shall be made and the average value taken as the recorded slump.
7. Slump checks for concrete in the laboratory shall be carried out as and when required by the manufacturer of concrete during the mix design stage and during the progress of work for control on field results.
8. Slump readings shall only be a guideline for concrete consistency and shall not be taken as the acceptability criteria for concrete placed at location. All slump test shall be carried out in accordance with IS: 1199.

b) Compacting Factor

1. For concrete whose ordered slump is 50 mm or less, compacting factor test shall be conducted at both field and central batch plant in addition to slump tests mentioned above.
2. Compacting factor check shall be done in field only at placement location, and shall also be conducted at central batch plant if concrete is totally mixed in plant.
3. For this test, sampling shall be done as for slump measurements in field and within the same frame as for slump test.
4. Only one compaction factor test shall be conducted for every 20 cum of concrete or part thereof placed at location for each type of concrete. Since the test is sensitive, every care shall be taken to conduct this test totally in compliance with procedure mentioned in IS: 1199.
5. Laboratory tests for determining compacting factor of concrete shall be done as per manufacturer's requirements for establishing and controlling the design mix of concrete.
6. Compacting factor test shall not be taken as an acceptance criteria and shall be treated only as a guideline to workability of concrete.

c) Consistency of Concrete:

This test shall be performed only at the batching plant laboratory using a Vee-Bee Consist meter, for determining and predicting the slump of concrete. Number and frequency of these tests shall be based on requirements of the manufacturer of concrete. Care shall be taken in producing mix design of required characteristic strengths of concrete within limits of Vee-Bee-Degrees between 1.6 and 4.5 for

concrete transported and placed by normal method and between 0.8 and 3.5 for concrete transported and placed by pumping methods.

d) **Weight, Cement Factor and Air contents Test** :

Freshly mixed concrete for every type shall be tested in the batch plant laboratory for each batch of concrete produced to determine weight per cubic metre of freshly mixed concrete, cement factor in concrete and the air content of the concrete.

Frequency and number of test shall be finalized by the manufacturer of concrete in consultation with the Engineer-in-Charge for his requirement of the mode of measurement of concrete produced.

The Engineer-in-Charge may at his discretion require further tests over and above those specified in IS code to be conducted on fresh concrete. The manufacturer and the placement Bidder shall have to comply with all such requirements.

v. **Sampling and Testing for Quality Control of Hardened Concrete**

(A) Test on cube crushing strength of concrete in accordance and compliance with IS:456 and IS:516 shall done as under:-

a. Sample of fresh concrete shall be taken from concrete at central batch plant mixer while loading delivery trucks or other transport and also from concrete transported to placement location.

b. Test on specimens made form samples collected at placement location shall be considered as field test specimens and results therefrom shall be the criterion of concrete strength. Test in specimens made from samples at the batch plant shall only be taken as guidelines test. Only in the case of doubtful result, the Engineer-in-Charge may refer to such guideline results for deciding on the quality of concrete.

c. For truck mix concrete and shrink mix concrete guideline test specimens shall be made from samples collected at discharge location from mixing trucks. For this purpose first and last 15% of the load shall be omitted while collecting samples.

d. Frequency of sampling shall be as given below for each grade of concrete of different workability's and for each type of specimens (field test specimens and guideline test specimens) for conducting 28 days crushing strength tests.

Quantity of concrete Delivered	Number of samples
Less than 5	1
6 to 15	2
31 to 50	3
51 and above sample for each	4 plus one additional 50 cum or part thereof

Each sample shall be of adequate quantity so that a minimum of 3 specimen cubes can be made test of the sample in accordance with IS: 516.

e. All test specimens shall be made compacted cured and tested in compliance with IS: 516 and test result interpreted in accordance with IS: 456 for acceptance of concrete strength, field specimens test results shall not be less than values given.

f. In addition to 28 day crushing strength test on specimens made at frequencies specified in above, early strength tests at 7 days shall also be conducted on field specimens as well as guideline test specimens. Frequency of sampling for this set of test shall also be same as those specified above. 7 day strength shall conform to values given. But these test results even if conforming to specified values shall only be taken a guideline values for projecting concrete strength and shall not be construed as conforming to specifications.

g. For each grade of concrete and for all workability conditions with different water – cement ratios and compositions of admixtures, preliminary test shall be conducted for crushing strength on finalization to design mix for each type of concrete. Such test shall be conducted both at 7 days and 28 days under laboratory conditions. Six test specimens shall be made for 7 days test and six test specimens shall be made for 28 days test. Average of the six test results of different periods shall not be less than those specified.

h. Crushing strengths on cubes shall also be conducted during the process of finalization of concrete design mix. Frequency and number of such tests shall be as per Mix of requirements of concrete manufacturer.

i. All test specimens for conducting crushing strength shall be properly labelled for identification indicating:-
i. Date of making specimen
ii. Grade of concrete
iii. Placement location exact
iv. Purchasers order number

j. In addition to crushing strength test on concrete, the Engineer-in-Charge may call for other tests on hardened concrete. The placement Bidder and the manufacturer of concrete shall comply with all such instructions.

(B) Non-destructive Tests

a. When the 28 days crushing values on field specimens and/ or specimens and/or specimens made for guideline test fall short of specified values, or in case of doubtful placement of concrete, the Engineer-in-Charge shall call for non-destruction tests on the structure. Such tests may be any one or a combination of the following:-

i. Rebound hammer test
ii. Windsor Penetration Probe test
iii. Pulse velocity (sonic or Ultrasonic) test
iv. Core test
v. Load test

b. Interpretation of rebound hammer, Windsor Probe and Pulse velocity test results shall rest with the Engineer-in-Charge.

c. Core test, if ordered by the Engineer-in-Charge, shall be done in accordance with IS: 516. Samples for such test shall be taken from locations to be identified by the Engineer-in-Charge and such samples shall be collected in compliance with IS: 1199.

d. If felt necessary, the Engineer-in-Charge may instruct load testing for any part of the structure based on doubtful concrete strengths. Such test shall be carried out as per details to be provided by the Engineer-in-Charge in consultation with the structural consultants.

e. The concrete manufacturer/ concrete placement Bidder shall arrange for all test to be conducted in accordance with these specifications, including all necessary tools, plants, equipment and material, and shall be responsible for conducting all test at his cost.

f. All test conducted at the field/ laboratory shall be carried out by qualified technicians employed by the concrete manufacturer/ concrete placement Bidder, in presence of authorized representative of the Engineer-in-Charge. All test reports and observation reports shall be jointly signed by the Engineer-in- Charge authorized representative and the technician conducting such test.

g. Engineer-in-Charge shall alone decide where such tests are to be conducted. He may instruct tests to be conducted at laboratories other than the field laboratory and such instructions shall be followed without claiming extra charges on this account.

h. The Concrete Manufacturer/ Placement Bidder shall set up a laboratory at this own expense which shall have facilities, for conducting all necessary field test on materials and field and laboratory test on concrete. The laboratory shall be staffed by the concrete Manufacturer/ Placement Bidder with qualified and experienced scientists and technicians.

APPENDIX A

CUBE TEST FOR COMPRESSIVE STRENGHT OF CONCRETE- MANDATORY LAB TEST

One sample (consisting of six cubes 15x15x15 cm) shall be taken for every 20 cum or part thereof concrete work ignoring any part less than 5cum or as often as considered necessary by the Engineer-in-charge. The test of concrete cubes shall be carried out in accordance with the procedure as described below. A register of cubes shall be maintained at the site of work in Appendix C of this clause. The casting of cubes, concrete used for cubes and all other incidental charge, such are curing, carriage to the testing laboratory shall be borne by the Bidders. The testing fee for the cubes, if any, shall be borne by the department.

A. Test Procedure

i. Mould

The mould shall be of size 15 cm x15 cm x 15 cm for the maximum nominal size of aggregate not exceeding 40 mm. For concrete with aggregate size more than 40 mm size of mould shall be specified by the Engineer-in-charge, keeping in view the fact that the length of size of mould should be about four times the size of aggregate.

The moulds for test specimens shall be made of non-absorbent material and shall be substantially strong enough to hold their form during the moulding of test specimens. They shall not vary from the standard dimensions by more than one percent. The moulds shall be so constructed that there is no leakage of water from the test specimen during moulding. All the cube moulds for particular site should, prior to use, be checked for accuracy in dimensions and geometric form and such test should at least be made once a year.

Each mould shall be provided with a base plate having a plane surface and made of non-absorbent material. This plate shall be large enough in diameter to support the moulds properly without leakage. Glass plates not less than 6.5mm thick or plain metal not less than 12 mm thick shall be used for this purpose. A similar plate shall be provided for covering the top surface of the test specimen when moulded.

Note: Satisfactory moulds can be made from machine or steel castings, rolled metal plates or galvanized.

ii. Sample of Concrete

Sample of concrete for test specimen shall be taken at the mixer or in the case of ready mixed concrete from the transportation vehicle discharge or as directed by Engineer-in-charge. Such samples shall be obtained by repeatedly passing a scoop or pail through the discharge stream of concrete. The sampling operation should be spread over evenly to the entire discharging operation. The samples thus obtained shall be transported to the place of moulding of the specimen to counteract segregation. The concrete shall be mixed with a shovel until it is uniform in appearance. The location in the work of the batch of concrete this sampled shall be noted for further reference. In case of paving concrete, samples shall be taken from the batch immediately after deposition of the sub grade. At least five samples shall be taken from different portion of the pile and these samples shall be thoroughly mixed before being used to form the test specimen. The sampling shall be spread as evenly as possible throughout the day. When wide changes occur during concreting, additional sample shall be taken if so desired by the Engineer-in-charge.

iii. Preparation of test specimens

The interior surfaces of the mould and base plate shall be lightly oiled before the concrete is placed in the mould. The samples of concrete obtained as described under the test specimen shall be immediately moulded by one of the following methods as indicated below:-

When the job concrete is compacted by manual methods, the test specimen shall be moulded by placing the fresh concrete in the mould in three layers, each approximately one third of the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge do the mould as the concrete there sided from it, in order to ensure a uniform distribution of concrete within the mould. Each layer shall be rodded 35 times with 16 mm rod, 60 cm in length, bullet pointed at the lower end. The strokes shall be distributed in uniform manner over the cross section of the mould and shall penetrate into underlying layer. The bottom layer shall be rodded through its depth. After the top layer has been rodded, the surface of the concrete shall be struck off with a trowel and covered with a glass plate at least 6.5 mm thick or a machined plate. The whole process of moulding shall be carried out in such a manner as to preclude the change of the water cement ratio of the concrete, by loss of water either by leakage from the bottom or over flow from the top of the mould.

When the job concrete is placed by vibration and the consistency of the concrete is such that the test specimens cannot be properly moulded by hand rolling as described above, the specimens shall be vibrated to give a compaction corresponding to that of the concrete. The fresh concrete shall be placed in mould in two layers, each approximately half the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mould as the concrete there slides from it, in order to ensure a symmetrical distribution of concrete within the mould. Either internal or external vibrators may be used. The vibration of each layer shall not be continued longer than is necessary to secure the required density. Internal vibrators shall only be used when the concrete is required to be compacted in layers. In compacting the first layer, the vibrators shall not be allowed to rest on the bottom of the mould. In placing the concrete for top extent that there will be no mortar loss during vibrations. After vibrating the second layer enough concrete shall be added to bring level above the top of the mould. The surface of the concrete shall then the struck off with a trowel and covered with a glass or steel plate as specified above. The whole process of moulding shall be carried out in such a manner as to preclude the alteration of water-cement ratio of the concrete by loss of water, either by leakage for the bottom or over flow from the top of the mould.

iv. Curing and storage of test specimen

In order to ensure reasonably uniform temperature and moisture conditions during the first 24 hours for curing the specimen and to protect them from damage, moulds shall be covered with wet straw or gunny sacking and placed a storage box so constructed and kept on the work site that its air temperature when containing concrete specimens shall remain 22℃ to 33℃. Other suitable means which provide such a temperature and moisture conditions may be used.

Note:-It is suggested that the storage box be made of 25 mm dressed tongued and grooved timber, well braced with battens to avoid warping. The box should be well painted inside and outside and should be provided with a hinged cover and padlock.

v. Testing

The specimens shall be tested in accordance with procedure as described below:

a. The tests shall be made at an age of concrete corresponding to that for which the strengths are specified.

b. Compression tests shall be made immediately upon removal of the concrete test specimen from the curing room i.e. the test specimen shall be loaded in damp condition. The dimensions of the test specimens shall be measured in mm accurate to 0.5mm.

c. The metal bearing plates of the testing machine shall be placed in contact with the ends of the test specimens. Cushioning materials shall not be used. In the case of cubes, the test specimen shall be placed in the machine in such a manner that the load is applied to sides of the specimens as cast. An adjustable bearing block shall be used to transmit the load to the test specimen. The size of the bearing block shall be same or slightly larger than that of test specimen. The upper or lower section of the bearing block shall be kept in motion as the head of the testing machine is brought to a bearing on the test specimen.

d. The load shall be applied axially without shock at the rate of approximately 140 Kg. per sq.cm. Per minute. The total load indicated by the testing machine at failure of test specimen shall be recorded and the unit compressive strength is calculated in kg per sq. cm. using the area computed from the measured dimension of the test specimen. The type of failure and Appearance of the concrete shall be noted.

APPENDIX B

ADDITIONAL TESTS FOR CONCRETE

B. In case the concrete fails when tested as per the method prescribed in Appendix A, one or more of the following check tests may be carried out at the discretion of Engineer-in-charge to satisfy the strength of the concrete laid. All testing expenditure shall be borne by the Bidder, the number of additional tests to be carried out shall be determined by the Engineer-in-charge. He shall be the final authority for interpreting the results of additional test and shall decide upon the acceptance or otherwise. His decision in this regard shall be final and binding. For the purpose of payment, the Hammering test results only shall be the criteria. Some of the tests outlined below:-

i. REBOUND HAMMER TEST

If a rebound hammer is regularly used by trained personnel in accordance with procedure described in IS: 13311 (part II) and a continuously maintained individual charts are kept showing a large number of reading and the relation between the reading and strength of concrete cubes made from the same batch of concrete, such charts may be used in conjunction with hammer readings to obtain an approximate indication of the strength of concrete in a structure for element. If calibration charts are available from manufactures, it can be used. When making rebound hammer test each result should be the average of at least 12 readings. Reading should not be taken within 20mm of the edge of concrete members and it may be necessary to distinguish between readings taken on a troweled face and those on a molded face. When making the tests on a precast unit, special care should be taken to bed them firmly against the impact of the hammer.

ii. CUTTING CORES

This method involves drilling and testing cores from the concrete for determination of compressive strength. In suitable circumstances, the compressive strength of the concrete in the structure may be assessed by drilling cores from the concrete and testing. The procedure used shall comply with the requirements of IS: 1199 and IS: 516.

The points from which cores shall be taken shall be representative of the whole concrete and at least three cores shall be obtained and tested. If the average of the strength of all cores cut from the structure is less than the specified strength, the concrete represented by the cores shall be liable to rejection and shall be rejected if a static load test (B-5) either cannot be carried out or is not permitted by the Engineer-in-charge.

iii. ULTRASONIC TEST

If an ultrasonic apparatus is regularly used by trained personnel in accordance with IS: 13311 (part I) and continuously maintained individual charts are kept showing a large number of readings & the relation between the reading and strength of cubes made from the same batch of concrete, such charts may be used to obtain approximate indications of the strength of concrete in the structures. In cases of suspected lack of compaction or low cube strength the results obtained from the ultrasonic test results on adjacent acceptable section of the structures may be used for the purpose of assessing the strength of concrete in the suspected portion.

iv. LOAD TESTS ON INDIVIDUAL PRECAST UNITS

The load tests described in this clause are intended as check on the quality of the units and should not be used as substitute for normal design procedure. Where members require special testing. Such special testing procedures shall be in an accordance with the specification. Test load shall be applied and removed incrementally.

a. Non Destructive Tests

The unit shall be supported at its designed point of support and loaded for five minutes with a load equal to the sum of the characteristic dead load plus one and a quarter time the characteristic imposed load. The deflection is then recorded. The maximum deflection after application of the load shall be in accordance with the requirements defined by the Engineer-in-charge. The recovery is measured five minutes after the removal of the load and the load then reimposed. The percentage recovery after the second loading shall be not less than that after the loading nor less than 90% of the deflection recorded during the second loading. At no time during the tests, shall the unit show any sign of weakness or faulty construction as defined by the Engineer-in-charge in the light of reasonable interpretation of relevant data.

b. Destructive Tests

The unit is loaded while supported at its design point of support and must not fail at its design load for collapse, within 15 minutes of time when the test load becomes operative. A deflection exceeding 1/40 of the test span is regarded as failure of the unit.

c. Special Tests

For very large units or units not readily amenable to the above test e.g. columns, the precast parts of composite beams and members designed for continuity or fixity, the testing arrangements shall be agreed upon before such units are cast.

v. Load Test of Structures or Parts of Structures

The test described in this clause are intended as a check where there is a doubt regarding structural strength. Test loads are to be applied and removed incrementally.

a. Age at Tests

The test is to be carried as soon as possible after the expiry of 28 days from the time of placing of the concrete. When the test is for a reason other than the quality of concrete in the structure being in doubt, the test may be carried out earlier, provided that the concrete has already reached specified characteristic strength.

b. Measurements During Tests

Measurements of deflection and crack width shall be taken immediately after applications of the load and, in the case of 24 hour sustained load test, at the end of 24 hour loaded period, after removal of the node and after 24 hour recovery period. Sufficient measurements shall be taken to enable side effect to be taken in account. Temperature and weather conditions shall be recorded during the tests.

c. Assessment of Results

In assessing the strength of a structure or a part of the structure following a loading test, the possible effects of variation in temperature and humidity during the period of the test shall be considered. The following requirements shall be met:

1. The maximum width of any crack measured immediately on application of the test load for local damage, is to be not more than 2/3 of the value of the appropriate limit state requirement.

2. For members spanning between two supports the deflection measured immediately on application of the test load for deflection is to be not more than 1/500 of the effective span limits shall be agreed upon before testing cantilevered portions of structure.

3. If maximum deflection in mm shown during 24 hour under load is less than $40L^2/D$ where L is effective span in mm and D is overall depth of construction in mm, it is not necessary for recovery to be measured and the requirement (D) does not apply, and

4. If within 24 hours of the removal of test load for collapse as calculated in reinforced concrete structure does not show a recovery of atleast 75 percent of the maximum deflection shown during the 24 hour under load, the loading should be repeated. The structure should be considered to have failed to pass the test if the recovery after second loading is not atleast 75 percent of the maximum deflection shown during the second loading.

vi. DETERMINATION OF WATER SOLUBLE AND ACID SOLUBLE CHLORIDES IN CONCRETE

Determination of water soluble and acid soluble chlorides in concrete shall be done as per method of test given in IS: 14959 (part 1) which covers volumetric method of test as described below:

a. Quality of Reagents
Unless otherwise specified, pure chemicals of analytical reagent grade and distilled water (see IS: 1070) shall be used in the test.
b. Nitric Acid (HNO_3) Concentrated (Specific Gravity 1.42)
Prepare the solution, (6N (approximately), by diluting 38ml of concentrated Nitric acid to 100ml with distilled water.
c. Ferric Alum($FeNH_4$ $(SO_4)_2$ 12 H_2O)
Dissolve 10g of ferric alum in 100 ml of distilled water and 1 ml of Nitric acid.
d Chromite 5% Solution
Dissolve 5 g of potassium chromate (K2 CrO4) 100 ml of distilled water to form 5% Solution. e.Nitrobenzene
f. Silver Nitrate ($AgNO_3$) Solution, 0.02N
Weigh 1.7 g of silver nitrate, dissolve in distilled water and dilute to 500 ml in a volumetric flask. Standardize the silver nitrate solution against 0.02 N sodium chloride solution using potassium chromate solution as indicator (5 percent m/v) in accordance with the procedure given in IS:3025 (Part 32)
g. Ammonium thiocyanate (NH_4 SCN) Solution
Weigh 1.7 g of ammonium thiocyanate (NH4 SCN) and dissolve in one litre of distilled water in a volumetric flask. Shake well and standardize by titrating with 0.02N silver nitrate solution using ferric alum solution as an indicator. Adjust the normality exactly to 0.02N.
h. Sodium chloride (NaCl) 0.02N

Weigh 1.1692 g of sodium chloride (NaCl) dried at 105 +/- 2℃, dissolve in distilled water and make upto 1000 m in a volumetric flask.

i. Use of Filter Paper

j. In the methods prescribed in this standard, relative numbers of Watman filter paper only have been prescribed since these are commonly used. However, any other suitable brand of filter papers with equivalent porosity may be used.

k. Procedure for Water Soluble Chloride

Weigh 1000+/5 g of fresh mortar or concrete sample in a 2 litre capacity beaker and 500 ml of distilled water (chloride free). Stir the mixture vigorously for 15 minutes. After allowing the mixture to sand for 10 to 15 minutes for settling, decant about 200 ml of the supernatant solution into a clean dry 250 ml capacity beaker. Immediately, Filter the solution through watman filter paper No.1 and collect the filtrate.

Pipette 50 ml of filtrate in a 250 ml capacity conical flask. Add 5 ml of 6 n Nitric acid. Add a known volume (x), preferably 25 ml of nitrobenzene. Shake vigorously to coagulate the precipitate. Titrate the excess silver nitrate with 0.02 n ammonium solution until a permanent faint reddish brown colour appears. Note down the volume (y) of ammonium thiocyanate used.

l. **Procedure for acid soluble chloride**

Weigh about +/- 5 g of the fresh motor or concentrate sample in a 2 litre beaker and add 50 ml of 6 N nitric acid and 450 ml of distilled water (chloride free) after stirring for few minutes. Stir the mixture vigorously for 15 minutes. After allowing the mixture to stand for 10 to 15 minutes for settling, decant about 200 ml, the supernatant solution into a clean dry 250 ml capacity beaker immediately, filter, the solution through watman filter paper No.1 and collect the filtrate.

Pipette 50 ml of filtrate in a 250 ml capacity conical flask. Add 5 ml of 6N nitric acid. Add a known volume (x) preferably 25 ml of standard silver nitrate solution. Add 1 ml ferric alum and 5 ml of nitrobenzene. Shake vigorously to coagulate the precipitate. Titrate the excess silver nitrate with 0.02 N ammonium thiocyanate solution until a permanent faint reddish brown colour appears. Note down the volume (Y) of ammonium thiocyanate used.

m. **calculation:**

Calculate the percentage of chloride (acid soluble/water soluble0 by mass of mortar or concrete as follows:

Chloride, percent = 0.00071(X-Y)
Where
X= volume of silver nitrate added, in ml
Y=volume of 0.02 N ammonium thiocyanate consumed.

NOTE: Interference of silver chloride particles (which are generated in situ) in titration by reacting with thiocyanate can be avoided by the addition of nitrobenzene which forms a film on silver chloride particles.

APPENDIX-C

REGISTER OF WORK TEST OF CONCRETE

a) Name of work	Concrete mix, (by volume)	Compressive strength in kg/cm2 on 7 days
b) Name of Bidder	1:1:2	210
c) Agreement no.	1:1:5:3	175
d) Sample No.	1:2:4	140
e) Identification mark		
f) Portion of work any quantity represented by sample		
g) Date and time of casting cube		
h) Proportion of mix /grade of concrete		

7 DAY'S TEST

(1) Due date of test	Cube no.
(2) Actual date of test	
(3) (a) Minimum strength	
(b) maximum strength	
(c) Average strength of three cubes	
(d) Difference between 3a and 3b	
(e) Difference in % age in terms of average strength i.e 3b-3a/3c) x100	
(4) Specified compressive strength of concrete mix used	
(5) (a) if 3(e) is more than 30%	Sample is not acceptable, then 28 days strength test shall be carried out.
(b) if 3(e) is equal to or less than 30% then proceed as below:-	
(i) difference between column 4 specified compressive strength and column 3 (c) i.e. actual average is higher, it will be denoted (+) and(-) if it is less	
(ii) difference in column 5(b) (I) terms of %age of specified strength	(3(c)-(4))/4 x 100
(iii) if the difference in column 5 (b) (I) is +ve and the same in terms of % age of specified strength (4) i.e. value of col. 5(b) (ii) is within (+15% range)	Acceptable & strength is considered in order

REGISTER OF WORK TEST OF CONCRETE

(a) Name of work	Concrete mix, (by volume)	Compressive strength in kg/cm2 on 7 days
(b) Name of Bidder	1:1:2	315
(c) Agreement no	1:1:5:3	265
(d) sample No.	1:2:4	210
(e) Identification mark		
(f) Portion of work any quantity represented by sample		
(g) date and time of casting cube		
(h) proportion of mix /grade of concrete		

28 DAYS TEST

(1) Due date of test	Cube no.
(2) Actual date of test	
(3) Actual compressive strength of cubes (min no. of cubes to be tested -there)	
(a) Minimum strength	
(b) Maximum strength	
(c) Average strength of three cubes	
(d) Specified compressive strength of concrete mix used	
(e) 70% specified strength	i.e. 70% of 3(d)
(e) 130% specified strength	i.e. 130% of 3(d)
(4) if 3(b) =3(f) and 3(a)≥3(e)	Value of 3(c) shall be compressive strength of sample
(5) if 3(c) is more than 3(f)	EE may order further
(6) if any test value exceeds 3(f)	It should be restricted to 3(f) for compulsion of strength
(7) if 3(c)≥ 3(d) but < 3(f)	Strength is in order and concrete accepted at full rates.
(8) if 3(c)< 3(d) but > 3(e)	Concrete may be accepted at reduced rates in a accordance with specification / codes
(9) if 3(c)< 3(e)	Work represented by this sample shall be rejected and action taken as prescribed in

APPENDIX-D

LIST OF EQUIPMENTS REQUIRED FOR SITE LABORATORY

A. Aggregate testing:

ITEMS		QUANTITY
1. Aggregate Testing	1. STANDARD SIEVES (INDIAN STANDARD)	
	(a) Set of coarse sieves 30 cm dia (GI sheet frames) with 1 set aperture size. (40 mm, 25 mm,20 mm,16mm, 17.5 mm,0 mm, 4.75 mm, all with lid and pan)	1 set
	(a-1) Motorized sieve shaker for the above sieves	1 no
	(b) Set of fine sieves 20 cm dia of brass with aperture size. (4.75 mm, 2.36 mm,1.18 mm,600mic, 300mic,150 mic, 75 mic, all with lid and pan)	1 set
	(b-1) Motorized sieve shaker for the	1 no
2. Flakiness & Elongation index screen		1 no
3. Riffle sample divider slot width 25 mm		1 no
4. 1 Los angles abrasion testing machine		1 no
5. Bulk density and voids of aggregates cylindrical metal measures with capacity (3 lit, 10lit, 15 lit, or 20 lit.)		1 no. each
6. density basket of galvanized wire height 20 cm		1 no
7. Pycrometer 1000 ml capacity with height 20cm		1 no
8. Hot- air blower (Hair dryer)		1 no
9. Aggregate impact value apparatus with automatic blow counter		
10. Hot-plate 1000 to 2000 wells with regulator cum switch		1 no
11. Drying pans (frying pans)		2 Nos
12. China clay dishes with dia 10cm & 15 cm		2 Nos/each
13. Watch glasses for above 10 cm& 15 cm		2 Nos/each

B. Concrete Testing:

1	Sieve brushes	2 Nos.
2	Concrete cube moulds 15x15x15 cm	50 Nos.
3	Ultrasonic test equipment	1 No.
4	Pruning rods 2 Kg weight length 40 cm and ramming face 25mm2	2 Nos.
5	Extra bottom plates for 15 cm cube mould	6 Nos.
6	Standard vibration table for gauging the cubes	2 Nos.

7	Compression testing machine with electricity cum manually operated temping unit with pressure gauge preferable 30cm dia, 0-150 to	1 No.
8	1 air content measuring apparatus	1 No.
9	Slump test apparatus complete	3 Nos.
10	Pocket concrete pernetrometer 0 to 50 Kg/sq.cm	1 No.
11	Baby mixer machine	1 No.
12	G.I. Tray approx. 1mx 1m with sides 10 cm high for hand mixing of concrete	2 Nos.
13	Concrete temperature measuring thermometer with brass protection sheath 0-100 degree centigrade	2 Nos.

C. Cement Testing

1	Motor cube moulds 7.07x7.07x7.07 cm	10 Nos.
2	Standard sand grade	54 Kgs./each
3	Mortar cube vibrator	1 No.
4	Vicat needle apparatus computer	1 No.
5	Biane's apparatus	1 No.

D. Weighing Equipment:

1	Physical balance capacity 200gms with weight pony	1 No.
2	Dial type spring balance preferable with zero correction knob capacity 100 kgs reading to ½ kg	2 Nos.
3	Counter scale capacity 1 kg and 10kg	1 No./ each
4	Weighing platform capacity 100kg	1 No.
5	Iron weight of0.5 kg,2 kg, 1kg, 500gm, 200 gm, 100gm.	2 No. / each
6	Brass weight of 50 gm,20 gm, 10 gm, 50gm, 5 gm, 2 gm, 1 gm.	2 No. / each

E. Water Measuring:

1	5 litres, 2litres, 1 litre, ½ litre	5 Nos/ each

F. Glass and Plastic Ware

1	Measuring cylinder TPX or poly propylene capacity 100 ml, 500 ml,250 ml,100 ml.	2 No. / each
2	Pyrex, corning or borosil beakers with cover capacity 500 ml, 200 ml, 50 ml,	2 No. / each
3	Wash bottle capacity 500 ml.	2 No. / each
4	Thermometers 1-100 degree cent grade's/max and min/ dry and wet with table	1 No.

G. Laboratory Tools

1	Set of box	2 Nos.
2	Hammer 1lb	2 Nos.
3	Rubber hammer	2 Nos.
4	Hacksaw with 6 blades	1 No.
5	Measuring tape 2 mtr.	2 Nos.
6	Depth gauge 20 cm	2 Nos.
7	Steel foot plate	2 Nos.
8	Vernier caliper	2 Nos.

H. Miscellaneous items:

1	Trowels made from saw blade, 3 mm thick 16x10 cm wooden blade	6 Nos.
2	Shovels & spade	6 Nos./each
3	Steel plates 5 mm thick 75x75cm	2 Nos.
4	Plastic or G.I. Buckets 15 lit, 10 lit, 5 lit.	2 Nos.
5	Wheel barrow	3 Nos.
6	Floor brushes , hair dusters, scrappers, wire brush, paint brush, shutter steel plate oil, kerosene with stove etc.	3 Nos.

8.13.0 Brick Work

A. List of applicable code

S.No	IS Code No.	Subject
1	IS:712	Specification for building limes.
2	IS:1077	Common burnt clay building bricks
3	IS:1200 (Part 3)	Method of measurements of brick works

S.No	IS Code No.	Subject
4	IS:2212	Code of practice for brick work. (1st Revision)
5	IS:2222	Specification for burnt clay perforated building bricks.
6	IS:2849	Specification for non-load bearing gypsum partition blocks, (Solid and hollow types
7	IS:3495	Method of test for burnt clay building bricks
8	IS:3812	Specification for fly ash for use as pozzolano and admixture
9	IS:4139	Specification of calcium silicate bricks
10	IS:4885	Specification for sewer brick
11	IS:5454	Methods of sampling of clay building bricks
12	IS:12894	Pulverized fuel ash lime bricks specification
13	IS:13757	Specification of burnt clay fly ash bricks
14	IS:1127	Recommendations for dimensions and workmanship of natural building stones for masonry work.
15	IS:2691	Burnt clay facing bricks
16	IS:4441	Code of practice for use of silicate type chemical resistant mortars

B. **List of Mandatory test**

Material	Test	Field / Laboratory test	Test procedure	Minimum quantity of material/work for carrying out
Bricks/Brick Tiles	Testing of Bricks/Brick Tiles for dimensions, Compressive strength, Water absorption and efflorecence	Lab	Appendix A,B,C & D of this clause	As per specification
Burnt clay perforated building bricks	Dimensions, Compressive strength, Water absorption and efflorecence	Lab	Appendix A,B,C & D of this clause	As per specification

C. **TERMINOLOGY**

Bond

The arrangement of the bricks in successive courses to tie the brick work together both longitudinally and transversely. The arrangement is usually designed to ensure that no vertical joint of one course is exactly over the one in the next course above or below it, and there is greatest possible amount of lap.

Bed Joint

Horizontal joint in brick work or masonry.

Closer

Any portion of a brick used in constructing a wall, to close up the bond next to the end brick of a course.

Coping or Weathering

The cover applied over or the geometrical form given to a part of structure to enable it to shed rain water.

Corbel

A cantilever projecting from the face of a wall to form a bearing.

Cornice

Horizontal or ornamental feature projecting from the face of a wall.

Course

A layer of bricks including bed mortar.

Cross joint

A joint other than a bed joint normal to the wall face.

Efflorescence

A powdery incrustment of salts left by evaporation. This may be visible on the surface or may be below surface. In the latter case, this is termed as crypto Efflorescence.

Header

A brick laid with its length across the wall.

Indenting

The leaving recesses into which future work can be bonded.

Jamb

The part of the wall at the side of an opening.

Joint

A junction of bricks.

Jointing

The operation of finishing joints as the masonry work proceeds.

Pier

A thickened section forming integral part of the wall placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical concentrated load. The thickness of a pier is the overall thickness including the thickness of the wall, or when bonded into one leaf of a cavity wall the thickness obtained by treating this leaf as an independent wall.

Pillar

Pillar means a detached masonry support. This can be rectangular, circular, elliptical etc. In case of rectangular pillar, the breadth shall not exceed three times the thickness and thickness itself shall not exceed more than thrice the length of brick.

Quoin

An external corner in brick work, the term may also denote the brick used to form the quoin.

Scaffolding

A temporary erection of timber or steel work used in the construction, alteration, demolition or repairs of a building to support or to attend of the hoisting or lowering of workmen, their tools and materials.

Scaffoldings are of two types, namely single and double scaffoldings. Single scaffolding consists of a row of verticals connected to wall by horizontal supported on and tied to the structure. Double scaffolding consists of two rows of verticals secured or leashed together with horizontal and diagonal bracings forming essentially a structure independent of the building. It may also connect to the structure at convenient points for the sake of better stability.

Sill

A brick work forming the lower boundary of door or window opening.

Spandrel

The space between the haunches and the road decking of an arch.

Stretcher

A brick laid with its length in the direction of the wall.

String course

A horizontal course projecting from a wall usually introduced at every floor level or windows or below parapet for imparting architectural appearance to the structure and also keeping off the rain water.

Templet

A pattern of sheet metal used as a guide for setting out specific section and shape.

Toothing

Bricks left projecting in alternate courses to bond with future work.

Wall joint

A joint parallel to the wall face.

D. **BRICKS/BRICK TILES/BRICK BATS/MECHANIZED AUTOCLAVE FLY ASH LIME BRICK**

Bricks used in the masonry may be of the following type.

a. **Common Burnt Clay Bricks**

i. Bricks shall conform to IS: 1077 & shall be hand-moulded or machine-moulded and shall be made from suitable soils. They shall be free from cracks and flaws and nodules of free lime.
ii. Hand-moulded bricks of 90 mm or 70 mm height shall be moulded with a frog 10 to 20mm deep on one of its flat sides; the shape and size of the frog shall conform to code. Bricks of 40mm height as well as those made by extrusion process may not be provided with frogs.
iii. The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour.

b. **Fly Ash Lime Bricks (FALG Bricks):** The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS: 12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side. Fly ash shall conform to IS: 3812.

Note: This item will be operated only for load bearing structure upto 2 storeys and for non-load bearing walls 23cms thick for multi-storeyed buildings.
Bottom ash used as replacement of sand shall not have more than 12% loss on ignition when tested.

Sand: Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

Lime: Lime shall conform to class 'C' hydrated lime of IS: 712.

Additives: Any suitable additive considered not detrimental to the durability of bricks may be used.

c. **Clay Fly Ash Bricks:** The clay fly ash bricks shall conform to IS: 13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter, the bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly Ash shall conform to grade me or grade II of IS: 3812.

d. **Calcium Silicate Bricks:** The bricks shall conform to IS: 4139. The Calcium silicate bricks shall be sound, compact and uniform in shape. Bricks shall be free from visible cracks, warpage, organic matter, large pebbles and nodules of free lime. Bricks shall be solid and with or without frog. The bricks shall be made of finely grounded sand siliceous rock and lime. In addition limited quantity of fly ash conforming to IS: 3812 may be used in the mix. These bricks are also known as Fly Ash Sand Lime bricks in the construction industry.

e. **Tile Brick:** The bricks of 4 cm height shall be moulded without frogs. Where modular tiles are not freely available in the market, the tile bricks of F.P.S. thickness 44 mm (1-3/4") shall be used unless otherwise specified.

f. **Brick Bats:** Brick bats shall be obtained from well burnt bricks.

g. **Mechanized Autoclave Fly Ash Lime Brick:** These bricks shall be machine moulded and prepared in plant by appropriate proportion of fly ash and lime. The autoclave fly ash bricks shall conform to IS: 12894. Visually, the bricks shall be sound, compact and uniform shape, free from visible cracks, warpage and organic matters. The brick shall be solid with or without frog, and of 100/80 mm in length, 40 mm width and 10 to 20 mm deep one of its flat side as per IS:12894. The brick shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour. Fly ash shall conform to IS: 3812 and lime shall conform to class 'C' hydrated lime of IS: 712.

I. **Dimensions**

A. The standard modular building bricks shall be as follows

Length (L)	Width (W)	Height (H)
mm	mm	mm
190	90	90
190	90	40

B. The following non-modular sizes of the bricks may also be used

Length (L)	Width (W)	Height (H)
mm	mm	mm
230	110	70
230	110	30

C. For obtaining proper bond arrangement and modular dimensions for the brick work, with the non-modular sizes, the following sizes of the bricks may also be used:

Length (L)	Width (W)	Height (H)
mm	mm	mm
70	110	70 1/3 length brick

II. **CLASSIFICATION**

Burnt clay fly ash bricks shall be classified on the basis of average compressive strength as given in Table 17. The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour.

Table 17 Classes of Burnt Clay-Fly Ash Bricks

Class Designation	Average Compressive Strength Not Less Than N/mm2
30	30.0
25	25.0
20	20.0

Class Designation	Average Compressive Strength Not Less Than N/mm2
17.5	17.5
15	15.0
12.5	12.5
10	10.0
7.5	7.5
5	5.0
3.5	3.5

III. **Sampling and Tests**

Samples of bricks shall be subjected to the following tests:
i. Dimensional tolerance.
ii. Water absorption.
iii. Efflorescence.
iv. Compressive strength.

a. For the purpose of this standard, the following definitions shall apply.

Lot - A collection of bricks of the same class and size, manufactured under relatively similar conditions of production. For the purpose of sampling, a lot shall contain a maximum of 50000 bricks. In case a consignment has bricks more than 50000 of the same classification and size, and manufactured under relatively similar conditions of production, it shall be divided into lots of 50000 bricks or part thereof.

Sample - A collection of bricks selected for inspection and/or testing from a lot to reach the decision regarding the acceptance or rejection of the lot.

Defective - A brick failing to meet one or more of the specified requirements.

Average - The sum of the observations divided by the number of observations.

b. **Methods of sampling**

The sample may be drawn either by random sampling, or stratified sampling method in accordance with IS: 4905-1968. The sample shall be taken by one of the methods given below so as to yield the number of bricks required.

(i) **Sampling in Motion**

Whenever practicable the sample shall be taken while the bricks are being moved, for example, during loading or unloading. The lot shall be divided into a number of convenient portions (not less than ten). Approximately equal number of bricks shall be drawn from each of these portions at regular intervals, such that the requisite number of bricks for inspection and testing is provided.

(ii) **Sampling from a Stack**

When it is necessary to take a sample from a stack, the stack shall be divided into a number of real or imaginary sections and the required number of bricks drawn from each section. For this purpose bricks in the upper layers of the stack shall be removed to enable units to be sampled from places within the stack.

(iii) **Sampling from Lorries or Trucks**

When it is necessary to take a sample from bricks loaded in Lorries or trucks. The sample bricks shall be taken from a number of lorries/trucks (not less than ten, if possible) such that when equal number of bricks are drawn from each of the lorries/trucks the number of bricks required for the inspection and testing is provided.

(iv) **Scale of sampling and criteria for conformity for visual and dimensional characteristics**

The bricks shall be selected and inspected for each lot separately for ascertaining their conformity to the requirements of the relevant specification.

The number of bricks to be selected from a lot shall depend on the size of the lot and shall be in accordance with col.1 and 2 of Table 18 for visual characteristics in all cases and dimensional characteristics if specified for individual brick. In case dimensions are specified for a group of 20 bricks. The scale of sampling for dimensional characteristics shall be in accordance with col.1 and 4 of Table 18. All these bricks shall be selected following the methods detailed above.

(A) **Visual Characteristics**

All the bricks selected as above in accordance with col.1 and 2 of Table 18 shall be examined for visual characteristics. If the number of defective bricks found in the sample is less than or equal to the corresponding number as specified in col.3 of Table 18, the lot shall be considered as satisfying the requirements of the visual characteristics. However, if the number of defective bricks in the sample is greater than the corresponding permissible number of defectives, the lot shall be deemed as not having met the visual requirements.

Table 18 Scale of sampling and criteria for conformity for visual and dimensional characteristics

No. of bricks in the lot	For characteristic specified for individual brick		For dimensional characteristic specified for group of 20 bricks – No. Of bricks to be selected
	No. of brick to be selected	Permissible no. of defectives in the sample	
2001 to 10000	20	1	40
10001 to 35000	32	2	60
35001 to 50000	50	3	80

NOTE - In case the lot contains 2000 or less bricks, the sampling shall be subject to agreement between the purchaser and the supplier.

(B) **Dimensional Characteristics**

The dimensions and tolerances have been specified in various standards for clay building bricks. In some standards the dimensions and tolerances have been specified for individual brick. In some other standards the dimensions and tolerances have been specified for a group of 20 bricks.

In case the dimensions and tolerances have been specified for individual brick, the scale of sampling and criteria for conformity shall be the same as for visual characteristics.

In case the dimensions and tolerances for bricks are specified as overall on a group of 20 bricks, the number of bricks to be selected for inspecting the dimensions and tolerances shall be in accordance with col.1 and 4 of Table 18. These bricks will be divided into groups of 20 bricks at random and each of the groups thus formed tested for all the dimensions and tolerances. A lot shall be considered having found meeting the requirements of dimensions and tolerances if none of the groups of bricks inspected fails to meet the specified requirements.

(v) **Scale of sampling and criteria for conformity for physical characteristics**

The lot which has been found satisfactory in respect of visual and dimensional requirements shall next be tested for physical characteristics like compressive strength, breaking load, transverse strength, bulk density, water absorption, efflorescence and warpage as specified in relevant material specification. The bricks for this purpose shall be taken at random from those already selected. The number of bricks to be selected and tested for each of these characteristics shall be in accordance with relevant columns.

Table 19 Scale of sampling for physical characteristics

Lot Size	Sample Size For Compressive Strength, Breaking Load, Transverse Strength, Bulk Density, Water Absorption & Efflorescence	Permissible No. Of Defectives For Efflorescence	Warpage Sample Size	Permissible No. Of Defectives
2001 to 10000	5	0	10	0
10001 to 35000	10	0	20	1
35001 to 50000	15	1	30	2

NOTE - In case the lot contains 2000 or less bricks, the sampling shall be subject to agreement between the purchaser and the supplier.

(vi) A lot shall be considered having satisfied the requirements of physical characteristics if the condition stipulated here in are all satisfied.

a. From the test results for compressive strength, the average shall be calculated and shall satisfy the requirements specified in relevant material specification.
NOTE - In case any of the test results for compressive strength exceeds the upper limit for the class of brick, the same shall be limited to the upper limit of the class for the purpose of averaging.
b. Wherever specified in the material specification the compressive strength of any individual brick tested in the sample shall not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 percent.
c. From the test results for water absorption and bulk density the average for the bricks in the sample shall be calculated and shall satisfy the relevant requirements specified in the material specification.

d. The number of bricks failing to satisfy the requirements of the efflorescence specified in the relevant specification shall not be more than the permissible number of defectives given in col.3 of Table 19.

c. **DIMENSIONS AND TOLERANCES**

i. **Tolerances**

The dimensions of bricks when tested in accordance with clause above shall be within the following limits per 20 bricks:

i. For modular size

Length 3720 to 3880 mm (3800 ± 80 mm) Width 1760 to 1840 mm (1800 ± 40 mm)
Height 1760 to 1840 mm (1800 ± 40 mm) {for 90 mm high bricks}
760 to 840mm (800 ± 40 mm) {for 40 mm high bricks}

ii. For non-modular size

Length 4520 to 4680 mm (4600 ± 80 mm) Width 2240 to 2160 mm (2200 ± 40 mm)
Height 1440 to 1360 mm (1400 ± 40 mm) {for 70 mm high bricks}
640 to 560 mm (600 ± 40 mm) {for 30 mm high bricks}

d. **Compressive strength**

The bricks, when tested in accordance with the procedure laid down in IS: 3495 (Part I): 1992 shall have a minimum average compressive strength for various classes.

The compressive strength of any individual brick tested shall not fall below the minimum compressive strength specified for the corresponding class of brick. The lot shall be then checked for next lower class of brick.

e. **Water absorption**

The bricks, when tested in accordance with the procedure laid down in IS:3495 (Part 2) : 1992 after immersion in cold water for 24 hours, water absorption shall not be more than 20 percent by weight up to class 12.5 and 15 percent by weight for higher classes.

f. **Efflorescence**

The bricks when tested in accordance with the procedure laid down in IS: 3495 (Part 3): 1992 the rating of efflorescence shall not be more than 'moderate' up to class 12·5 and 'slight' for higher classes.

IV. **BRICKWORK**

(A) **Classification**

The brick work shall be classified according to the class designation of bricks used.
(B) **Mortar**

The mortar for the brick work shall be as specified, and conform to accepted standards. Lime shall not be used where reinforcement is provided in brick work.

(C) **Soaking of Bricks**

A. Bricks shall be soaked in water before use for a period that is sufficient for the water to just penetrate the whole depth of the bricks (see Notes). Wetting the bricks assists in removing the dirt, sand and dust from them. Further, it prevents the suction of

water from the wet mortar, as otherwise the mortar is likely to dry out soon and crumble before attaining any strength. The bricks shall not be too wet at the time of use, as they are likely to slip on the mortar bed and there will be difficulty in ensuring plumb of the wall. Moreover, proper adhesion of bricks to mortar will not be possible if the bricks are too wet.

NOTES

i. The period of soaking may be easily found at site by a field test in which the brick MO soaked in water for different periods and then broken to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in the construction work.
ii. If the bricks are soaked for the required time in water that is frequently changed, the soluble salts in the brick will be leached out, and subsequent efflorescence will be reduced.

A. When bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked on a clean place, where they are not again spoiled by dirt, earth, etc.

(D) **LAYING OF BRICKWORK**

i. **General**

a. Brick shall be laid on a full bed of mortar.

When laying, the bricks shall be slightly pressed so that the mortar gets into all the pores of the brick surface to ensure proper adhesion. Cross joints and wall joints shall be properly flushed and packed with mortar so that no hollow spaces are left. Properly filled joints ensure maximum strength and resistance to penetration of moisture which takes place mainly through joints.

In the case of thick walls (two-brick thick and over), the joints shall be grouted at every course in addition to bedding and flushing with mortar.

The course at the top of the plinth and sills at the top of the wall just below the roof slab or floor slab and at the top of the parapet, shall be laid with bricks on edge (applicable only in the case of traditional bricks); and at corners and dead-ends the bricks shall be properly radiated and keyed into position by using cut-bricks (also known as 'punja' bricks or 'maruconas').

b. Bricks with 20 mm deep frog shall be used frog-down. Bricks with 10 mm deep frog shall be used either frog-up or frog-down.
c. The courses shall be aligned and care shall be taken to keep the perpendiculars.
d. The brickwork shall be built in uniform layers; corners and other advanced work shall be racked back. No part of a wall during its construction shall rise more than one metre above the general construction level, to avoid unequal settlement and also improper jointing.
e. The face joints shall be finished either by jointing or by pointing as specified.

ii. **Walls**

a. All quoins shall be accurately constructed and the height of the courses checked with storey rods as the work proceeds. In general, quoin bricks shall be headers and stretchers in alternate courses, the bond being established by placing a quoin closer next to the queen header.

b. Acute and obtuse quoins shall be bonded, where practicable, in the same way as square quoins. Obtuse quoins shall be formed with squints showing a three-quarter brick on one face and a quarter brick on the other.

iii. **Plasters**

These shall be set out as to avoid broken bond.

iv. **Openings**

a. The depth of reveals and rebates shall, where practicable, conform to standard brick sizes in order to avoid cutting of bricks and thereby weakening the work.
b. The arrangement of bond at quoins at jambs of openings shall be symmetrical.

v. **Partition**

For half-brick partitions to be keyed into main walls, indents shall be 1eR in the latter.

(E) **Fixing of Frames**

i. Where door or window frames of timber are fixed in the openings, the fixing shall be done, generally withhold-fasts of adequate size and strength securely embedded in the brickwork or in chases later filled up by cement mortar or concrete. Hold-fasts shall be fixed in the brickwork for a sufficient length and then burned up at end into a cross joint, thus avoiding indiscriminate cutting of bricks Iron hold-fasts shall be given a .protective coat of bitumen to avoid rusting. Woodwork faces in contact with brickwork shall be treated with wood preservative to prevent attack from insects and termites.
ii. Fixing of steel doors and windows shall be done in accordance with IS: 1081-1960.
iii. Fixing of timber door & windows shall be done in accordance with IS: 9913-1968.

iv. The frames shall preferably fixed simultaneously as the masonry work proceeds, as this construction will ensure proper bond without gaps between the masonry and the frames.

(F) **Protection Against Damage**

i. Care shall be taken during construction that edges of jambs, sills, heads, etc., are not damaged.
ii. In inclement weather, newly built work shall be covered with gunny bags or tarpaulin so as to prevent the mortar from being washed away.

(G) **Curing**

In hot and dry weather, the mortar is likely to dry up before it has attained its final set and may crumble. This shall be prevented by keeping the brickwork constantly wet for at least seven days, except in the case of brickwork with mud mortar for which no such curing is required.

(H) **Provision for Service Installations**

To facilitate taking service lines later without inordinate cutting of completed work, sleeves and chases shall be provided during the construction itself. Such sleeves shall slope down outwards in external walls so that their surface cannot form channels for easy passage of water inside.

(I) **SCAFFOLDING**

a. Single scaffolding shall not be used on important works, since subsequent filling up of the putlog holes and rendering of their surface would give an unsightly

appearance. Another disadvantage with single scaffolding is that workmen arc apt to support them on window and similar openings, thereby spoiling the frames and shutters.

i. Where single scaffolding is adopted, the placing of the poles, which are to rest on the brickwork under construction, shall be so adjusted as to affect only one of the headers at the point of support in the various courses.

b. Scaffolding shall be designed to withstand all the dead, live and impact loads which are likely to come on them. They shall also be so designed as to ensure the safety of the workmen using them and shall conform in all respects to the requirements of the relevant building regulations on safety, health and welfare and also the local building bye-laws.

(J) INSPECTION

i. General

The object of inspection of brick masonry work is to ensure its satisfactory performance and also to ascertain whether all the recommended practice of workmanship is adopted at every stage. As the correct strength of masonry cannot be ascertained without destruction, a close supervision during the course of construction is necessary to ensure satisfactory performance. The strength of brickwork depends on the strength of individual brick, strength of mortar, bond and workmanship.

ii. Inspection of Materials

In case of large works, samples of bricks, sands, surkhi, lime, cement, etc., which go to form the brickwork, shall be periodically tested in a laboratory to make sure that they conform to the requirements stated above. Simple field tests may suffice in the case of small works.

iii. Inspection of Workmanship

A close supervision while the work is in progress will ensure a better quality work with the materials available for use. The following shall be observed at the time of inspection:

a. All loose material dirt and ret lumps of mortar which may be lying over the surface over which brickwork is to be freshly started, shall be removed with a wire brush.
b. All the bricks shall be thoroughly soaked in clean water immediately before use.
c. The surface over which the brickwork is to be started shall be slightly wetted.
d. The first course itself shall be made horizontal by providing enough mortar in the bed joint to till up any undulations in the bed course.
e. Plastic mortar results in thorough bedding of the brick and more complete filling of the joints which ensure greater strength. Care shall be taken to see that the required quantity of water is added to the mortar at the mixing platform itself and not over the course.
f. All the joints shall, as far as possible, be thin and the specifications mentioned in this specification in this regard shall be strictly adhered to.
g. Care shall be taken to see that there is no through joints and the lap is not less than half the width of the brick, and that all the vertical joints are properly filled with mortar.
h. The verticality of the walls and horizontality of the courses shall be checked very often with plumb bob and spirit level respectively.

i. No portion of the work shall be left more than 1 m lower than the other. Where the masonry of one part has to be delayed the work shall be 'raked back' suitably at an angle not exceeding 45° according to bond and not toothed.
j. Where plastering is required to be done all the vertical as well as horizontal joints shall be raked to a depth of about 10 mm while the mortar is wet, and this will ensure satisfactory adhesion between the plaster and brickwork, and
k. Care shall be taken to ensure that the brick work is kept wet for seven days commencing from 24 hours after the course is laid.

APPENDIX-A

TEST FOR DIMENSIONAL TOLERANCE

A. Sampling

As per the specification.

B. Procedure

All the blisters, loose particles of clay and small projections shall be removed from the surface of Bricks. Each specimen of 20 bricks shall then be arranged upon a level surface successively in contact with each other and in straight line. The overall Length of the assembled bricks (20 No's) shall be measured with a steel tape sufficiently long to measure the whole row at one stretch.

C. Tolerance

The actual dimensions of bricks when tested shall be within the following limits per 20 bricks.

Modular Bricks

Length 3720 to 3880 mm (3800 ± 80 mm) Width 1760 to 1840 mm (1800 ± 40 mm)
Height 1760 to 1840 mm (1800 ± 40 mm) for 90 mm high brick
760 to 840 mm (800 ± 40 mm) for 40 mm high brick

Non-Modular Bricks

i. For class 10

Length 4520 to 4680 mm (4600 ± 80 mm) Width 2240 to 2160 mm (2200 ± 40 mm)
Height 1440 to 1360 mm (1400 ± 40 mm) for 70 mm high bricks
640 to 560 mm (600 ± 40 mm) for 30 mm high bricks

ii. For other classes
Length (4320 to 4680) mm
Width (2130 to 2310) mm
Height (1340 to 1460) mm for 70 mm high bricks
840 to 920 mm for 44 mm high bricks

D. Criteria for Conformity

A lot shall be considered conforming to the requirements of dimensions and tolerances if all the groups of bricks are tested to meet the specified requirements.
a. Measurement of Length
b. Measurement of Width
c. Measurement of Height

APPENDIX -B
TEST FOR COMPRESSIVE STRENGTH

A. Specimen

Five whole bricks shall be taken from the samples as specimens for this test. Length and width of each specimen shall be measured correct to 1 mm.

B. Apparatus

The apparatus consists of compression testing machine, the compression plate of which shall have a ball seating in the form of portion of a sphere the centre of which shall coincide with the centre of the plate.

C. Procedure

i. **Pre-conditioning**: The specimen shall be immersed in the water for 24 hours at 25°to 29℃. Any surplus moisture shall be allowed to drain at room temperature. The frog of the bricks should be filled flush with mortar 1:3 (1 cement: 3 clean coarse sand of grade 3 mm and down) and shall be kept under damp jute bags for 24 hours, after that these shall be immersed in clean water for three days. After removal from water, the bricks shall be wiped out of any traces of moisture.

ii. **Actual Testing:** Specimen shall be placed with flat faces horizontal and mortar filled face upward between three 3 ply plywood sheets each of thickness 3 mm and carefully centered between plates of the testing machine. Plaster of Paris can also be used in place of plywood sheets to ensure a uniform surface. Load shall be applied carefully axially at uniform rate of 14 N/mm^2 per minute till the failure of the specimen occurs.

D. Reporting the Test Results

The compressive strength of each specimen shall be calculated in N/mm^2 as under:

$$\text{Compressive Strength} = \frac{\text{Maximum load at failure (in N)}}{\text{Area of Specimen (in sq mm)}}$$

In case the compressive strength of any individual brick tested exceeds the upper limit of the average compressive strength specified for the corresponding class of brick, the same shall be limited to the upper limit of the class for the purpose of calculating the average compressive strength. Compressive strength of all the individual bricks comprising the sample shall be averaged and reported.

E. Criteria for Conformity

A lot shall be considered having satisfied the requirements of average compressive strength if the average compressive strength for the corresponding class of brick tested is not below the minimum average compressive strength specified for the corresponding class of bricks by more than 20 percent.

APPENDIX-C
TEST FOR WATER ABSORPTION

A. No. of Specimen

Five whole bricks shall be taken from samples as specimen for this test.

B. Apparatus

A balance required for this test shall be sensitive to weigh 0.1 percent of the weight of the specimen.

C. Procedure

i. **Pre-conditioning:** The specimen shall be allowed to dry in a ventilated oven at a 110℃ to 115℃ till it attains a substantially constant weight. If the specimen is known to be relatively dry, this would be accomplished in 48 hours, if the specimen is wet, several additional hours may be required to attain a constant weight. It shall be allowed to cool at room temperature. In a ventilated room, properly separated bricks will require four hours for cooling, unless electric fan passes air over them continuously in which case two hours may suffice. The cooled specimen shall be weight (W1) a warm specimen shall not be used for this purpose.

ii. **Actual Testing:** Specimen shall be completely dried before immersion in the water. It shall be kept in clean water at a temperature of 27℃ ± 2℃ for 24 hours. Specimen shall be wiped out of the traces of water with a damp cloth after removing from the water and then shall be weighed within three minutes after removing from water (W2).

D. Reporting the Test Results

The water absorption of each specimen shall be calculated as follows and the average of five tests shall be reported.

$$\text{Water Absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

E. Criteria for Conformity

A lot shall be considered having satisfied the requirements of water absorption if the average water absorption is not more than 20% by weight.

APPENDIX-D

TEST FOR EFFLORESCENCE

A. No. of Specimen

Five whole bricks shall be taken as specimen for this test.

B. Apparatus

Apparatus required for this test shall be a shallow flat bottom dish containing distilled water.

C. Procedure (actual testing)

The brick shall be placed vertically in the dish with 2.5 cm immersed in the water. The room shall be warm (18℃ to 30℃) and well ventilated. The bricks should not be removed until it absorbs whole water. When the whole water is absorbed and the brick appears to be dry, place a similar quantity of water in that dish and allow it to evaporate as before. The brick shall be examined after the second evaporation.

D. Reporting the Test Results

The rating to efflorescence in ascending order shall be reported as 'NIL', 'SLIGHT', 'MODERATE', 'HEAVY' or 'SERIOUS' in accordance with the following :

i. **NIL:** When there is no perceptible deposit of efflorescence.
ii. **SLIGHT**: When not more than 10 per cent of the area of the brick is covered with a thin deposit of salts.
iii. **MODERATE:** When there is heavier deposit and covering up to 50% of the area of the brick surface but unaccompanied by powdering or flaking of the surface.
iv. **HEAVY:** When there is a heavy deposit of salts covering 50% or more of the brick surface but unaccompanied by powdering or flaking of the surface.
v. **SERIOUS:** When there is heavy deposit of salts, accompanied powdering and/or flaking of the surface and tending to increase in the repeated wetting of the specimen.

E. Criteria for Conformity

A lot be considered having satisfied the requirements of efflorescence if for 4 out of the specimen of 5 bricks, the rating of efflorescence is not beyond "Moderate".

8.14.0 Grouting

A. General Requirements

i. This part of the specification covers the requirements of grouting of block outs, pockets, foundation bolt holes, and of spaces below the base plate and machine bases, etc.
ii. Crushing strength of grout shall be one grade higher than the foundation concrete. Minimum crushing strength shall be 30 N / Sq.mm, unless otherwise specified.
iii. The contact area between the grout and base plate shall not be less than 80%

B. Materials

i. Cement shall be Ordinary Portland Cement conforming to IS: 8112.

ii. Sand shall be clean and well graded conforming to IS: 383. For fluid mix grout, sand conforming to zone-4 grade shall be used. Coarse aggregate wherever used shall also conform to IS: 383.
iii. Clean potable water as recommended for concrete mix shall be used.

C. Admixtures

i. Anti-shrinkage ready mix admixtures of approved make shall be used.
ii. Plasticizer conforming to IS: 9103 shall be used to increase the workability, wherever required.

D. Types of Mix.

a. This shall be of following types.

i. Cement-Sand Grout (Fluid mix and / or plastic mix):

The proportion of cement to sand shall generally be 1:2, unless otherwise specified.

ii. Cement aggregate grout (stiff mix):

The approximate proportions of cement, sand and coarse aggregate shall be 1:1.25:2 by weight, with a maximum size of aggregate as 10mm. This mix shall generally be used for grout thickness above 40mm for dry pack application.

b. Depending upon the case of placement and method of application there shall be following three grout consistencies.

i. Fluid Mix:

Water-Cement ratio shall be 0.6(max.). Plasticiser shall be added to increase workability. This grout mix shall be suitable for application with low-pressure grouting equipment or self-flowing and suitable for grouting of pockets /blockouts, etc.

ii. Plastic Mix:

Water-Cement ratio shall be about 0.5. This grout mix shall be suitable for application with trowel or rod.

iii. Stiff Mix:

Water-cement ratio shall generally be 0.4. This grout mix shall be suitable for dry- pack application. The consistency should allow pressurizing into firm hard ball without cracking.

E. Surface Preparation

The blockouts, bolt holes, underside of the base plate, concrete surfaces, gap between the concrete top surface and underside of base plate etc. shall be cleaned thoroughly by use of compressed air, just prior to taking up the grouting operations.

F. Mixing

Cement, sand, aggregate, and anti-shrinkage admixture of approved quality and proven make shall be first blended thoroughly in the required proportion as per manufacturer's specifications. Grout shall then be prepared by mixing this

admixture with water and plasticizer. Any grout which has been mixed for a period longer than half an hour shall not be used on the work.

G. Placing

i. In case of fluid mix / plastic mix, a grout of suitable mix shall be poured immediately after preparation, into the blockouts, pockets, bolt holes, the space between the top surface of the foundation concrete and the underside of the base plate either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the blockout is completely filled with grout without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried. Grouting, once commenced, shall be done continuously. Grout shall be worked from one end to the other (to prevent air entrapment) until the grout oozes out through the grout holes provided in the base plates.

ii. In case of stiff mix, the space between the top surface of foundation concrete and the underside of the base plate shall be dry packed by firmly pressing or ramming into place against fixed supports.

iii. When it is clear that the center of base has been properly filled, the grout outside the base plate shall be briefly rammed to ensure compaction below the edges. Shims provided for the alignment of bases shall be positioned at the edges of the base to permit subsequent removal, which shall take place not less than 7 days after the grouting has been executed. The resulting cavities shall be made good with the same grade of grout as has been used for grouting under the rest of the base plate.

H. Curing

The work shall be cured for a period of at least 7 days commencing 24 hours after the completion of the grouting. The curing shall be done by covering the surfaces with wet gunny bags and flooding.

8.15.0 Steel work

A. List of applicable code

S.No	IS Code No	Subject
1	IS:63	Whiting for paints and putty
2	IS:198	Varnish gold size
3	IS:228	Structural steel (Standard quality)
4	IS:277	Specification for galvanized steel sheets (Plain and corrugated
5	IS:800	Code of practice for use of structural steel in general in steel construction
6	IS:806	Code of practice for use of steel Tubes in general building construction
7	IS:808	Dimensions for Hot rolled steel beams, columns, channel and angle Sections
8	IS:812	Glossary of terms relating to welding and cutting metals
9	IS:813	Scheme of symbols for welding

S.No	IS Code No	Subject
10	IS:814	Covered electrodes for manual metal arc welding of carbon and carbon Manganese steel
11	IS:816	Code of practice for use of metal arc welding for general construction in Mild steel
12	IS:817	Code of practice for training and testing of metal arc welders
13	IS:818	Code of practice for safety and healthy requirements in electric and gas Welding and cutting operations
14	IS:822	Code of procedure for inspection of welds
15	IS:823	Manual for metal arc welding in mild steel
16	IS:1038	Steel doors, windows and ventilators
17	IS:1081	Code of practice for fixing and glazing of metal (Steel and aluminium) Doors, windows and ventilators
18	IS:1148	Hot rolled steel rivet bars (upto 40 mm diameters) for structural purposes
19	IS:1161	Steel tubes for structural purposes
20	IS:1182	Recommended practice for radiographic examination of fusion welded butt Joints in steel plates
21	IS:1200 pt(VIII)	Method of measurements of steel work and iron works
22	IS:1363 Part I	Hexagon head bolts, screws, and nuts of product grade C (Hexagon Head bolt)
23	IS:1363 Part II	Hexagon Head Bolts, screws and nuts of product Grade ‘C’
24	IS:1363 Part-III	Hexagon Head Bolts, screws and Nuts of product grade ‘C’
25	IS:1367	Technical supply conditions for threaded steel fasteners
26	IS:1599	Method for bend test
27	IS:1608	Metallic materials – Tensile Testing at Ambient Temperature
28	IS:1821	Dimensions for clearance holes for bolts and screws
29	IS:1852	Rolling and cutting tolerance for hot rolled steel products
30	IS:1894	Method for tensile testing of steel tubes
31	IS:1977	Structural steel (ordinary quality)
32	IS:2062	Hot Rolled low, medium and high tensile structural steel
33	IS:2074	Ready mixed paint, air drying red-oxide zinc chrome priming
34	IS:4351	Specification for steel door frames
35	IS:4711	Methods for sampling of steel pipes, tube and fittings
36	IS:4736	Hot – dip zinc coating on mild steel tubes
37	IS:4923	Hollow Steel Sections for Structural Use - Specification
38	IS:7452	Specification for hot rolled steel sections for doors, windows and ventilators
39	IS:802	Code of practice for use of structural steel in overhead transmission line
		Part-I: Load and permissible stresses.
		Part-II: Fabrication, galvanizing, inspection and packing

S.No	IS Code No	Subject
40	IS:819	Code of practice for resistance spot welding for light assemblies in mild steel
41	IS:919	Recommendations for limits and fits for engineering.
42	IS:1365	Slotted counter sunk head screws (dia range1.6 to 20 mm)
43	IS:1730	Dimensions for steel plate, sheet and strip for structural and general engineering purpose
44	IS:1731	Dimensions for steel flats for structural and general engineering purposes
45	IS:3664	Code of practice for ultrasonic pulse echo testing by contact and immersions methods
46	IS:4759	Hot dip zinc coatings on structural steel and other allied products
47	IS:7318 [Part-I]	Approval test for welders when welding procedure approval is not required
48	IS:5334	Code of practice for magnetic particle flaw detection of welds
49	IS:7215	Tolerances for fabrication of steel structures
50	IS:7280	Base-wire electrodes for submerged arc welding of structural steel

B. Mandatory test

Notes:

i. The mandatory tests shall be carried out when the quantity of materials to be incorporated in the work exceeds the minimum quantity specified.
ii. Optional tests specified or any other tests, shall be carried out in case of specialised works or important structures as per direction of the Engineer-in-charge/Owner/Consultant.
iii. Testing charges, including incidental charges and cost of sample for testing shall be borne by the Bidder for all mandatory tests.
iv. In case of non-IS materials, it shall be the responsibility of the Bidder to establish the conformity of material with relevant IS specification by carrying out necessary tests. Testing charges including incidental charge and cost of sample for testing shall be borne by the Bidder for such tests.

The mandatory tests shall be as follows:

Material	Test	Field / Laboratory test	Test procedure	Minimum quantity of material/ work for carrying out	Frequency of testing
Steel	Tensile test	Lab	IS:1599	20 tonne or part thereof	Every 20 tonne
	Bend test				
Steel tubular pipes	Tensile test	Lab	IS:1608	Every 8 tonne or part thereof	Every 8 tonne or part thereof
	Bend test		IS:2329		
	Flattening test		IS:2328		

C. DEFINITIONS/TERMINOLOGY

Bead

A single run of weld metal deposited on surface.

Butt Weld

A weld in which the weld metal lies substantially within the extension of the planes arc the surfaces on the parts joined.

Crater

A depression left in weld metal where the arc was broken or the flame was removed.

End Crater

A crater at the end of a weld or at the end of a joint.

Fillet Weld

A weld of approximately triangular cross-section joining two surfaces approximately at the right angles to each other in a lap joint, tee joint or corner joint. It is of two types:

(1) Continuous

(2) Intermittent.

Fusion Welding

Any welding process in which the weld is made between metals in a state of fusion without hammering or pressure.

Non- fusion welding

A term applied to the deposition, by the Oxy-Acetylene process of filler metal on parent metal without fusion of the latter.

Oxy-Acetylene Pressure Welding

Pressure welding in which any Oxy-Acetylene flame is used to make the surface to be united plastic. No filler metal is used.

Run

The metal deposited during one passage of the electrode or blow pipe in the making of a joint.

Weld

A union between two pieces of metal at faces rendered plastic or liquid by heat or pressure, or both, Filler metal may be used to effect the union.

D. MATERIALS

Micro-Alloying Elements

Elements such as niobium, boron, vanadium and titanium added singly or in combination to obtain higher strength to weight ratio and better toughness, formability and weldability as compared to unalloyed steel of similar strength level.

Weldability

A metallic substance is considered to be weldable by a given process and for the given purpose, when metallic continuity to a stated degree can be obtained by welding using a suitable procedure, so that the joints comply with the requirements specified in regard to both their local properties and their influence on the construction of which they form a part.

Controlled Rolling

A hot rolling process in which the temperature of the steel and its reduction ratio are controlled, particularly during the final rolling passes, in order to achieve fine grain micro structure and optimum mechanical properties.

Normalizing Rolling

A hot rolling process in which the final rolling passes are carried out at a suitable higher temperature, followed by cooling in natural air to a temperature below the transformation temperature, in order to produce a structure, analogous to that obtained by a separate normalizing treatment of hot rolled product.

(1) Steel

I. Supply of Material :

General requirements relating to supply of structural steel shall conform to IS: 8910.

II. Grades :

While placing the order the steel should be designated by 'Designation'

III. Manufacture :

The processes used in the steel making and further hot rolling into steel plates, strips, sections, flats, bars, etc., are left to the discretion of the manufacturer/supplier. If required, secondary refining may follow steel making, as also normalizing rolling/controlled rolling during manufacturing of sections or as per the agreement between the purchaser and the manufacturer/supplier.

IV. Freedom from Defects:

i. All finished materials shall be well and cleanly rolled to the dimensions, sections and masses specified. The finished material shall be reasonably free from surface flaws; laminations; rough/jagged and imperfect edges and all other harmful defects.
ii. Minor surface defects may be removed by the manufacturer/supplier by grinding provided the thickness is not reduced locally by more than 4 percent below the minimum specified thickness. Reduction in thickness by grinding greater than 4 percent but not exceeding 7 percent may be made subject to mutual agreement between the purchaser and manufacturer/supplier.
iii. Subject to agreement with the purchaser, surface defects which cannot be dealt with may be repaired by chipping or grinding followed by welding and inspection by a mutually agreed procedure such that :
    a. After complete removal of the defects and before welding, the thickness of the item is not to be reduced by more than 20 percent at any place.
    b. Welding is carried out by procedure APPROVED by competent authority with approved electrodes and the welding is ground smooth to the correct nominal thickness; and

c. Subsequent to the finish grinding, the item may be required to be normalized or otherwise heat treated at the purchaser's discretion.

iv. Welding as mentioned above is not permissible for grade designation E 250 material.

V. Chemical Composition :

Ladle Analysis the ladle analysis of the steel, when carried out by the method specified in the relevant part of IS: 228 or any other established instrumental /chemical method. In case of dispute, the procedure given in IS: 228 and its relevant parts shall be the referee method and where test methods are not specified shall be as agreed to between the purchaser and the manufacturer/supplier.

(2) Rivets

Rivets shall be made from rivet bars of mild steel as per IS: 1148.

(3) Bolts

These are of two type namely turned and fitted bolts and black bolts. Turned & fitted bolts are turned to exact diameter in automatic lathe. For these bolts, whether reamed or drilled bolts, the same unit stresses are allowed as for rivets. In case of black bolts which are not finished to exact sizes, a lower working stress other than for turned bolts is adopted. They shall conform to IS: 1367 – Technical supply conditions for threaded steel fasteners.

(4) Electrodes

The electrodes required for metal arc welding shall be covered electrodes and shall conform to IS: 814.

E. STEEL WORK IN SINGLE SECTION FIXED INDEPENDENTLY WITH CONNECTING PLATE

The steel work in single section of R.S. joists, flats, Tees Angles fixed independently with or without connecting plate, is described in these clauses.

(1) Fabrication

The steel sections as specified shall be straightened and cut square to correct lengths and measured with a steel tape. The cut ends exposed to view shall be finished smooth. No two pieces shall be welded or otherwise jointed to make up the required length of member. All straightening and shaping to form, shall be done by pressure. Bending or cutting shall be carried out in such a manner as not to impair the strength of the metal.

(2) Painting

All steel surfaces which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust. Surfaces not in contact but inaccessible after shop assembly, shall receive the full specified protective treatment before assembly. This does not apply to the interior of sealed hollow sections. Part to be encased in concrete shall not be painted or oiled. A priming coat of approved steel primer such as Red Oxide/Zinc Chromate primer conforming to IS: 2074 shall be applied before any member of steel structure are placed in position or taken out of workshop.

(3) Erection

Steel work shall be hoisted and placed in position carefully without any damage to itself and other building work and injury to workmen. Wherever necessary,

mechanical appliances such as lifting tackle winch etc. shall be used. The suitability and capacity of all plant and equipment used for erection shall be upto the satisfaction of the Engineer-in-charge.

F. STEEL WORK IN BUILT UP SECTIONS (RIVETED AND BOLTED)

The steel work in built up section (Riveted and bolted) such as trusses, framed work etc. is specified in this clause.

(1) Laying Out

A figure of the steel structure to be fabricated shall be drawn on a level platform to full scale. This may be done in full or in parts, as shown on drawings or as directed by the Engineer-in- Charge.

(2) Fabrication

Fabrication shall generally be done as specified in IS:800. In major works or where so specified, shop drawings giving complete information for the fabrication of the component parts of the structure including the location, type, size, length and details or rivets, bolts or welds, shall be prepared in advance of the actual fabrication and approved by the Engineer-in- charge. The drawings shall indicate the shop and field rivets, bolts and welds. The steel members shall be distinctly marked or stenciled with paint with the identification marks as given in the shop drawings. Great accuracy shall be observed in the fabrication of various members, so that these can be assembled without being unduly packed, strained or forced into position and when built up, shall be true and free from twist, kinks, buckles or open joints. Wooden or metal sheet templates shall be made to correspond to each member, and position of rivet holes shall be marked accurately on them and holes drilled. The templates shall then be laid on the steel members, and holes for riveting and bolting marked on them. The ends of the steel members shall also be marked for cutting as per required dimensions.

The base of steel columns and the positions of anchor bolts shall be carefully set out at the required location.

a. The steel section shall be straight or to be straightened or flattened by pressure unless required to be of curvilinear form and shall free from twists. These shall be cut square either by shearing or sawing to correct length and measured by steel tape. No two pieces shall be welded or joined to make up for the required length of member.

b. **Making Holes :**

Holes through more than one thickness of materials for members, such as compound stanchion and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, provided the holes are punched 3mm less in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall be not greater than 16 mm.

Rivet Holes

The diameter for rivets and black bolts holes shall be taken as the nominal diameter of a rivet/ black bolts plus 1.5 mm for rivets/ bolts of nominal diameter less than or equal to 25 mm and 2.0 mm for rivets of nominal diameter exceeding 25 mm, unless specified otherwise. Holes for turned and fitted bolts shall be drilled or reamed large by 0.2 to 8 mm depending upon the dia. of bolts.

Holes shall have their axis perpendicular to the surface bored through. The drilling or reaming shall be free from burrs, and the holes shall be clean and accurate. Holes for rivets and bolts shall not be formed by gas cutting process.

Holes for counter sunk bolts shall be made in such a manner that their heads sit flush with the surface after fixing.

c. **Assembly :**

Before making holes in individual members, for fabrication and steel work intended to be riveted or bolted together shall be assembled and clamped properly and tightly so as to ensure close abutting, or lapping of the surfaces of the different members. All stiffeners shall be fixed (or placed) tightly both at top and bottom without being drawn or caulked. The abutting joints shall be cut or dressed true and straight, and fitted close together.

Web plates of girders, which have no cover flange plates, shall have their ends flush with the tops of angles unless otherwise required. The web plate when spliced, shall have clearance of not more than 5mm. The erection clearance of cleated ends of members connecting steel to steel shall preferably be not greater than 1.5 mm. The erection clearance at the ends of beams without web cleats shall not be more than 3 mm at each end but where for practical reasons, greater clearance is necessary, seating designed suitably shall be provided.

Column splices and butt joints of struts and compression members requiring contact for stress transmission shall be accurately, machined and close butted over the whole section. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc. after riveting together shall be accurately machined so that the parts connected, butt against each other over the entire surfaces of contact. Connecting angles or channels shall be fabricated and placed in position with great accuracy so that they are not unduly reduced in thickness by machining.

The ends of all bearing stiffeners shall be machined or grounded to fit tightly both at top and bottom.

d. **Riveting :**

Rivets shall be used, where slip under load has to be avoided.

Preliminaries before Riveting

Members to be riveted shall have all parts firmly placed and held together before and during riveting, and special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

Process of Riveting

The riveting shall be carried out by using machines of the steady pressure type. However, where such facilities are not available hand riveting may be permitted by the Engineer-in-charge. The rivets shall be heated red hot, care being taken to control the temperature of heating so as not to burn the steel. Rivets of diameter less than10mm may be driven cold. Rivets shall be finished neat with heads full and of equal size. The heads shall be central on shanks and shall grip the assembled members firmly.

All loose, burnt, or badly formed rivets with eccentric or deficient heads shall be cut out and replaced. In cutting out rivets, care shall be taken so as not to injure the assembled members. Caulking and recapping shall not be permitted.

For testing rivets, a hammer weighing approx. 0.25 kg shall be used and both heads of the rivet (Specially the machine head) shall be tapped. When so tested, the rivets shall not give a hollow sound and a jar where so specified, other tests shall be carried out to ensure the soundness of rivets. All rivets heads shall be painted with approved steel primer paint within a week of their fixing.

e. **Bolting :**

The nominal length of the bolt shall be the distance from the underside of the head to the further end of the shank. The nominal diameter of the bolt shall be the diameter at the shank above the screwed threads. Bolts, nuts and washers shall be thoroughly cleaned and dipped in double boiled linseed oil, before use. All bolts heads and nuts shall be hexagonal unless specified otherwise. The screwed threads shall conform to IS: 1363 and the threaded surface shall not be tapered. The bolts shall be of such length as to project at least two clear threads beyond the nuts when fixed in position, and these shall fit in the holes without any shake. The nuts shall fit in the threaded ends of bolts properly.

Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project through the nut at least two thread. In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness under the nuts to avoid any threaded portion of the bolt being within the thickness of the parts bolted together.

Where there is a risk of the nuts being removed or becoming loose due to vibrations or reversal of stresses, these shall be secured from slackening by the use of lock nut, spring washers as directed by the Engineer-in-charge.

(3) Erection

i. Steel members shall be hoisted and erected in position carefully, without any damage to itself, other structures and equipment and injury to workmen. The method of hoisting and erection proposed to be adopted by the Bidder shall be got approved from the Engineer-in-charge in advance. The Bidder however shall be fully responsible for the work being carried out in a safe and proper manner without unduly stressing the various members and proper equipment such as derricks, lifting tackles, winches, ropes etc. shall be used.

ii. The work of erection may be done in suitable units as may be directed by the Engineer-in charge. Fabricated members shall be lifted at such points so as to avoid deformation or excessive stress in members. The structure or part of it placed in position shall be secured against over-turning or collapse by suitable means.

During execution, the steel members shall be securely bolted or otherwise fastened when necessary temporarily braced to provide for all loads including those due to erection equipments and its operation to be carried safely by structure during erection. The steel members shall be placed in proper position as per approved drawing, final riveting or permanent bolting shall be done only after proper alignment has been checked and confirmed.

iii. Trusses shall be lifted only at nodes. The trusses above 10 m in span shall not be lifted by slinging at two mid points of rafters, which shall be temporary braced by a wooden member of a suitable section. After the trusses are placed in position, purlins and wind bracings shall be fixed as soon as possible.

The end of the truss which faces the prevailing winds shall be fixed with holding down bolts, and the other end kept free to move. In case of trusses of spans upto 10m the free end of the truss shall be laid on lead sheet or steel plate as per design, and the holes for holding down bolts shall be made in the form of oblong slots so as to permit the free movements of the truss end. For larger spans the truss shall be provided with proper bearing as per design.

iv. Columns and stanchions shall be erected truly vertical with the necessary cross bracing etc. and the base shall be properly fixed with the foundation concrete by means of anchor bolts etc. as per drawing.

v. Anchor bolts to be placed in the concrete foundation should be held in position with a wooden template. At the time of concreting anchor bolt locations shall be provided with suitable timber mould or pipe sleeve to allow for adjustment which shall be removed after initial setting of concrete. The spaces left around anchor bolts shall be linked to a stopping channel in the concrete leading to the side of the pedestal and on the underside of the base plate to allow the spaces being grouted up after the base plate is fixed in the position along with the column footing. Grouting shall be of cement mortar 1:3 (1 cement: 3 coarse sand) or as specified.

vi. **Bedding of Column, Stanchions etc.:-**

Bedding shall not be carried out until the steel work has been finally levelled, plumbed and connected together. The stanchion shall be supported on steel wedges and adjusted to make the column plumb. For multi-storeyed buildings, the bedding shall not be done until sufficient number of bottom lengths of stanchions have been properly lined, levelled and plumbed and sufficient floor beams are fixed in position. The base plates shall be wedged clear of the bases by M.S. wedges and adjusted where necessary to plumb the columns. The gaps under the base plate may be made upto 25 mm which shall be pressure grouted with cement grouts. With small columns, if permitted by the Engineer-in-charge, the column base shall be floated on a thick cement grout on the concrete pedestal. The anchor bolt holes in the base plate may be made about 10 to 15 mm larger than the bolts. In such cases suitable washers shall be provided.

(4) Painting

Before the members of the steel structure are placed in position or taken out of the workshop these shall be painted.

G. STEEL WORK IN BUILT UP SECTION (WELDED)

The steel work in built up sections (welded) such as in trusses, form work etc. is specified in this clause.

(1) Laying out

It shall be as specified in the above clause.

(2) Fabrication

Straightening, shaping to form, cutting and assembling, shall be as per above clause as far as applicable, except that the words “riveted or bolted” shall be read as “welded” and holes shall only be used for the bolts used for temporary fastening as shown in drawings.

i. **Welding :**

Welding shall generally be done by electric arc process as per IS:816 and IS:823. The electric arc method is usually adopted and is economical. Where electricity for public is not available generators shall be arranged by the Bidder at his own cost

unless otherwise specified. Gas welding shall only by resorted to using oxyacetylene flame with specific approval of the Engineer-in-charge. Gas welding shall not be permitted for structural steel work Gas welding required heating of the members to be welded along with the welding rod and is likely to create temperature stresses in the welded members. Precautions shall therefore be taken to avoid distortion of the members due to these temperature stresses.

The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the types of electrodes to be used. Symbol for welding on plans and shops drawings shall be according to IS:813.

As far as possible every efforts shall be made to limit the welding that must be done after the structure is erected so as to avoid the improper welding that is likely to be done due to heights and difficult positions on scaffolding etc. apart from the aspect of economy. The maximum dia of electrodes for welding work shall be as per IS:814. Joint surfaces which are to be welded together shall be free from loose mill scale, rust, paint, grease or other foreign matter, which adversely affect the quality of weld and workmanship.

ii. **Precautions :**

All operation connected with welding and cutting equipment shall conform to the safety requirements given in IS:818 for safety requirements and Health provision in Electric and gas welding and cutting operations.

iii. Operation, Workmanship and process of Welding is described in “Appendix A” of this clause.

iv. Inspection and testing of welds shall be as per IS:822.

v. **Assembly:**

Before welding is commenced, the members to be welded shall first be brought together and firmly clamped or tack welded to be held in position. This temporary connection has to be strong enough to hold the parts accurately in place without any disturbance. Tack welds located in places where final welds will be made later shall conform to the final weld in quality and shall be cleaned off slag before final weld is made.

vi. **Erection :**

The specification shall be as described except that while erecting a welded structure adequate means shall be employed for temporary fastening the members together and bracing the frame work until the joints are welded. Such means shall consists of applying of erection bolts, tack welding or other positive devices imparting sufficient strength and stiffness to resist all temporary loads and lateral forces including wind. Owing to the small number of bolts ordinarily employed for joints which are to be welded, the temporary support of heavy girders carrying columns shall be specially attended.

Different members which shall be fillet welded, shall be brought into as close contact as possible. The gap due to faulty workmanship or incorrect fit if any shall not exceed. 1.5 mm if gap exceeds 1.5 mm or more occurs locally the size of fillet weld shall be increased at such position by an amount equal to the width of the gap.

vii. **Painting :**

Before the member of the steel structures are placed in position or taken out of the workshop these shall be painted.

H. STEEL WORK WELDED IN BUILT-UP SECTIONS USING STRUCTURAL STEEL

i. In Stringers, Treads, Landing etc. of Stair cases including use of Chequered Plate wherever required

ii. In Grating, Frames, Guard Bar, Ladder, Railings, Bracket, Gates and similar work.

1. General specifications for these items to be same as for steel work welded in built- up sections except that steel used for fabrication of these items to be of type used for structural use/purposes.

2. Steel members used for fabricating these items to be designed structurally to withstanding the all loads to be carried out by the members during erection, fixing and functional use in designed life. Work to be executed as per structural drawings.

I. STEEL WORK WELDED IN BUILT-UP SECTIONS FOR HAND RAIL USING M.S. TUBULAR/ERW TUBULAR PIPES AND G.I. PIPES

(1) General specifications to be same as for steel work welded in built-up section.

(2) Hot finished welded (HFW) Hot finished seamless (HFS) and electric resistance welded tube shall conform to IS:1161.

G.I. pipes used for Hand rail to be conforming to IS:1239-Part I for medium grade. GI pipes to be screwed and socketed type and of required nominal bore.

Galvanising of GI pipes shall conform to IS:4736.

The fittings for GI pipes to be conforming to IS:1239 (Part-II).

All screwed tubes and socket of GI pipes shall have pipe threads conforming to the requirements of IS:554.

TABLE 20 CHEMICAL COMPOSITION OF STEEL

Grade designation	**Ladle Analysis Percent, Max**			
	C	Mn	S	P
(1)	**(2)**	(3)	(4)	(5)
Fe 290	0.25	1.25	0.055	0.055
Fe 330	0.25	1.25	0.055	0.055
Fe 370	0.25	1.25	0.055	0.055

Notes:

1. When the steel is aluminium killed, the total aluminium content shall not be less than 0.02 percent. When the steel is silicon killed, silicon content shall not be less than 0.10 percent. When the steel is silicon-aluminium killed, the silicon shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.
2. Micro alloying may be allowed subject to mutual agreement between the purchaser and the supplier. Micro alloying elements like Nb, V or Ti, when used individually or in combination, the total content shall not exceed 0.20 percent.

3. Copper may be present between 0.20 to 0.35 percent as mutually agreed to between the purchaser and the manufacturer. The copper bearing quality shall be designated with a suffix Cu, for example Fe 330 Cu.
4. Nitrogen content of steel shall not exceed 0.012 percent which shall be ensured by the manufacturer by occasional check analysis.

J. STEEL DOORS, WINDOWS, VENTILATORS AND COMPOSITE UNITS

Hot rolled steel sections for fabrication of steel doors, windows, ventilators and fixed lights shall conform to IS: 7452. Shapes weights and designations of hot rolled sections shall be as per IS: 7452.

Tolerance in thickness of the sections shall be + 0.2 mm. The fabricated steel doors, windows, ventilators and composite units shall confirm to IS: 1038 with up-to-date amendments and shall be IS marked (IS: 1038).

(1) The steel doors and windows shall be according to the specified sizes and design. The size of doors and windows shall be calculated, so as to allow 1.25 cm clearance on all the four sides of opening to allow for easy fitting of doors windows and ventilators into opening. The actual sizes of doors, windows and ventilators shall not vary by more than + 1.5 mm from those given in the drawing.

(2) **Fabrication**

a. **Frames:** Both the fixed and openable frames shall be made of sections which have been cut to length and mitred. The corner of fixed and openable frames shall be welded to form a solid fused welded joint conforming the requirements given below. All frames shall be square and flat. The process of welding adopted shall be flush but welding or can be any other process as agreed to between the supplier and the purchaser which shall fulfil the requirements given in clause 6.1.1 of IS:1038, metal arc welding or any other suitable method. The section for glazing shall be tennoned and riveted into the frames and where they intersect the vertical tie shall be broached and horizontal tee threads through it, and the intersection closed by hydraulic pressure.

Requirements of Welded Joints

i. **Visual Inspection Test:** When two opposite corners of the frame are cut, paint removed and inspected, the joint shall conform to the following:-
   a. Welds should have been made all along the place of meeting the members and tack welding shall not be permitted.
   b. Welds should have been properly grounded and
   c. Complete cross section of the corner shall be checked up to see that the joint is completely solid and there are no cavities visible.

ii. **Micro and Macro Examinations:** From the two opposite corners obtained for visual test, the flanges of the sections shall be cut with the help of a saw. The cut surface of the remaining portions shall be polished, etched and examined. The polished and etched faces of the weld and the base metal shall be free from cracks and cavity and reasonably free from under cutting overlaps, gross porosity and entrapped slag.

iii. **Fillet Weld Test:** The fillet weld in the remaining portion of the joint shall be fractured by hammering. The fractured surfaces shall be free from slag inclusion porosity, crack penetration defects and fusion defects.

b. **Doors:** The hinges shall be of 50 mm projecting type. Non projecting type hinges may also be used, if approved by Engineer-in-Charge. The hinge pin shall be of

electro- galvanized steel or aluminium alloy of suitable thickness and size. Door handles shall be approved by the Engineer-in-Charge. Suitable latches lock for door openable both from inside and outside shall be provided.

In the case of double doors, the first closing leaf shall be the left hand leaf locking at the door from the push side. The first closing shutter shall have a concealed steel bolt at top and bottom. The bolts shall be so constructed as not to work loose or drop by its own weight.

Single and double leaf shutter door may be provided with a three way bolting device. Where the device is provided in the case of double leaf shutters, concealed brass or steel bolts shall not be provided.

c. **Windows**

i. For fixed windows, the frames shall be fabricated as done for doors.
ii. Side hung windows.

For fixing steel hinges, slots shall be cut in the fixed frame and hinges inserted inside and welded to the frame at the back. The hinges shall be of projecting type with thickness not less than 3.15 mm and length not less than 65 mm and width not more than 25 mm. Non projecting type hinges may also be allowed if approved by the Engineer-in-Charge. The diameter of hinge pins shall not be less than 6 mm.

The hinge pin and washer shall be of galvanized steel or aluminum alloy of suitable thickness. For fixing hinges to inside frame, the method described above may be adopted but the weld shall be cleaned, or the holes made in the inside frame and hinge riveted.

The handle of side hung shutters shall be pressed brass, cast brass, aluminium or steel protected against rusting and shall be mounted on a steel plate. Thickness of handle shall not be less than 3 mm in case of steel or brass and 3.5 mm in case of aluminium. The handle plate shall be welded, screwed and/ or revitted to the opening frame in such a manner that it should be fixed before the shutter is glazed and should not be easily removable after glazing.

The handle shall have a two point nose which shall engage with a brass or aluminium alloy striking plate on the fixed frame in a slightly opened position as well as closed position. The boss of handle shall incorporate a friction device to prevent the handle from dropping under its own weight and the assembly shall be so designed that the rotation of the handle may not cause it to unscrew from the pin.

The height of the handle plate in each type of standards windows will be as specified, otherwise it shall be at a height of 3/8 of the height of shutter, from its bottom. The strike plate shall be so designed and fixed in such a position in relation to the handle that with the later bearing against its stop, there shall be adequately tight fit between the casement and outer frames.

In case where no friction type hinges are provided, the windows shall be fitted with peg stays which shall be either of black oxidised steel, pressed or cast brass or as specified, 300 mm long or as specified with steel peg and locking brackets. The pegs stay shall have three holes to open the side hung casement in three different angles. The peg stay shall be of minimum thickness 2 mm in case of brass or aluminium and 1.25 mm in case of steel. Where specified friction hinges shall be provided. Side hung shutters fitted with friction hinges shall not be provided with a peg stay.

If specified, side hung shutters may be fitted with an internal removable fly proof screen in a 1.25 mm thick sheet steel frame to the outer frame of the shutter by brass turn buckles at the jambs, and brass studs at the sill to allow the screen being

readily removed. The windows with removable fly proof screen shall be fitted with a through the screen level operator at the sill level to permit the operation of the shutter through an angle of 90° without having to remove the fly proof screen. The lever shall permit keeping the shutter open in minimum three different positions.

d. **Ventilators**

i. Top Hung Ventilators

The steel butt hinges for top hung ventilators shall be riveted to the fixed frame or welded to it at the back after cutting a slot in it. Hinges to the opening frame shall be riveted or welded. Top hung ventilators shall be provided with a peg stay with three holes which when closed shall be held tightly by the locking bracket. The locking bracket shall either be fitted to the fixed frames or to the window.

ii. Centre Hung Ventilators

Central hung ventilators shall be hung on two pairs of brass or aluminium cup pivots as specified, riveted to the inner and outer frames of ventilators to permit the ventilator shutter to swing to angle of approx. 85°. The opening portion of the ventilators shall be so balanced that it remains open at any desired angle under normal weather conditions.

A black oxidised steel spring catch approved by the Engineer-in-Charge shall be fitted in the centre of the top of the centre hung ventilator, for the operation of ventilators. The spring catch shall be secured to the frame with M.S. screws and shall close into a mild steel or malleable iron catch plate riveted, screwed or welded to the outside of the outer window frame bar.

A black oxidised cord pulley wheel in galvanized mild steel brackets shall be fitted at sill of the centre hung window with mild steel screws or alternatively welded together with mild steel or malleable iron cord-eye riveted or welded to the bottom inner frame bar of the window in a position corresponding to that of pulley.

Removable fly-proof screen may be provided as specified for doors. This shall be fitted with a through the screen operator to enable operating and keeping the shutter open in minimum three different positions.

e. **Composite Units:** Composite Units consist of a combination of two or more units of doors, windows and ventilators etc. as the case may be. The different units shall be coupled by using applicable coupling sections.

(3) **Glazing**

Wherever the ventilators, windows and doors shall be coupled with a coupling sections, mastic cement shall be applied between the junctions to make the joint water tight.

i. The glass panes shall have square corners and straight edges. The glass panes shall be so cut that it fits slightly loose in the frames. In doors, windows and clerestory windows of bath, WC and lavatories frosted glass panes shall be used which shall weight not less than 10.00 kg/m^2.

ii. Glazing shall be provided on the outside of the frame unless otherwise specified. Putty of approved make conforming to IS: 419 shall be used for fixing glass panes. Putty shall be applied between glass panes and glazing bars. Putty shall then be applied over the glass pane, which shall stop 2 to 3 mm from the sight line of the back rebate to enable the painting to be done upto the sight line to seal the edge of the putty to the glass. The oozed out putty shall be cleaned and

from putty cut to straight line. Quantity of putty shall not be less than 185 gm/ metre of glass perimetre. Putty shall be painted within 2 to 3 weeks, after glazing is fixed to avoid its cracking.

Note: Putty may be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil to the mixture to form a stiff paste and adding varnish to the paste at the rate of 1 litre of varnish to the 18 kg paste.

iii. Four glazing clips may be provided per glass pane for a size larger than 30 cm x 60 cm for all types, where the glass panes size exceed 80 cm x 200 cm, 6 glazing clips shall be used. In case of doors, windows and ventilators without horizontal glazing bars, the glazing clips may be spaced according to the slots, in the vertical members provided the spacing does not exceed 30 cm otherwise the spacing shall be 30 cm.

Note: Where large size glass panes are required to be used or where the door or window is located in heavily exposed situation, holes for glazing clips have to be drilled prior to fabrication and cannot be done at any later stages. Use of glazing clips shall be specified while placing the order.

iv. Where specially stipulated, fixing of glass panes may be done with metal or wooden beading instead of mere putty. Where beading is proposed to be used, the manufacturers shall be intimated in advance to drill holes for hard screws. Usually beads shall be fixed with screws spaced not more than 10 cm from each corner and the intermediate not more than 20 cm apart. When glass panes are fixed with wooden or metal beading having mitred joints, a thin layer of putty shall be applied between glass panes and sash bars and also between glass panes and the beading. Size of M.S. beading shall be 10 x 10 mm box section manufactured from 1.6 mm thick sheet unless otherwise specified in the item.

(4) **Finishing**

All steel surfaces shall be thoroughly cleaned of rust, scale and dirt. Where so specified. The steel surface shall be treated for rust proofing by the hot dip, zinc spray or electro galvanizing process. A priming coat of approved steel primer i.e. red oxide/ zinc chromate primer conforming to IS: 2074 shall be given. The fabricated steel door, windows, ventilators and composite units shall be inspected in the factory and approved by the Engineer-in-charge before priming coat is applied. Final finishing coat shall be given to the doors, windows and ventilators after they are erected and fixed in final position. The rate shall be exclusive of final finishing coats but shall include the priming coat.

(5) **Fixing**

(a) Steel, doors and windows shall be so stacked as to keep them in true shape without damage. Doors, windows and ventilators shall be fixed as described below.

(b) Opening may be flush or rebated as shown in the drawing. The opening may have rendered finish or a “fair faced” finish (i.e. without rendering as in case of marble or stone facing). Where openings are flush and with a rendered finish a clearance of 1.25 cm shall be provided between the steel frame and opening. In case of external masonry finish “fair faced” and with rebated jambs, a minimum 1.25 cm clearance between frame and opening shall be provided opening in steel work shall be so designed that the outer flange of the door, windows, or ventilator frame section overlaps the steel surface by 10 mm.

Note: The sizes of Indian Standard doors, windows and ventilators, are designed for modular opening 1.25 cm larger all round than the doors, windows etc. This gap of 1.25 cm is for the purpose of fixing of doors, windows etc. In masonry opening, the gap is filled up with mastic cement and plaster after the door or windows are fixed in position. In the case of steel or timber modular opening, extra steel or timber fillets will be necessary to cover this gap of 1.25 cm.

(c) **Fixing in Masonry Openings a. Fixing with Lugs**

i. Doors, windows and ventilators unit, shall not be "built in" as the work proceeds but opening shall be left out and frames fitted afterwards so that the minimum specified clearance between opening and unit frame is left all- round. The size of the opening shall first be checked and cleared of obstruction, if any. The position of the unit and fixing holes shall be marked on the jamb. Necessary holes shall be made in the masonry and lugs not less than 10 cm long 15 x 3 mm size M.S flat fixed in cement concrete blocks 15 x 10 x10 cm size of 1:3:6 mix (1 cement : 3 coarse sand:6 graded stone aggregate 20mm nominal size). The frames of units shall be set in the opening by using wooden wedges at the jamb, head and sill, (wedges shall preferably be placed near the points where a glazing bar meets the frames and be plumbed in position).

ii. After, the frame shall be fixed with the lugs with 20 mm long and 6.3 mm dia. G.I. counter sunk machine screws and nuts. In case of flush opening which are rendered smooth, wedges shall be removed and gap between unit and the jambs shall be filled with cement mortar.

iii. In case of flush jamb with external "fair faced" finish the gap between the opening and frame shall be filled with mastic from inside till it oozed out on eternal face. The oozing mastic shall be cleaned and flush pointed. The internal gap shall be filled with mastic to about 1/3rd depth the rest with cement mortar.

iv. In case of rebated jambs and jambs finished "fair faced" externally, the mastic shall be freely applied to the inside channel of frame, jamb and sill, so as to ensure a watertight joint. After the units is firmly fixed in position surplus mastic shall be cleaned and flush pointed.

b. **Fixing with Screws and Plugs:** In R. C. C. work where lugs cannot be embedded due to reinforcement bars etc. rawl plugs or other approved metallic fasteners may be fixed in proper position and frame fixed to them with 60 mm galvanized cross recessed head wood screws of designation 10.

(d) **Fixing in Wood Work Opening :** Opening in wood work are normally rebated and approved mastic or rubber linings shall be applied to jambs, sill and channel before fixing in position, the frame shall be set in opening using wooden wedges and fixed to the opening with 60 mm galvanized wood screws of designation 10. Extra timber fillets of hard wood to match the adjoining work shall also be provided around the frame to close the extra gap between opening and frame.

(e) **Fixing in Steel Work Opening:** Before placing the unit frame in position approved mastic shall be applied and a mild steel or hard wood fillet shall be provided around the frame to close the extra gap between opening and frame. The unit shall then be fixed to the opening with fixing clips or with nuts and bolts as shown in the drawings or as directed by the Engineer-in-Charge.

(f) **Fixing of Composite Units :** The fixing procedure for composite units shall generally be as described except that: Where large units shall be formed by coupling individual units together (with coupling sections), the mullions and transom shall be bedded in mastic to ensure water tightness. Mastic shall be applied liberally to the channels of

the outside frame section before assembly and after coupling. All oozing out mastic shall be cut out neatly.

(6) **Precautions**

Care shall be taken that steel doors and windows etc. are not deformed/ damaged during subsequent constructions. Particular care shall be taken that scaffolding do not rest on the steel door window frames or glazing bars.

All fittings and hinges (projecting hinges) shall be protected, preferably with alkathene sheets so that these may not be damaged during execution of work.

K. GENERAL STRUCTURAL STEEL WORKS

I. FOUNDATION BOLT ASSEMBLY (a) General

i. Foundation bolt shall comprise of foundation bolts, nuts, lock nuts, anchor plates, stiffener plates, protective tape etc.
ii. All foundation bolts other than nut and lock nuts shall be site-fabricated.
ii. Every bolt shall be provided with nut and lock nuts. The nut and lock nuts shall be of reputed make and manufacture as approved by the engineer.

(b) Fabrication

i. The fabrication of bolt assemblies shall include threading, cutting, grinding, drilling, welding, etc. complete.
ii. All bolts, bolt assemblies, etc. shall be fabricated to the correct dimensions and shapes as shown on the drawings. The bolts shall have coarse pitch screw thread in the diameter range 8 to 64 mm and 6 mm pitch screw thread for diameter greater than 64 mm, as per IS: 4218.
iii. For fabrication of any particular size of bolt indicated on the drawing, the diameter of the threaded portion of the bolt shall be considered as the diameter of the bolt.
iv. All nuts shall be of steel with well-formed hexagonal heads, unless specified otherwise, forged from solid metal and shall be dipped in hot boiled linseed oil as soon as these are made. The nuts shall fit well on the bolts.
v. Splicing in the foundation bolt can be done with full strength butt weld, which shall be further strengthened by provision of stiffening ribs for the full strength of the bolt.
vi. While splicing the foundation bolts, it shall be ensured that not more than 25% of the foundation bolts of each pedestal are spliced.

(c) Erection

i. During erection, necessary temporary members like template, bracing, supports, etc. to ensure proper positioning of the assemblies and alignment of the bolts and holding them firmly during concreting shall be provided by the Bidder at his own cost.
ii. All materials shall be erected in plumb and in level (unless otherwise specified) and at true locations as shown on the drawings.
iii. Fabrication and erection shall be carried out as per IS: 800. Welding shall conform to IS: 816 and IS: 9595.

II. FABRICATION AND ERECTION OF STRUCTURAL STEEL

(a) General Requirements

i. This covers fabrication, erection, alignment, welding, etc. of mild steel, medium and high tensile steel, at all levels, involving rolled sections including rounds, pipes /hollow sections, built-up sections fabricated out of

plates, and / or rolled sections including pipes / hollow sections, chequered plates, in columns, beams, crane girder, gantry girders, roof trusses, portals, purlins, space frames, shear connectors, hangers, struts, monorail beams, galleries, stiffeners, wall beams, sheeting runners, brackets, stub columns, bracing, cleats, trestles, base plates, splice plates, chequered plate floorings, decking plates, floor plates, seal plates, diaphragm, steel frame grid over false ceiling, walkways, platforms, ladders, stairs, stringers, treads, landings, handrails, toe plates, M.S. rungs, insert plates, edge protection, embedments, lugs, posts, stays, gates, louvers, lacing, gusset plates, washers, bunkers, silos, hopper, strakes, all sampling and testing etc. all complete.

III. **Material**

ii. The provisions of IS: 800 shall be followed as general guidance along with all other relevant Indian Standards, Codes and Acts, unless otherwise specifically mentioned.

B.1 **Mild Steel**

i. Rolled sections and plates up to and including 20mm thickness shall conform to grade 'A' of IS: 2062 and shall be semi-killed. Plates beyond 20mm thickness shall conform to grade 'B' of IS: 2062. All steel upto and including 40mm thickness shall be in as rolled condition. Plates beyond 40mm thickness shall be normalized and ultrasonically tested.
ii. Rolled sections and plates conforming to IS: 808 and IS: 226 respectively can also be used as available in the stock of the owner.
iii. Pipes shall conform to IS: 1161.
iv. Hollow (square and rectangular) steel sections shall be hot formed conforming to IS: 4923 and shall be of Grade Yst 240.
v. Chequered plate shall conform to IS: 3502 and steel shall conform to grade A of IS: 2062.

B.2 **Medium and High Tensile Steel**

i. Medium and high tensile steel shall generally conform to grade 'Fe-490B' of IS: 8500 or equivalent.
ii. Rolled sections and plates up to and including 20mm thickness shall be semi-skilled and plates beyond 20mm thickness shall be killed
iii. All steels upto and including 40mm thickness shall be in as rolled condition. Plates beyond 40mm thickness shall be normalized and ultrasonically tested.

All other materials (nuts, lock nuts), consumables etc. shall be as per applicable standards and codes.

In case any defect like laminations is noticed in the steel sections and plates during fabrication and erection, same shall be immediately brought to the notice of the engineer, who shall direct the usage or non-usage of the same. In case of non-usage, the Bidder shall return the same to the owner's store at his own cost. However, in case of usage, the Bidder shall take necessary precautions such as plug welding etc. and as directed by the engineer, without any extra cost to the owner.

IV. **Splicing**

i. All splicing works shall be for full strength.
ii. Shop splicing of all plates shall be carried out by full strength full penetration butt welds. Shop splicing for all rolled sections (beams, channels, angles, hollow

sections, etc.) shall be carried out using web and flange cover plates. Shop splicing for solid round sections shall be done by combination of butt weld and stiffening (splice) plates.

iii. Field splicing of built-up section is generally not envisaged. However it can be provided only in exceptional cases, if indicated in the scope / design drawings, with butt weld followed by splice cover plates. Splice cover plates shall be designed for the full strength.

iv. In case any additional splices are needed than those indicated in the design / scope drawings by the Bidder, on account of limitation of crane (i.e. by not mobilizing crane of specified capacity), then the same can be provided subject to a maximum penal recovery of steel sections used for such additional splicing, at the rates specified for reconciliation of structural steel consumption under relevant clauses of special conditions of contract.

V. Fabrication

D.1 Site Fabrication

The fabrication of works shall be carried out generally in accordance with IS: 800 as well as with the stipulations contained in these specifications. IS: 9178 (Parts I and II) shall be followed as general guidance for fabrication and erection of bins / silos.

All structures shall be completely site fabricated, in the fabrication/ pre-assembly yard developed by the Bidder, at his own cost, within the project site.

D.2 Straightening

All steel materials shall be straight and free from bends or twists. If the sections are distorted or twisted during transit, storage, etc. they shall be straightened and / or flattened, as directed by engineer, at an ambient temperature. Minor kinks or bends may however be corrected by limited heating under careful supervision.

D.3 Preparation of Cutting Plans

The Bidder shall prepare necessary cutting plans for all fabrication work taking into consideration the availability of materials and cut pieces generated during the work with the object of minimizing wastage. Care shall be taken by the Bidder to ensure maximum utilization of cut pieces and if required by providing additional butt weld, at his own cost.

D.4 Cutting

The cut edges of all plates / sections shall be perfectly straight and uniform throughout. Plates shall be cut with pug cutting machine only unless otherwise directed by the engineer. Gas cut edges shall be clean, square and free from distortion and burrs.

D.5 Bending and Rolling

Bending of plates and rolled sections to the specially required shapes for fabrication shall be done on plate bending machine or by cold bending process without resorting to heating, hammering, angle smithy and black smithy process.

D.6 Grinding

i. All the edges cut by flame shall be ground before they are welded. Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom.

ii. In case of crane girders, the bottom of the knife-edge support shall be accurately ground to provide effective bearing on the column bracket. The top surface of column bracket shall also be ground similarly.
iii. The ends of column shafts together with attached gussets, stiffeners, angles, channels, etc. after welding together shall be accurately ground, so that the parts connected butt over the entire surface of contact.
iv. The column base slabs shall be similarly ground over the bearing surface and shall have effective contact with the end of the shaft. The bearing face that is to be grouted direct to a foundation need not be ground.

D.7 **Clearances**

The erection clearance for cleat ends of members connecting steel to steel shall not be greater than 2mm at each end, unless approved by the engineer.

D.8 **Drilling**

i. Holes through more than one thickness of material for members, such as compound stanchion and girders, flanges, shall be drilled after the members are assembled and tightly clamped or bolted together.
ii. All holes in the washer plates shall be drilled using drilling / lathe machine. Small holes (having diameter up to and including 50mm), provided in the base plate for grouting, and shall be made by drilling. Large holes (having diameter more than 50mm), provided in the base plate and or horizontal brackets plates directly welded to the column flange, for passage of the foundation bolt can be made by gas cutting and all surfaces obtained by gas cutting shall subsequently be made smooth by grinding / filing.

D.9 **Assembly**

i. The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any is provided. If the individual components are to be bolted, parallel and tapered drifts shall be used to align the parts so that the bolts can be accurately positioned.
ii. Items like roof trusses, galleries shall be trial assembled keeping in view the actual site conditions, prior to dispatch to site for erection so that they can be conveniently pre-assembled before erection or conveniently pre-assembled during erection. Necessary match marks shall be made on these components before disassembly in the shop and dispatching.
iii. For columns which are fabricated in two or more parts, controlled / trial assembly shall be carried out in the pre assembly / fabrication yard before dispatch to the erection Site.

D.11 **Bolting**

i. Bolting will involve the provision of bolts in clearance holes and/or high strength friction grip fasteners.
ii. The diameter of the bolt hole shall be taken as the nominal diameter of the bolt plus 1.5mm, unless noted otherwise.
iii. Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
iv. Flat washers shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads / nuts bear upon the bevelled surfaces they shall be provided with the square tapered washers of suitable thickness to afford a seating square with the axis of the bolt as per satisfaction of engineer.

v. All bolts and nuts shall be of steel, with well-formed hexagonal heads. The nuts shall be good fit on the bolts and minimum two clear threads shall show through the nut when it has been finally tightened up.
vi. Notwithstanding anything to the contrary contained in IS: 1363, IS: 1364, and IS:1367, the unthreaded length of the bolt shall be equal to total thickness of metal being bolted together plus 2mm. The threaded length shall be equal to at least the diameter of bolt plus 6mm.
vii. IS: 4000 shall be followed for high strength friction grip bolts.

VI. Welding

i. The works shall be done as per approved fabrication drawing which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld.
ii. Welding of structural steel shall be done by an electric arc process, submerged arc welding / MIG welding / manual metal arc welding. Welding shall conform generally to relevant acceptable standards viz. IS: 816, IS: 9595, IS: 814, IS: 1024, IS: 4354 and Indian Standard hand book for metal arc welding, and other standards, codes of practice internationally accepted. For welding of any particular type of joint, Bidder shall give evidence acceptable to the owner of having satisfactorily completed appropriate tests as described in any of the Indian Standards - IS: 817, IS: 7307 and international standard as relevant.
iii. Welding process employing semi-automatic welding machine and / or MIG welding and / or fully automatic welding machine shall be used for welding longitudinal fillet welds (connecting flange with web) and butt joints for fabrication of columns, framing beams and crane girders, unless manual arc welding is specifically approved by the engineer. Necessary jigs and fixtures and rotation of structural shall be so arranged that vertically down-hand position of welding becomes possible. 'open-arc-welding' process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.
iv. Wherever welding is done for assembling the components of structural, the job shall be so positioned that down-hand welding is possible.
v. Any structural joint shall be welded only by those welders who are qualified for all welding procedures and positions required in such a joint.
vi. The Bidder shall maintain records of all the welders identification marks, the joints welded by each welder, the welding procedure adopted, welding machine employed, pre and post heating done and any non-destructive test done and stress relieving / heat treatment performed on such joints. All such records for entire welding operation shall be accessible to the engineer for scrutiny.
vii. In fabrication of plated columns / beams and built-up members all shop splices in each component part shall be made before such component part is welded to other parts of the member. Wherever weld reinforcement interferes with proper fitting between components to be assembled for welding, these welds shall be ground flush prior to assembly.
viii. The members to be joined by fillet welding shall be brought and held as close together as possible and in no event shall be separated by more than 3mm. If the separation is
1.5mm or greater, the fillet weld size shall be increased by the amount of separation.
ix. The bins / silos shall be made of mild steel plates joined together with full strength butt weld and provided with stiffeners at regular intervals. Stiffeners shall be welded on the external face.

a. Electrodes

i. The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired. Only low hydrogen electrodes shall be used

for welding of medium / high tensile steel and for mild steel plate thickness above 20 mm.

ii. All low hydrogen electrodes shall be baked and stored before use as per manufacturer's recommendation. The electrodes shall be re-baked at 250℃ - 300℃ for one hour and later on cooled in the same oven to 100℃. It shall be transferred to a holding oven maintained at 60℃ - 70℃. The electrodes shall be drawn from this oven for use.
iii. Where coated electrodes are used they shall meet the requirements of IS: 814 and relevant ASME - Sec. II. Covering shall be heavy to withstand normal conditions of handling and storage.
iv. Only those electrodes that give radiographic quality welds shall be used for welds, which are subjected to radiographic testing.
v. Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform to the requirements of F-60 class of AWSA-5-17-69 and IS: 3613. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.
vi. The Bidder shall take specific approval of the weld for the various electrodes proposed to be used on the works before any welding is started.

b. **Edge Preparation for Welding**

Suitable edge as per weld joint detail shall be prepared either by machines or by automatic gas cutting. All edges cut by flame shall be ground before they are welded.

A.1 Pre Heating and Post Heating

i. Mild steel and medium / high tensile steel plates thicker than 20mm, will require Pre-Heating of the parent plate prior to welding as mentioned in Table - 1 for mild steel and Table - 2 of IS:9595 for medium / high tensile steel, however, higher pre heat temperature may be required as per approved welding procedure and it shall be followed. In welding materials of unequal thickness, the thicker part shall be taken for this purpose.
ii. Base metal shall be preheated, not withstanding provisions of IS: 9595 to the temperature given in Table - 1 for mild steel and Table - 2 for medium / high tensile steel, prior to welding or tack welding. When base metal not otherwise required to be pre heated is at a temperature below 0℃ it shall be pre heated to atleast 20℃., prior to tack welding or welding. Pre heating shall bring the surface of the base metal to the specified pre heat temperature and this temperature shall be maintained as minimum inter-pass temperature while welding is in progress.
iii. All butt welds with plates thicker than 50mm and all site butt welds of main framing beam supporting the bunker shall require post weld heat treatment as per procedure given in AWS D-1.1. Post heating shall be done up to 600℃ and rate of application shall be 200℃ per hour.

iv. The post heat temperature shall be maintained for 60 minutes per 2.5cm thickness. For maintaining slow and uniform cooling, asbestos pads shall be used for covering the heated areas.

B.1 Welding Sequence

i. The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect or by a counter distortion.

ii. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.
iii. Each case shall be carefully studied before finally following a particular sequence of welding.
iv. Butt weld in flange plates and / or web plates shall be completed before the flanges and webs are welded together.
v. The beam and column stiffeners shall preferably be welded to the webs before the web and flanges are assembled unless the web and flanges of the beam or column are assembled by automatic welding process.
vi. All welds shall be finished full and made with correct number of runs.
The welds being kept free from slag and other inclusions. All adhering slag being removed from exposed faces immediately after such run.
vii. Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid as to leave the edges unmelted.
viii. Puddling shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

ix. Non-uniform heating and cooling should be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.

x. The ends of butt welds shall have full throat thickness. This shall be obtained on all main butt welds by the use of run off and run on pieces adequately secured on either side of main plates. The width of these pieces shall not be less than the thickness of the thicker part joined. Additional metal remaining after the removal of extension pieces shall be removed by grinding or by other approved means and the ends and surface of the welds shall be smoothly finished. Where the abutting parts are thinner than 20mm the extension pieces may be omitted but the end of the butt welds shall then be chipped or gouged out to sound metal and side welded to fill up the ends to the required reinforcement.

xi. The fusion faces shall be carefully aligned. Presetting shall control Angle shrinkage. Correct gap and alignment shall be maintained during the welding operation.

xii. All main butt welds shall have complete penetration and back surface of the weld being gouged out clean before first run of the weld is given from the back. However, partial penetration butt weld shall be permitted, when specifically shown in the fabrication drawings.

xiii. Intermittent welds shall be permitted only when specifically approved in the fabrication drawings.
xiv. The welding shrinkage shall be minimized by adopting the correct welding procedure and method. In long and slender member extra length should be provided at the time of fabrication for shrinkage.

C.1 Testing Of Welders

i. On the basis of the welding procedure, the Bidder shall conduct qualification test. All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 817 and IS: 1181 and ASME IX / AWS D1.1.
ii. All necessary arrangements required for the testing of welders are to be provided by the Bidder.

D.1 Production Test plate

Test plates shall be incorporated on either side of at least one main butt weld of each flange plate and web plate of every main frame column. The weld shall be continuous over the test plate. The test plate shall be cut from extensions of the main plates and shall be fixed so that metal lies in the same direction as that of the main plate.

Test plates shall be prepared and tested in accordance with the accepted standards, in the presence of the weld or his authorised representative. The Bidder shall provide all testing equipment and facilities for carrying out these tests. Should any of these tests fail, further radiographic examination of the welds shall be done. These tests for the test plates and radiographic examination are additional to those contemplated in the specification.

E.1 Rectification And Correction

Wherever defects like improper penetration, extensive presence of blow holes, undercuts, cracking, slag inclusion, etc. are noticed by visual Inspection / other tests, the welds, in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary, and re-welded. The gouging shall as far as possible be done using gouging electrodes.

F.1 Correction of Defective welds

Correction of defective welds shall be carried out as directed by owner without damaging the parent metal. When a crack in the weld is removed magnetic particle inspection or any other equally positive means shall be used to ensure that the whole of the crack and material up to 25mm beyond each end of the crack has been removed. Cost of all such tests and operation incidental to correction shall be to Bidder's account.

VII. **Primer Painting**

i Chlorinated rubber based zinc phosphate primer shall be with non-saponificable plasticiser. The primer shall have high build formulation, as per BS: 5493 (One pack chemical resistant primer).

ii. Unless specified otherwise in the schedule of items, surface preparation shall be done in accordance with IS: 1477 (Part - I). The surface shall be cleaned and degreased in accordance with one or more of the methods given in IS: 1477 (Part - I). The surface shall be de-rusted and de-scaled either mechanically or chemically by one or more of the methods given in IS: 1477. However flame cleaning and blast cleaning shall be resorted to wherever specifically mentioned in the schedule of items. While cleaning with power wire-brush, care shall be taken not to do it excessively, since mill scale easily gets burnished to a smooth even surface to which paints does not adhere, and this will be detrimental to the performance of paint. Power tools shall remove all accessible weld flux and splatter.

iii. Primer paint shall be applied by spray. Dry film thickness (DFT) of the chlorinated rubber based zinc phosphate shall be minimum 50 microns.

VIII. **Erection and alignment**

i. **Erection marks**

Erection marks in accordance with approved fabrication drawing shall be clearly painted on the fabricated steelwork. Each piece shall be marked in at least two places. Each piece shall also have its weight marked thereon.

ii. The center lines of all columns, elevations and beam bearings shall be marked on the sections to ensure proper alignment and assembly of the pieces at site.

iii. **Erection Scheme**

a. The Bidder shall submit for review of the owner his erection scheme for the erection of all types of structural.
b. The Bidder before commencement of fabrication work, to avoid any future modification shall check the erect-ability of the structural. The erection scheme shall indicate the approximate weight of the structural members, position of lifting hook, crane boom length, crane capacity at different boom length and at different boom inclination etc.
c. The erection scheme shall also give details of the method of handling, transport, hoisting, including false work / staging, temporary bracing, guying, temporary strengthening etc. It will also give the complete details of the number and capacity of the various erection equipment that will be used such as cranes, winches, etc. along with disposition at the time of erection of column, trusses etc.
d. The Bidder shall examine the site conditions and transportation clearances before deciding whether columns, trusses, beams are to be transported in one piece or in more than one piece. All those steel members which are to be required to be erected in single piece but are transported in more than one piece shall be assembled, aligned bolted, welded, tested etc. on the proper assembly bed before erection at site.
e. The erection of columns, trusses, trestles, portals, beams etc. shall be carried out in one single piece as far as practicable unless specified otherwise in the design drawing. Conveyor galleries shall generally be erected as box pieces i.e. the bottom chord and bracing, top chord and bracing, side vertical posts and tracing, end portals and roof-trusses shall be completely welded prior to erection and if required temporary strengthening during erection shall be made.
f. The sheeting runners and roof sheeting purlins may be erected individually. When erection joints are provided in columns, their location shall generally be just above a floor level.
g. The structural steel shall be erected frame-wise. Thereafter, the frames shall be progressively aligned and all erection welding completed. The secondary beams shall thereafter be erected, aligned and welded bay wise / floor-wise.

IX. Embedding In Concrete

All embedments shall be placed true to level and location. It shall be ensured by the Bidder by provision of the temporary members and if required by welding of embedment lugs with nearby reinforcement. Embedments shall not be disturbed during concreting.

X. Protection Against Damage In Transit

a. All steelwork shall be efficiently and sufficiently protected against damage in transit from fabrication yard to erection site from any cause whatsoever. All projecting plates and all ends of members at joints shall be stiffened.
b. If the steel has been unduly bent in transit or during handling by the Bidder which cannot be rectified in the opinion of the weld, such steel shall be counted as wastage and the cost recovered from the Bidder at the time of reconciliation of the steel as per the provisions of the contract.

XI. Stability of Structures

The Bidder shall be responsible for the stability of the structures at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interfere with the movement or working of other agencies working in the area. For the purpose of guying, the Bidder shall not use other structural in the vicinity, which are likely to be damaged by the guy.

XII. Temporary Structures

The stipulations contained in the Indian standard safety code for erection of structural steel work (IS: 7205) shall be followed, for ensuring safety of men and material. This shall include provision of temporary structures by the Bidder, at his own cost for proper approach and working platforms during the erection of structures to the satisfaction of weld. The Bidder at his own cost shall provide any temporary strengthening needed. Temporary structures shall include access ladders, working platforms, railings etc. All temporary structures shall be subsequently dismantled and removed.

XIII. **Setting Column Bases**

Column bases shall be set so that the column load is uniformly transmitted to the foundation. The Bidder shall carefully check the location and layout of anchor bolts embedded in foundations to ensure that the structures can be properly erected as shown on the drawing. In some cases the bolts may be provided in the pipe sleeves / pockets in foundations for subsequent adjustment in final alignment of the foundation bolt. Before erection of columns on their foundations, the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose material. The Bidder shall be responsible to provide all packing and shim plates whatsoever required for erection of the structural at his own cost.

XIV. **Alignment**

The Bidder shall be responsible for the correct alignment and leveling of all steelwork on site to ensure that the columns are in plumb and all the structures are erected conforming to the specified permissible erection tolerances. Welding works shall be done only after the approval of alignment of erected structures, by the weld.

XV. **High performance painting system**

A. Materials

i. Zinc silicate primer (minimum 75 micron Dry Film Thickness - DFT) shall be inorganic (Ethyl) self-curing high built (Solid by volume minimum 60%) formulation as per BS: 5493 (Inorganic Zinc rich systems).
ii. Intermediate (Under) coat (minimum 75 micron DFT) shall be of polyamide cured titanium di-oxide / micaceous iron oxide pigmented high performance (solid by volume minimum 60%) epoxy coating as per BS : 5493 (two pack chemical resistant under coats).
iii. Finish coat (minimum 75 micron DFT) shall be of polyamide cured colored pigmented high performance (solid by volume minimum 60%) epoxy coating as per BS: 5493 (two pack chemical resistant finishes).
iv. Final finish coat (minimum 25 Micron DFT) shall be of polyurethane colour pigmented (solid by volume minimum 40%) as per BS: 5493 (two pack chemical resistant finishes).
ii. All paints including primer shall be of reputed brand / manufacturer and as approved by the engineer.

B. Preparation of Surface

i. The surfaces shall be blast cleaned to near white metal surface (SA 2 ½) i.e. 2nd quality (requiring at least 95% of the surface completely cleaned) as given in BS: 4232. For blast cleaning dry method as approved shall be used.
ii. Approved type of abrasives shall only be used for blast cleaning of steel surfaces. To avoid contamination of the adjoining areas with abrasive, suitable enclosure shall be provided to carry out the blast cleaning operation. If required prior approval from the factory inspector / pollution control board etc. shall be obtained regarding the method of blast cleaning and abrasives used therein.

iii. Steel may be blast cleaned either before or after fabrication. Immediately after blast cleaning of the steel surfaces, primer coat shall be applied onto the surfaces.

C. Application of paint

i. The Bidder shall submit the total painting scheme and works shall be started after the approval of the scheme, from the engineer.
ii. Painting works shall be carried out on structures as per the approved scheme. The total painting scheme to be submitted to the engineer shall include the following:
a. Method of blast cleaning giving the details and sizing of various equipment required, abrasive used, enclosure provided to avoid contamination of the adjoining area, expected productivity on an eight (08) hour shift working etc.
b. Arrangement of airless spray with the equipment rating.
c. Drying time to be allowed before the application of subsequent coat.
d. Recommended paint for primer, intermediate (under) coat, finish coat and final finish coat with their brand name and designation, considering the requirements of BS:5493 for long range (typical time to first maintenance 10 to 20 years), life for exterior exposed non polluted inland atmosphere.
e. Number of coat and the thickness of each coat to be applied to achieve the specified thickness of each coat i.e. primer, intermediate (under), finish and final finish coats.
f. Environmental conditions i.e. ambient temperature and humidity at the time of application of the paint.
g. Quality control setup for painting i.e. checking of surface preparation, thickness of each coat, quality of applied paints vis-a-vis the approved sample etc.
h. Method of touch up painting for surfaces damaged during handling, transit, erection, welding, subsequent to painting, removal of the temporary supports etc.
i. Reference of relevant Indian / International standards for the testing and acceptance.
iii. Before application of inorganic zinc silicate primer, the steel surfaces shall be blast cleaned to near white metal surface (SA 2 ½).
iv. Primer paint and intermediate (Under) coat shall be done by airless spray. However finish coat and final finish coat can be applied either by spray and or brush.
v. All subsequent coats shall be applied only after acceptance of the previous applied coat. Inaccessible surfaces shall be primer painted before shop assembly.
vi. For final touch up painting of surfaces, which are damaged during handling, transit, erection, etc. surfaces shall be well prepared, by rubbing the entire damaged area using wire brush, emery paper etc. and shall be provided with minimum 100 micron (DFT) of self-priming high build epoxy based primer followed by intermediate, finish and final finish coats as described elsewhere in this document. Touch up painting of areas welded subsequent to painting and areas exposed after removal of temporary supports shall also be carried out in same way.
vii. Rectification of the damaged painted surfaces on account of welding / handling etc. of each coat shall be done by touch up painting, before the application of next coat, using minimum 100 micron (DFT) self-priming high build epoxy based primer followed by various coats in sequence of thickness as specified elsewhere.

D. Acceptance Criteria

i. All painted surfaces shall be uniform and pleasing in appearance.

ii. Dry film thickness of each coat shall be checked and measured by using Elcho meter. The thickness as measured shall not be less than the minimum thickness specified for the coat of paint under relevant clauses of the technical specification.
iii. Colour, texture shall match exactly with the approved sample.
iv. Sampling, testing and quality assurance requirements are given elsewhere in part C of the technical specification.

XVI. **Permanent bolts, nuts and washers**

1) **General Requirements**

i. Permanent bolts shall be used for field connections only for those joints where so specified in the design document.
ii. All bolts, nuts, washers shall be of reputed make as approved by the engineer.

2) **Material**

i. Permanent Mild Steel Bolts

The permanent mild steel bolts shall be of carbon steel of product Grade 'C' as per IS:1363 (part - 2). The technical supply condition shall be as per IS: 1367 (part - I). The threads shall be of class 8g as per metric screw threads of IS: 4218 (part - 6). The bolts shall be of diameter up to 39mm and shall conform to mechanical properties class 4.6 as per IS: 1367 (part - 3).

ii. Permanent Mild Steel Nuts

The permanent mild steel nuts shall be of carbon steel of product grade C meeting the requirements of IS: 1363 (part - 2). The technical supply condition shall be as per IS: 1367 (part - 1). The Threads shall be of tolerance class 7H as per metric screw threads as per IS: 4218 (part - 6). The nuts up to diameter 16mm shall be of property class 5 and for diameters beyond 16mm and up to 39mm shall conform to property class either 4 or 5 as per the provisions of IS: 1367 (part - 6) or ISO 898 / 2.

iii. Permanent Mild Steel Washers

The permanent mild steel washers shall be of ordinary grade conforming to the requirements of IS: 5369 and IS: 2016. The washers shall be supplied in natural finish.

iv. Permanent High Strength Structural Bolts

The permanent high strength structural bolts shall be either of carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered or carbon steel quenched and tempered of product grade C meeting the provisions of IS: 3757. The technical supply condition shall be as per IS: 1367 (part - 1). The threads shall conform to tolerance class 6g of IS: 4218 (part - 6). The bolts shall conform to mechanical properties class 8.8 as per IS: 1367 (part - 3).

v. High Strength Structural Nuts

High strength structural nuts shall be of product grade B meeting the requirements of IS: 6623. The technical supply condition shall be as per IS: 1367. The threads shall confirm to tolerance class 6H as per metric screws threads of IS: 4218 (part - 6). The nuts shall conform to property class 8 of IS: 1367 (part - 6) / ISO: 898 / 2 and all nuts shall be hardened and then tempered at temperature of at least 425℃.

vi. Washers for High Strength Structural Bolts and Nuts

The various types of washers for use with high strength structural bolts and nuts shall be of ordinary grade as per IS: 5369 and shall meet all the requirements of IS: 6649. The washer shall be made according to IS: 1570 (part - 2). The washer shall be thorough hardened and tempered. Washer shall be supplied in dull back heat-treated condition with residual coating of light oil.

L. Installation

i. Installation of the high strength bolts / high strength friction grip bolts shall be as per the requirements specified in IS: 4000.
ii. Mild steel bolts shall be installed and placed in position as per IS: 1363 / IS: 1367.

M. Dismantling of Steel Work

i. In case it is found that certain erection marks already erected at any elevation are to be dismantled for any reason whatsoever, this shall be done only on the written orders / permission of the engineer.
ii. Such dismantling shall be done carefully without damaging other structural and lowered to ground. Thereafter, it shall be carried to the field fabrication shop, if modifications are to be carried out or return to the project stores if the dismantled member is not to be re-erected at all. This operation may involve temporary dismantling, cutting, re-welding, supporting and restoring to correct position all temporarily dismantled members, realigning of all other adjacent connected members, to their correct positions as well.

N. Additions to, alterations in and / or modification

i. Modification of Erection Marks

In case, it is found that certain erection marks as already detailed and approved in fabrication drawings, require additions, alterations and modifications; this shall be done on the written orders of the engineer. Wherever a modification is ordered, the Bidder shall request the engineer in writing to examine the stage of completion of the erection mark. The weight of the erection mark (i.e. the calculated weight as per approved bill of materials) shall be recorded and termed as the unmodified weight of the erection mark.

ii. Additions To, Alterations In

a. If additions to, alterations in and / or modifications are intimated before completion and acceptance of fabrication of erection marks as per originally approved fabrication drawings, such changes shall not be classified as additions to, alterations in and / or modifications of erection marks and no payment shall be due to the Bidder for such additions, alterations and modification. If additions to, alterations in and / or modifications is ordered after completion and acceptance of fabrication and / or erection, payment shall be due to the Bidder for additions to, alterations in and / or modifications.
b. Normally the work of additions to, alterations in and / or modifications of erected erection marks shall be carried out in the erected position. Only in exceptional cases, where the engineer specifically approves that modification cannot be carried out in the erected position, the erection mark shall be dismantled.
c. The work of additions to, alterations in and / or modifications may involve cutting of certain portions and parts, gouging of welds, cuttings, grinding, fabrication, welding, drilling holes specifically required for the work, straightening, raising to the required level, removal of bends, painting and touch up painting, transporting the cut and removed parts / items, pieces re-utilised out of cut and removed parts / items and new steel to be added. Wherever modification is involved it shall be done carefully without damaging other structural. In case of

cutting from an erected member, the cut portion shall be safely lowered to the ground. Thereafter pieces not utilised out of such cut and removed parts shall be returned to the project stores if the weld feels that these cannot be used elsewhere. Further the member from where the piece /item has been cut shall be ground smooth at the cut joint location. Modification may involve temporary dismantling, cutting, re-welding, supporting and restoring to the correct position of all temporarily dismantled members realigning of other adjacent connected members as well. Modifications to erection marks at erection site shall involve transporting the fabricated part / items (pieces re-utilized out of cut and removed parts / items and or new steel added) to erection site, raising to required level and welding in position. Modifications to erection marks in fabrication yard shall involve turning and handling of structural.

d. Additions to, alterations in and / or modifications may be ordered either before erection or after erection and may have to be carried out either in erected position at erection site on the ground or in the fabrication shop. The scheme of dismantling and modification wherever required shall be got approved by the engineer before the work is taken up.

O. Re-erection of erection marks after additions, alterations and modifications

i. The items, where additions to, alterations in and / or modifications or change of erection mark have been ordered and such operations have necessarily to be carried out after dismantling, shall require re-erection.

ii. The work of re-erection includes carriage of modified erection marks from the field fabrication shop to erection site, lifting of same to the required position, aligning, and erecting in position, inclusive of erection bolts, tack welding and final welding and touch up painting etc., all complete to the satisfaction of the engineer. The work shall also involve the re-erection of members which had to be temporarily dismantled including temporary dismantling, cutting, re-welding, supporting and restoring to the correct position of all temporarily dismantled members, realignment of other adjacent connected members including gouging of welds, realigning, re-welding, etc. of such members.

P. Sheeting works

i. General Requirement

This part of the specification covers the technical requirements of colour-coated sheet and allied works for roofing, decking and cladding, with or without thermal insulation. Supply and installation of the 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 Bidder.

ii. Material

a) Troughed permanently colour coated metal decking sheet for floor/roof decking shall be made by steel feed material of minimum 0.8 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. Alternatively aluminium feed material of minimum 0.9 mm (bare metal thickness) thick colour coated aluminium alloy of series 31,000 and above as per IS: 737 and IS: 1254 can also be used for metal decking. Steel/aluminium alloy shall be colour coated with total coating thickness of 35 microns (nominal) comprising of silicon modified polyester (SMP with silicon content 30% to 50%) paint or super polyester paint, of minimum 20 microns (nominal) dry film thickness(DFT) on one side (exposed side) on 5 micron (nominal) primer coat and 5 microns (nominal) SMP or super polyester paint over 5 micron (nominal) primer coat (or 10 micron SMP /super polyester

paint)and of approved profile, sectional properties, colour and shade. SMP and super polyester paint systems shall be of category 3 as per AS2728.

b) Troughed permanently colour coated metal sheet for roofing and side cladding (internal and external) shall be

(i) Made using steel feed material of minimum 0.6mm (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.
(ii) Made using high tensile steel material of minimum 0.5mm (bare metal thickness i.e. metal thickness excluding thickness for zinc aluminium coating and colour coating) coated with zinc aluminium alloy @ 150gm/sq.m. Of minimum yield strength of 350 as per AS1397.
(iii) Alternatively aluminium feed material of minimum 0.7 mm (bare metal thickness) thick colour coated aluminium alloy of series 31,000 and above as per IS 737 and IS: 1254 can also be used.
(iv) Steel/aluminium alloy shall be colour coated with total coating thickness of 35 microns (nominal) comprising of silicon modified polyester (SMP with silicon content of 30 % to 50%) paint or Super Polyester paint, of minimum 20 microns (nominal) dry film thickness (DFT) on external face on 5 micron (nominal) primer coat and 5 microns (nominal) SMP or super polyester paint over 5 micron (nominal) primer coat (or 10 micron SMP / super polyester paint) on internal face. SMP and Super polyester paint systems shall be of category 3 as per AS2728.
(v) Sheet shall be of approved profile, sectional properties, colour and shade

c) Plain permanently colour coated steel metal sheet for ridge and hips, flashings, trimmings, closure for vertical and horizontal joints, capping etc. shall be
(i) Using steel feed material of minimum 0.6mm (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.
(ii) Using high tensile steel feed material of minimum 0.5mm (bare metal thickness i.e. metal thickness excluding thickness for zinc aluminium coating and colour coating) coated with zinc aluminium alloy @ 150gm/sq.m of minimum yield strength of 350 Mpa, as per AS1397.
(iii) Alternatively aluminium feed material of minimum 0.7 mm (bare metal thickness) thick colour coated aluminium alloy of series 31,000 and above as per IS: 737 and IS: 1254 can also be used.
(iv) Steel/aluminium alloy shall be colour coated with total coating thickness of 35 microns (nominal) comprising of silicon modified polyester (SMP with silicon content of 30 % to 50%) paint or Super Polyester paint, of minimum 20 microns (nominal) dry film thickness (DFT) on external face on 5 micron (nominal) primer coat and 5 microns (nominal) SMP or super polyester paint over 5 micron (nominal) primer coat (or 10 micron SMP / super polyester paint) on internal face. SMP and Super polyester paint systems shall be of category 3 as per AS2728.
(v) Sheet shall be of approved colour and shade

d) 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 1.7 m under total super imposed loading (DL +LL) of 450 kg per Sq.m.
e) For metal roofing and side cladding, the sectional modulus and moment of inertia of troughed profile per metre width shall be such that the deflection of sheets is limited to span/250 over a span of 1.5 m under adverse wind loading

f) 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 atleast 3 nos. of fasteners shall be used per sheet.

g) Sealant used for cladding shall be butyl based, two parts poly sulphide or equivalent approved, non stainless material and be flexible enough not to interface with fit of the sheets.

h) Filler blocks as a trough filler shall be used to seal cavities formed between the profiled sheet and the support or flashing. The filler blocks shall be manufactured from black synthetic rubber or any other material approved by the Engineer.

i) For insulation of cladding and other areas, mineral wool conforming to IS: 8183 shall be used. The density shall be 32 or 48 kg. /Cu.m. for glass or rock wool respectively. The nominal thickness of insulation shall be 50mm.

j) Special coated fasteners shall be used conforming to class 3 as per AS3566 and shall be tested to 1000 hours slat spray test.

k) Percentage elongation of the mild steel sheet having minimum yield strength of 250MPa, shall be 23% as per IS:2062

iii. Installation and Fixing

A. Metal Decking

i. The sheeting shall be fixed as per the working drawings. Sheets shall be supplied in required sizes (based on purlin 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.

ii. Distorted, blemished or water stained sheets shall not be used.

iii. Before installing decking sheet, it shall be ensured that the purlins are in true planes, correctly placed and securely fixed.

iv. 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 not to exceed 500 mm.

v. 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.

vi. 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.

vii. Length of the sheet shall be such as to cover minimum 3 span Purlin spacing.

viii. The roof decking sheets shall be fixed to the purlins with the help of self-drilling and tapping type fasteners and neoprene washers

ix. Sheets shall be laid over the supporting purlins with a minimum bearing of 50 mm and end projection of 75 mm at lap joints.

x. 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.

B. Roofing and cladding

i. The sheeting shall be fixed as per the working drawings. Sheets shall be supplied in required sizes (based on purlin spacing) according to the cutting schedule. Generally cutting of sheets 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 finalized at the time of working drawings can be allowed at site. Wherever possible, site cut edges shall be concealed at laps or with flashing. 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.

ii. Distorted, blemished or water stained sheets shall not be used.
iii. Before installing roofing/cladding, it shall be ensured that the supporting structure i.e. purlins/runners are in true planes, correctly placed and securely fixed.
iv. 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 and cap of matching colour. Maximum spacing of the fasteners not to exceed 500 mm.
v. Precautions shall be taken during the erection of roofing/ cladding to ensure that partially erected roofing/cladding and insulation (pending placing of external cladding sheet) are protected during inclement weather to prevent the ingress of water and damage at all times.
vi. During erection of roofing/cladding, ladders shall not be leaned on any cladding without precautions being taken against damage.
vii. The fasteners shall be installed by means of power tools and provided with neoprene seal.
viii. Length of the sheet shall be such as to cover minimum 3 span purlin spacing.
ix. Expansion joints shall be provided to take care of movements due to temperature variations.
x. The sheets shall be laid on the steel purlins/runner or scantlings to a true plane with the lines of profiles truly parallel to or normal to other sides of the area to be covered, unless otherwise required as in special shape.
xi. Cladding erection for each elevation shall commence at the bottom and proceed towards the top, in order to ensure tight fitting laps.
xii. The sheets shall be laid with a minimum overlap of 15 cm at the ends and side laps shall be of one trough length subject to a minimum of 50 mm, having a proper water tight arrangement. The minimum lap of sheets with ridges, hips and valleys shall be 15 cm measured at right angles to the line of the ridge, hip and valley respectively.
xiii. In case of insulated sheeting works, the insulation shall be provided.
xiv. In case double skin cladding, inner sheet and outer sheet can be directly fixed to the opposite faces of the sheeting runner totally concealing the supporting steel structure.
xv. Crimping and curving wherever specified shall be provided over the profile sheet.

C. Flashing, trimming etc.

Flashings, cappings, trimming, closure for vertical/horizontal joints, ridge and hips etc. shall be provided with a minimum lap of 15 cm. The lapping of sheets shall provide the dust free, airtight enclosure. If required this may be achieved by using 2-parts polysulphide sealing compound or butyl tape.

Aprons, closures, flashings and other similar fittings shall be formed at works before delivery to site. Site forming or dressing of these items will be approved only in special locations.

The black synthetic rubber external trough fillers are to be secured by the mechanical fixings to the flashings or parapet capping.

Q. Erection

This section covers the general requirements for erection of galvanized steel structures

i. Steel members shall be hoisted and erected in position carefully, without any damage to itself, other structures and equipment and injury to workmen. The

method of hoisting and erection proposed to be adopted by the Bidder shall be got approved from the Engineer-in-charge in advance. The Bidder however shall be fully responsible for the work being carried out in a safe and proper manner without unduly stressing the various members and proper equipment such as derricks, lifting tackles, winches, ropes etc. shall be used.

ii. The work of erection may be done in suitable units as may be directed by the Engineer-in charge.

Fabricated members shall be lifted at such points so as to avoid deformation or excessive stress in members. The structure or part of it placed in position shall be secured against over- turning or collapse by suitable means.

During execution, the steel members shall be securely bolted or otherwise fastened when necessary temporarily braced to provide for all loads including those due to erection equipments and its operation to be carried safely by structure during erection. The steel members shall be placed in proper position as per approved drawing, final riveting or permanent bolting shall be done only after proper alignment has been checked and confirmed.

iii. Trusses shall be lifted only at nodes. The trusses above 10 m in span shall not be lifted by slinging at two mid points of rafters, which shall be temporary braced by a wooden member of a suitable section. After the trusses are placed in position, purlins and wind bracings shall be fixed as soon as possible.

The end of the truss which faces the prevailing winds shall be fixed with holding down bolts, and the other end kept free to move. In case of trusses of spans upto 10m the free end of the truss shall be laid on lead sheet or steel plate as per design, and the holes for holding down bolts shall be made in the form of oblong slots so as to permit the free movements of the truss end. For larger spans the truss shall be provided with proper bearing as per design.

iv. Columns and stanchions shall be erected truly vertical with the necessary cross bracing etc. and the base shall be properly fixed with the foundation concrete by means of anchor bolts etc. as per drawing.

v. Anchor bolts to be placed in the concrete foundation should be held in position with a wooden template. At the time of concreting anchor bolt locations shall be provided with suitable timber mould or pipe sleeve to allow for adjustment which shall be removed after initial setting of concrete. The spaces left around anchor bolts shall be linked to a stopping channel in the concrete leading to the side of the pedestal and on the underside of the base plate to allow the spaces being grouted up after the base plate is fixed in the position along with the column footing. Grouting shall be of cement mortar 1:3 (1 cement: 3 coarse sand) or as specified.

vi. **Bedding of Column, Stanchions etc.:-**

Bedding shall not be carried out until the steel work has been finally levelled, plumbed and connected together. The stanchion shall be supported on steel wedges and adjusted to make the column plumb. For multi-storeyed buildings, the bedding shall not be done until sufficient number of bottom lengths of stanchions have been properly lined, levelled and plumbed and sufficient floor beams are fixed in position. The base plates shall be wedged clear of the bases by M.S. wedges and adjusted where necessary to plumb the columns. The gaps under the base plate may be made upto 25 mm which shall be pressure grouted with cement grouts. With small columns, if permitted by the Engineer-in-charge, the column base shall be floated on a thick cement grout on the concrete pedestal. The anchor bolt holes in the base plate may be made about 10 to 15 mm larger than the bolts. In such cases suitable washers shall be provided.

vii. **Painting**

Before the members of the steel structure are placed in position or taken out of the workshop these shall be painted as specified in painting specification.

viii. **Erection scheme**

The Bidder shall submit a broad erection scheme, within a reasonable time of the award of work and issue of LOI. This erection scheme shall describe the methods proposed to be employed by the BIDDER for unloading, transporting within the site, handling, assembling, hoisting and erecting of the structural and miscellaneous steel components and the type, capacity and quantity of equipment that the BIDDER proposes to bring to site for all these operations. The scheme shall also indicate the strength and trade wise composition of the work force and supervisory personnel that will be deployed by the BIDDER for the various operations.

ix. **Erection programme**

The Bidder shall submit, with the bid, a detailed erection programme as soon as possible after issue of the LOI. This programme shall be accompanied by a layout plan identifying the areas proposed for unloading, main storage, subsidiary storage, assembly and the transportation of equipments and fabricated material between the storage and work areas. The layout shall clearly indicate the points at which proposed erection begins, the direction in which it is proposed to progress, the deployment of equipment, access route for cranes to reach work areas etc. Full details of method of handling, joisting and erection including false work/ staging, temporary bracing, guying etc., shall be furnished by the BIDDER in this erection programme along with complete details of the erection equipment that will be used. A site organisation chart showing the number of supervisory personnel, the number and composition of the various gangs shall also accompany the erection programme.

Any modifications to the erection programme directed by the OWNER/CONSULTANT for the reasons of inadequacy of the quantity and/ or capacity of the erection equipment, temporary bracing, guying etc., or safety of the erection methods, or stability of the erected portions of structures, or unsuitability of the erection sequence due to interference with the work of other agencies shall be incorporated by the BIDDER and the work shall be carried out in accordance with the revised programme. Approval by the OWNER shall not relieve the BIDDER from the responsibility for the safe, sound, accurate and timely erection of structural steel work as required by the OWNER. The BIDDER shall also make no extra claims for bringing additional equipment to site for erection if so directed by the OWNER. The BIDDER shall be deemed to have visualised all erection problems while bidding for the work and no additional compensation shall be claimed on this account.

x. **Erection procedure**

i. All structural steel shall be erected as shown on the drawings. Proper size steel cable slings etc. shall be used for hoisting. Guys shall not be anchored to existing structures, foundations etc. unless so permitted by the OWNER in writing.
ii. Structural steel frames shall be erected plumb and true. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure 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 and Stability.
iii. As erection progresses, the work shall be securely bolted to take care of all dead load, wind, seismic and erection stresses.

iv. No final bolting shall be done until the structure has been properly aligned and approved by the Owner/Consultant. No cutting, reaming or enlarging of the holes shall be carried out without the prior approval of the Owner/Consultant.
v. After steel has been erected all bare and abraded spots, bolt heads and nuts shall be spot painted with appropriate zinc rich paint equivalent to galvanizing. Before paint is applied, the surface shall be dry and free from dust, dirt, scale and grease. All surfaces inaccessible after erection shall receive two coats of the approved paint before erection.

xi. **MARKING**

i. Each individual member shall be marked with its respective identification mark given to it on the erection drawings. The marking shall be stamped with a metal die before galvanizing with figure at least 2 cms high, in such a manner and to such optimum depth as to be clearly visible after galvanizing.
ii. The markings shall be on the outer surface of all angle sections and near one end but clear of bolt holes. For other members such as channels, flats, gusset plates etc. the markings shall be so stamped that they are easily discernible when sorting out members.
iii. Marking on like pieces shall be in identical locations. Members having lengths 3 meters or more shall be stamped at each end.
iv. After galvanizing, marks shall be circled or bracketed with black paint. xii.

xii ERRORS

Any error in shop work which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins will be classified defective workmanship. All replacement material shall be supplied without any extra cost to Owner and the cost of handling, transport and delivery will be borne by Bidder.

xiii. **PACKING AND DELIVERY**

i. All parts of the structure shall be dispatched unassembled to be bolted together at site.
ii. All similar parts of the same structure shall be bundled together before dispatch, except such parts as would make too heavy a bundle for convenience in handling, Gross weight of each bundle shall not exceed approximately 600 Kgs. The bundles shall be securely tied at the two ends with galvanised steel binding wire straps of adequate strength to withstand transit handling. Long members shall be similarly securely fastened at one or more intermediate points.
iii. Cleat angles, brackets, gusset plates and similar small pieces shall be nested, securely wired together through bolt holes and wrapped with galvanized steel wire of adequate strength to ensure against part falling during transit. Gross weight of such a bundle shall not exceed 50 kg.
iv. G.I. Bolts, nuts and washers of GKW make or approved equal make shall be shipped in wooden boxes strong enough to withstand transit handling. The various sizes of bolts shall be kept separate in sacks within the main container. Each container shall carry a list of bolts contained therein, printed in waterproof ink on paper, resistant to moisture. The weight of each container shall not exceed 25 kg.
v. Any loss or damage arising out of insufficient or defective packing shall be borne by Bidder. Copies of bills of materials shall be furnished to Owner/Consultant for each consignment dispatched.
vi. Each bundle or package shall have the following details marked on it properly stencilled in indelible ink on the top members in the bundle and on wooden boxes or bags carrying smaller components.
    a. The name or designation and address of consignee
    b. The ultimate destination
    c. The relevant mark of structure members, bolts and nuts, gussets or other attachments for easy identification

xiv. **SITE OPERATIONS**

All the work shall be carried out as per the guidance of Owner. An experienced and qualified Superintendent shall be in full time charge of the job.

The BIDDER shall complete all preliminary works at site well before the arrival of structural steel, such as establishment of office, stores, unloading arrangement, labour quarters if any, electrical and water connections, winches, derricks, cranes, compressors, all tools and tackles, welding sets, torque wrenches, spud wrenches, staging etc. as part of this contract and any other work that may be necessary so as to start erection immediately after the arrival of first batch of steel at site.

The BIDDER shall furnish 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 completion of the job. The BIDDER shall also provide necessary passage ways, fences, safety belts, helmets, lights and other fittings to the satisfaction of the OWNER and to meet the rules of local authorities and for protection to his men and materials. A licensed electrician shall be kept on the job for the entire duration of the work to maintain the Bidder's electrical equipment and connections.

If a portion of the work of project area cannot be made available to the BIDDER for his activities due to operations being carried out by other agencies, he shall suitably modify his sequence of operations so as to continue work without interruption. The BIDDER shall work in coordination with other agencies working on the project site and plan his work suitably so as not to hinder the progress of construction at site.

xv. **ANCHOR BOLTS**

i. The anchor bolt for steel structure in FGD area shall be in Bidder scope.
ii. The BIDDER shall carefully check the location and layout of anchor bolts to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/foundations shall be reported to the Owner.

xvi. **ASSEMBLY & CONNECTIONS**

i. Field connections may be effected by use of galvanized bolts as shown in the approved drawings.
ii. All welding shall be in accordance with IS: 816 - Code of Practice for Use of Metal Arc welding for General Construction in Mild Steel and IS: 823 – Code of Procedure for Manual Arc Welding of Mild Steel.
iii. All assembling shall be carried on a level platform.
iv. Drifts shall be used only for drawing the work to proper position and must not be used to such an extent as to damage the holes. Size of drifts, larger than the nominal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of the OWNER.
v. Corrections of minor misfits and reasonable amount of reaming shall be considered as a part of erection. Any error in shop which prevents proper fit on a moderate amount of reaming and slight chipping or cutting shall be immediately reported to the OWNER.

xvii. **INSPECTION**

The OWNER or their authorized representatives shall have free access to all parts of the job during erection and all erection shall be subjected to their approval. In case of faulty erection all such dismantling and re-erection required will be at the BIDDER'S cost. No paint shall be applied to bolts until these have been approved by the Owner/Consultant.

i. The work and materials covered by this specification shall be subject to inspection by the Owner/Consultant. Inspection shall also include the stacking of finished material in Bidder's works and loading into cars or wagons, for shipment or dispatch to the consignee.

ii. The Owner/Consultant shall have free access at all times to all parts of the shop where raw material is stacked and where material is being fabricated and shall be provided with all reasonable facilities for inspection and tests. Equipments and instruments required for carrying out routine inspection shall be furnished by Bidder. No materials shall be dispatched without inspection unless such inspection is waived in writing by Owner/Consultant.
iii. Inspection by Owner/Consultant or waiving of inspection and release of material shall not relieve Bidder from the responsibility of furnishing materials to conform to the requirements of this specification, nor invalidate any claim which may be made because of defective or unsatisfactory material, workmanship and galvanizing.

iv. Any material that is rejected by the Owner/Consultant shall be promptly replaced by Bidder without extra cost. The fact that certain material has been accepted at Bidder's works shall not prevent final rejection at site if it fails to meet specification requirements or if fabrication inaccuracies prevent proper assembly.

xviii **TOLERANCES**

i. Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb. Further, all tolerances shall also apply to members as erected unless otherwise specified.
ii. The shift of column axis at column base from the marked axis shall not exceed 5 mm.

All column tiers shall be plumb within a tolerance of 1 in 500 and the structure as a whole plumb within a tolerance of 1 in 1000. In no case, however, the displacement from plumb of column tiers exceeds 10 mm and the total displacement of the structure as a whole exceeds 25 mm for structures up to 50 meters height. For structures taller than 50 meters an additional displacement of 1 mm for every 2.5 meters additional height shall be permitted subject to a maximum displacement of 50 mm unless otherwise specified.
iii. BEAMS

Beams on erection shall be considered to be correctly positioned when all the connections including splices are completed and the following conditions where applicable exist.

a. A beam up to 1800 mm deep is within + 6 mm of its correct level.
b. A beam over 1800 mm deep is within + 10 mm of its correct level.
c. The web of beam is within + 3 mm of its correct position connections to other members.

iv. The difference in level between the ends of any two beams of approximately the same height and connected to the same column does not exceed + 1.5 mm.
v. The weight and dimensional tolerances for rolled shapes and sections shall not exceed the limit specified by IS: 808 and IS: 1852.
vi. Finished members shall not have lateral variations greater than 1/1000 of the axial length between points of lateral supports.
vii. Finished members without ends finished for contact bearing shall have a tolerance 1.5 mm for members up to 3 m in length. For members over 3 m long an additional 1 mm for every 3 m length may be allowed but in no case will a tolerance more than 3 mm be allowed for any member.

xix. **SAFETY PRECAUTIONS**

i. Bidder shall take all necessary precautions for the safety of his own personnel as well as those of other Bidders working in the area.
ii. The job shall be executed in a professional manner with proper planning and quality control.

iii. All the personnel working in the construction site shall be provided with safety helmets. Personnel working at higher elevations shall be provided with safety belts. Adequate first aid facilities shall be provided by the Bidder at his own cost. Any negligence on the part of the Bidder in terms of safety measures would be viewed seriously and consequences arising out of such negligence will be the sole responsibility of the Bidder.

iv. Bidder shall take precautionary measures such as providing sheets/ covers below the erection area to provide protection against falling materials. Area where erection is being done shall be suitably barricaded to prevent movement of personnel underneath and signboards shall be put in such areas where erection is being done.

APPENDIX A

WELDING PROCESS

a. The work shall be positioned for downward welding wherever possible.
b. Arc length voltage and amperage shall be suited to the thickness of material, type of groove and other circumstances of the work. The welding current and electrode sizes for different types of joints shall be as per IS: 9595.
c. The sequence of welding shall be such as will avoid undue distortion and minimize residual shrinkage stresses. Recommendation of IS: 9595 shall be followed.

Process of Welding

The electrode manipulation during welding shall be such as to ensure that:

i. The parent metal is in a fused stage when the filler metal makes contact with it.
ii. The weld metal does not overflow upon any unfused parent metal forming overlapping.
iii. The parent metal is not under-cut along the weld toes.
iv. The flowing metal floats, the slag, the oxides, and the gas bubbles to the surface behind the advancing pool. In case any of these requirements is unattainable by manipulation, the current shall be adjusted or the electrode size changed.
Each time the arc is started the electrode shall be moved in such a way that the fusion of base metal at the starting point is assured. At the completion of a run the movement of electrode shall be slowed down to fill the arc crater.

After every interruption of the arc except at completion of a run, the arc shall be restarted ahead of the previous deposit and then move back to fill the crater or such alternative technique shall be used as will ensure complete filling of the crater, or complete fusion between the new and old deposit and the base metal at the point of junction, and result in continuity of weld, Before welding operation is completed, all traces of slag shall be removed from the deposit, by chipping if necessary, and the deposit and the adjoining base metal shall be wire brushed and cleaned at all points. The requirements shall apply not only to successive layers, but also to successive beads, and to the over lapping area wherever a junction is made on starting a new electrode.

v. The welds shall be free from cracks, discontinuity in welding and other defects such as (i) under-size, (ii) over-size, (iii) under-cutting and (iv) over-cutting in the case of fillet welds and defects (ii), (iii) & (iv) in the case of butt welds.

All defective welds which shall be considered harmful to the structural strength shall be cut out and re-welded.

In case of welded butt joints in steel of thickness upto 50mm the weld joint shall be subjected to radiographic examination as described in IS:1182.

All welds shall be cleaned of slag and other deposits after completion. Till the work is inspected and approved painting shall not be done. The surface to be painted shall be cleaned of spatter, rust, loose scale, oil and dirt.

Flooring

A. List of applicable code

S.No	IS Code No	Subject
1	IS:269	Specification for 33 grade ordinary Portland Cement
2	IS:1200-Part XI (Part 11)	Method of measurement of Building and Civil Engineering work paving, floor finishes, dado and skirting
3	IS:1237- Edition 2.3	Specification for cement concrete flooring tiles
4	IS:1322	Specification for bitumen felts for water proofing and damp proofing
5	IS:1443	Code of practice for laying and finishing of cement concrete flooring tiles
6	IS:1580	Specification for bituminous compounds for water proofing and caulking purpose
7	IS:2571	Code of practice for laying in-situ cement concrete flooring
8	IS:8041	Specification for rapid hardening Portland cement
9	IS:8042	Specification for white Portland cement
10	IS:8043	Specification for hydrophobic Portland cement
11	IS:8112	Specification for 43 grade ordinary Portland cement
12	IS:12330	Specification for sulphate resisting Portland cement
13	IS:4457	Acid and/or alkali Resistant tiles.
14	IS:1130	Specification for marble (blocks, slabs and tiles)
15	IS:2114	Code of practice for laying in-situ terrazzo floor finish
16	IS: 3462 (1986)	Unbacked flexible PVC flooring
17	IS: 5318 (1969)	Code of practice for laying of flexible PVC sheet and tile flooring
18	IS:809	Rubber flooring materials for general purposes
19	IS:1195	Bitumen mastic for flooring
20	IS:1196	Code of practice for laying bitumen mastic flooring
21	IS:5491	Code of practice for laying in situ granolithic concrete floor topping
22	IS:1197	Code of practice for laying of rubber floors
23	IS:2441	Code of practice for fixing ceiling coverings.

B. CEMENT CONCRETE FLOORING

I. Cement Concrete

Cement concrete of specified mix grade shall be used and it shall generally conform to the specifications

II. **Base Concrete**

a. Flooring shall be laid on base concrete where so provided. The base concrete shall be provided with the slopes required for the flooring. Flooring in verandah, Courtyard, kitchens & baths shall have slope ranging from 1 : 48 to 1 : 60 depending upon location and as decided by the Engineer-in-Charge. Floors in water closet portion shall have slope of 1:30 or as decided by the Engineer-in-Charge to drain off washing water. Further, necessary drop in flooring in bath, WC, kitchen near floor traps ranging from 6 mm to 10 mm will also be provided to avoid spread of water. Necessary margin to accommodate this drop shall be made in base concrete. Plinth masonry off set shall be depressed so as to allow the base concrete to rest on it.

b. The flooring shall be commenced preferably within 48 hours of the laying of base concrete. The surface of the base shall be roughened with steel wire brushes without disturbing the concrete. Immediately before laying the flooring, the base shall be wetted and a coat of cement slurry @ 2 kg of cement spread over an area of one sq.m so as to get a good bond between the base and concrete floor.

c. If the cement concrete flooring is to be laid directly on the RCC slab, the top surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry @ 2 kg of cement spread over an area of one sq.m so as to get a good bond between the base and concrete floor.

III. **Thickness**

The thickness of floor shall be as specified in the description of the item.

IV. **Laying**

1) **Panels:**

Flooring of specified thickness shall be laid in the pattern including the border as given in the drawings or as directed by the Engineer-in-Charge. The border panels shall not exceed 450 mm in width and the joints in the border shall be in line with panel joints. The panels shall be of uniform size and no dimension of a panel shall exceed 2 m and the area of a panel shall not be more than 2 sq.m. The joints of borders at corners shall be mitred for provision of strips.

2) **Laying of Flooring with Strips:**

Normally cement concrete flooring shall be laid in one operation using glass/ aluminium/ PVC/brass strips/stainless steel strips or any other strips as required as per drawing or instructions of the Engineer-in-Charge, at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels. 4 mm thick glass strips or 2 mm PVC strips or 2 mm aluminium or brass strips shall be fixed with their tops at proper level, giving required slopes. Use of glass and metallic strips shall be avoided in areas exposed to sun. Cost of providing and fixing strips shall be paid for separately.

Concreting:

Cement concrete shall be placed in the panels and be levelled with the help of straight edge and trowel and beaten with thapy or mason's trowel. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given. Beating shall cease as soon as the surface is found covered with a thin layer of cream of mortar. The evenness of the surface shall be tested with straight edge. Surface of flooring be true to required slopes. While laying concrete, care shall be taken to see that the strips

are not damaged/disturbed by the laborers. The tops of strips shall be visible clearly after finishing with cement slurry.

3) **Laying of Flooring without Strips :**

Laying of cement concrete flooring in alternate panels may be allowed by the Engineer-in-Charge in case strips are not to be provided.

Shuttering:

The panels shall be bounded by angle iron or flats. The angle iron/flat shall have the same depth as the concrete flooring. These shall be fixed in position, with their top at proper level giving required slopes. The surface of the angle iron or flats, to come in contact with concrete shall be smeared with soap solution or non-sticking oil (Form oil or raw linseed oil) before concreting. The flooring shall butt against the unplastered masonry wall.

Concreting:

The concreting shall be done in the manner described under this specification. The angle iron/ flats used for Shuttering shall be removed on the next day of the laying of cement concrete. The ends thus exposed shall be repaired, if damaged with cement mortar 1 : 2 (1 cement : 2 coarse sand) and allowed to set for minimum period of 24 hours. The alternate panels shall then be cleaned of dust, mortar, droppings etc. and concrete laid. While laying concrete, care shall be taken to see that the edges of the previously laid panels are not damaged and fresh mortar is not splashed over them. The joints between the panels should come out as fine straight lines.

V. **Finishing**

a. The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some time, till moisture disappears from it or surplus water can be mopped up. Use of dry cement or cement and sand mixture stiffening the concrete to absorb excessive moisture shall not be permitted. Excessive trowelling shall be avoided.
b. Fresh cement shall be mixed with water to form a thick slurry and spread @ 2 kg of cement over an area of one sqm of flooring while the flooring concrete is still green. The cement slurry shall then be properly processed and finished smooth.
c. The edges of sunk floors shall be finished and rounded with cement mortar 1:2 (1 cement: 2coarse sand) and finished with a floating coat of neat cement.
d. The junctions of floor with wall plaster, dado or skirting shall be rounded off where so specified.
e. The men engaged on finishing operations shall be provided with raised wooden platform to sit on so as to prevent damage to new work.

VI. **Curing**

The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty gunnies bag shall be avoided as the colour of the flooring is likely to be bleached due to the remnants of cement dust from the bags.

VII. **Precautions**

Flooring in lavatories and bath room shall be laid only after fixing of water closet and squatting pans and floor traps. Traps shall be plugged while laying the floors and opened after the floors are cured and cleaned. Any damage done to W.C.'s squatting pans and floor traps during the execution of work shall be made good.

During cold weather, concreting shall not be done when the temperature falls below 4℃. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone. During hot weather,

precautions shall be taken to see that the temperature of wet concrete does not exceed 38° C. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge. To facilitate rounding of junction of skirting, dado and floor, the skirting/dado shall be laid along with the border or adjacent panels of floor.

C. ACID OR ALKALI RESISTANT TILES

I. Manufacture and Finish

The tiles shall be of vitreous ware and free from deleterious substances. The iron oxide content allowable in the raw material shall not exceed two percent. The tiles shall be vitrified at the temperature of 1100℃ and above and shall be kept unglazed. The finished, tile, when fractured shall appear fine grained in texture, dense and homogenous. The tiles shall be sound, true to shape, flat and free from flows and manufacturing defects affecting their utility.

The tiles shall be conforming to IS: 4457. The tiles to be tested for water absorption, compressive strength, acid resistance as per IS: 4457. Sampling procedure for acceptance tests and criteria for conformity to be as per IS: 4457. The tiles shall be of required colour.

II. Dimensions and Tolerances

Ceramic unglazed vitreous acid-resistant tiles shall be made in three sizes namely 98.5 x 98.5 mm, 148.5 x 148.5 mm and 198.5 x 198.5 mm. They shall be available in the following thickness: 35, 30, 25, 20 and 15 mm. The depth of the grooves on the underside of the tile shall not exceed 3 mm. Tolerance on length, breadth and thickness of tiles shall be + 2 percent.

III. Shape

The tiles shall be square shaped. Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles shall have dimensions which shall be such as to make two half tiles, when joined together, match with the dimension of full tile. The shape of tiles other than square shall be as agreed to between the purchaser and the manufacturer. Tiles shall be checked for Squareness and warp as per IS: 4457.

IV. Performance Requirements

The tiles when tested in accordance with method given in IS: 4457, shall conform to be requirement specified in the code (IS: 4457).

V. Loss in Abrasion

The maximum percentage of loss in abrasion of the ceramic unglazed vitreous acid resistant tiles determined in accordance with the procedure laid down in IS:1237, shall be as mentioned in IS:4457.

VI. Marking

Tiles shall be legibly marked on the back with the name of the manufacturer or his trade mark. Manufacturer's batch number and year of manufacture.
Each tile may also be marked with the ISI certification mark.

VII. Preparation of Surface and Laying

Preparation of surface and laying to be according to the procedure given except the cement used to be acid and or alkali resistant cement and cement mortar to be used to be acid and or Alkali resistant mortar.

Thickness of bedding of mortar for flooring to be 10 mm or specified on the item and for dado/skirting to be 12 mm or specified on item.

VIII. **Pointing and Finishing**

As specified except that cement used for pointing to be acid and or alkali resistant cement.

D. Marble stone for wall

I. **Marble Stone**

It shall be as specified below.

II. **Dressing of Slabs**

Every stone shall be cut to the required size and shape, fine chisel dressed on all sides to the full depth so that a straight edge laid along the side of the stone shall be fully in contact with it. The top surface shall also be fine chisel dressed to remove all waviness. In case machine cut slabs are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid anywhere along the machine cut surfaces is in contact with every point on it. The sides and top surface of slabs shall be machine rubbed or table rubbed with coarse sand before paving. All angles and edges of the marble slabs shall be true, square and free from chippings and the surface shall be true and plane.

The thickness of the slabs shall be 18 mm as specified in the description of the item.

Tolerance of + 3% shall be allowed for the thickness. In respect of length and breadth of slabs a tolerance of + 2% shall be allowed.

III. **Laying**

a. Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 cement: 4 coarse sand) or as given in the description of the item.

b. The average thickness of the bedding mortar under the slab shall be 20 mm and the thickness at any place under the slab shall be not less than 12 mm.

c. The slabs shall be laid in the following manner:
Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg of cement per sq.m. The edges of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the marble slabs as given in the description of the item.

The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels, and, slopes as instructed by the Engineer-in- Charge. Joint thickness shall not be more than 1 mm.

Due care shall be taken to match the grains of slabs which shall be selected judiciously having uniform pattern of Veins/streaks or as directed by the Engineer-in-Charge.

d. The slabs shall be matched as shown in drawings or as instructed by the Engineer-in- Charge.

e. Slabs which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster skirting or dado. The junction between wall plaster and floor shall be finished neatly and without waviness.

f. Marble slabs flooring shall also be laid in combination with other stones and/or in simple regular pattern/design as described in item of work and/or drawing.

IV. **Polishing and Finishing**

Slight unevenness at the meeting edges of slabs shall then be removed by fine chiselling and finished in the same manner except that cement slurry with or without pigments shall not be applied on the surface before each polishing.

E. **CARBORUNDUM TILES**

They are classified as follows

1) General Purpose Tiles — used in such places where normally light loads are taken up by the floors; such as office buildings, schools, colleges, hospitals and residential buildings (usually indoor floors).
2) Heavy Duty Floor Tiles — Used for heavy traffic conditions; such as foot paths, ramps, entrances and staircases of public buildings, passages of auditoriums and storage godowns (public path or industrial floors).

I. **MATERIALS**

1. Cement

Cement used in the manufacture of tiles shall be 33 grade ordinary Portland cement conforming to IS:269 or 43 grade ordinary Portland cement conforming to IS:8112 or 53 grade ordinary Portland cement conforming to IS:12269 or Portland pozzolana cement (fly ash based) conforming to IS:1489 (Part 1) or Portland pozzolana cement (calcined clay based) conforming to IS:1489 (Part 2) or Portland slag cement conforming to IS:455 or rapid hardening Portland cement conforming to IS:8041 or white Portland cement conforming to IS:8042.

2. Aggregates

Aggregates used in the backing layer of tiles shall conform to the requirements of IS:383. For the wearing layer, unless otherwise specified, aggregates shall consist of marble chips or any other natural stone chips of similar characteristics and hardness, marble powder or dolomite powder, or a mixture of the two.

3. Pigments

Pigments, synthetic or otherwise, used for colouring tiles shall have durable colour. It shall not contain matters detrimental to concrete and shall according to the colour required be one of the following or their combination:

Sl.no	Pigments	Ref to IS No.
1	Black or red or brown pigment	IS 44
2	Green pigments	IS 54
3	Blue pigments	IS 55 or IS 56 or IS 3574
4	White pigments	IS 411
5	Yellow pigments	IS 50 or IS 3574 (Part 1)

The pigments shall not contain zinc compounds or organic dyes.

Lead pigments shall not be used unless otherwise specified by the purchaser.

II. **BEDDING**

1. Preparation of Mortar

Both cement mortar as well as lime mortar can be used for preparation of bed for laying of tiles. The method of preparation and laying of each type of mortar shall be as follows:

2. Cement Mortar

Cement mortar shall consist of one part of Portland cement and six parts of coarse sand by volume thoroughly mixed manually or by a mechanical mixer. The quantity of water added shall be the minimum necessary to give sufficient plasticity and workability for laying. A high water-cement ratio will produce a screeded bed with a high drying shrinkage and should be avoided.

Spreading of Cement Mortar

Before spreading of cement mortar, it is essential to ensure that the base is well compacted and the surface is rough to form suitable key. The base shall then be cleaned of all scum, laitance or plaster droppings or any other loose foreign matter. It shall be properly wetted without allowing any water pools on the surface. The mortar shall then be evenly spread over the base for two rows of tiles and about three to five metres in length with thread level fixed at both ends to act as a guide. The top of mortar shall be kept rough so that cement slurry can be absorbed. The thickness of the bedding shall normally be not less than 10 mm and not more than 30 mm in any one place. Immediately after, the laying of tiles shall start.

3. Lime Mortar

Lime mortar may be prepared in any of the following proportions
a. 1 lime, 1 surkhi, 2 coarse sand; or
b. 1 lime, 3 surkhi; or
c. 1 lime, 3 Coarse sand.

The ingredients shall be thoroughly mixed by volume in dry form. Care shall be taken to ensure that there are no hard lumps present. Water shall then be added and the ingredients thoroughly mixed.

4. Spreading of Lime Mortar

Cleaning and wetting of the base shall be done. Lime mortar shall then be evenly and smoothly spread over the base and levelled with a screed batten to a slightly rough surface for providing key for the tiles. The thickness of mortar shall be the same as in the case of cement mortar, that is, 10 mm minimum and 30 mm

maximum at any one place. Screeds properly levelled shall be fixed at the correct height to suit the thickness of the screeded bed. The area of bedding should be as much as can be covered with tiles during the following day. The freshly laid portion of the mortar bedding shall be protected from damage by providing suitable barricading.

III. LAYING OF TILES

Laying of tiles should commence in the next morning by which time the bedding becomes sufficiently hard to offer rigid cushion for the tile and enables masons to place wooden planks and squat on them. Neat cement slurry of honey-like consistency shall be spread over the mortar bed, over such an area at a time as would accommodate about 20 tiles. The tiles shall be fixed in this grout one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The mason shall keep the joints as close as possible and in straight lines. The joints between the tiles shall normally be I.5 mm wide. After the tiles have been laid in a room or the day's laying work is completed, the surplus cement slurry and the joints shall be cleaned and washed fairly deep with the help of a broom stick. It shah be seen that the cement slurry is cleaned before it sets hard. The day after the tiles have been laid, the joints shall be filled with cement grout of the same shade as the colour of the matrix of the tile. The freshly laid portion of the tiles shall be prevented from damage by providing suitable barricading.

Tiles which are fixed in the floor adjoining the wall shall go about 10 mm under the plaster, skirting or dado as may be required by the designer. For this purpose, the wall plaster may be left unfinished by about 50 mm above the level of the proposed finished flooring and the unfinished strip may be plastered later on after the tiles are fixed. In odd situations where a full tile cannot be provided, tiles shall be cut to size and then fixed.

After fixing, the flooring should be kept moist and allowed 'to mature undisturbed for seven days so that the bedding and joints set properly. After this, it may be used for light traffic. Heavy traffic shall not be allowed on the floor for at least 14 days after fixing the tiles.

Wherever big areas of floor are to be tiled, the level of the central portion of the floor shall be kept about 10 mm higher than the level marked at the walls unless specified otherwise. This is normally done to avoid the optical illusion of a depression in the central portion of the tiled hall.

IV. GRINDING AND POLISHING

Grinding and polishing of the tiles shall be commenced only after the floor as well as the joints have properly set and in no case earlier than 14 days of laying. Grinding should preferably be done using a machine except for skirting.

For grinding terrazzo tile flooring, the first grinding shall be with machine fitted with Carborundum stones of 48 to 60 grit. When the floor is rubbed even and chips show uniformity it shall be cleaned with water making bare all pin holes. Grouting in the same shade is then briskly applied SO that all pin holes are properly filled in. The grout shall be kept moist for a week for proper setting. Thereafter, the second grinding operation with Carborundum of 120 grit is commenced. The floor is grouted again to fill in fine pin holes. After curing, the floor is left with this protective film till other works are completed and all workers quit. Before the final grinding the floor is swept clean. Final grinding is then done with carborundum of 220 to 350 grit using plenty of water and taking care that any foreign matter, particles of sand, etc, are prevented. When surface is rendered smooth, it is washed with water. Afterwards oxalic acid powder is vigorously applied with machine fitted with hessian bobs to bring out sheen. Wash the floor clean and apply dry linen to suck-in

moisture. If desired, wax polish may finally be applied mechanically with clean hessian bobs. Superfluous wax is mopped-up with saw dust to prevent slipperiness.

Saw dust may be allowed to remain on the surface till occupation. This will protect the surface and help to increase lustre. When saw dust is spread, water should not be spilled as this is likely to give stains on the polished surface.

When hand grinding and polishing has to be adopted the various processes in the same sequence shall be carried out.

In the case of plain cement and coloured tiles the process of polishing shall be the same except that initial grinding with Carborundum stone of 48 to 60 grit may not be necessary.

V. LAYING OF ROUGH TILES

Where tiles have been supplied and fixed in rough condition (not ground and filled by the manufacturer), the first grinding shall be done not less than 14 days after fixing the tiles. The initial grinding shall be done with carborundum stones of 36 to 48 grit.

VI. PERMISSIBLE TOLERANCE IN LAYING

The permissible deviation from datum depends on the area involved; for large open areas, a deviation of tip to 15 mm may be tolerated. Localized deviations of 3 mm in any 3 m may be accepted in a nominally flat floor.

The finished floor shall have an even, smooth and shining surface. Joints should be in correct alignment.

A. UPVC Rain water pipe

a) List of applicable codes

Sl.No.	IS.Code No	Subject
1	IS:4985	Unplasticized PVC pipes for potable water Supplies — Specification
2	IS:4669	Methods of test for poly vinyl chloride resins
3	IS:4905	Methods for random sampling
4	IS:5382	Rubber sealing rings for gas mains, water mains and sewers
5	IS:6307	Specification for rigid PVC sheets
6	IS:10148	Positive list of constituents of polyvinyl chloride resins and its copolymers for safe use in contact with foodstuffs, pharmaceutical and drinking water.
7	IS:12231	Specifications for UPVC (rigid) pipes for use in suction and delivery lines of agricultural pumps.
8	IS:12235	Methods of test for unplasticized PVC Pipes for potable water supplies.
	Part:1	Measurement of outside diameter
	Part:2	Measurement of wall thickness
	Part:3	Test for opacity
	Part:4	Determining the detrimental effect on the composition of water

b) **TERMINOLOGY**

Nominal Size (DN)

The numerical designation for the size of a pipe, other than a pipe designated by thread size, which is a convenient round number approximately equal to the manufacturing dimension in millimeters (mm).

Nominal outside Diameter
The specified outside diameter, in millimeters assigned to a nominal size.

Outside Diameter at any Point (d_e)
The value of the measurement of the outside diameter of a pipe through its cross section at any point of the pipe, rounded off to the next higher 0.1 mm. The quotient of the outer circumference of a pipe and 3.142 (n) in any cross-section, rounded off to the next higher 0.1 mm.

Minimum Mean Outside Diameter (d_{em}, min)
The minimum value for the mean outside diameter as specified for a given nominal size.

Maximum Mean Outside Diameter (d_{em}, max)
The maximum value for the mean outside diameter as specified for a given nominal size.

Mean Inside Diameter at Mid Point of Socket Length (dim)
The arithmetical mean of two measured inside diameters perpendicular to each other at the mid point of the socket length.

Out-of-Roundness (Ovality)
The difference between the measured maximum and the measured minimum outside diameter in the same Cross-section of the pipe.

Nominal Wall Thickness (e_n)
A numerical designation of the wall thickness of a component which is a convenient round number, approximately equal to the manufacturing dimension in millimeters (mm).

Wall Thickness at any Point (e)
The value of the measurement of the wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1 mm.

Minimum Wall Thickness at any Point (e_{min})
The minimum value for the wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1 mm.

Maximum Wall Thickness at any Point (e_{max})
The maximum value for the wall thickness at any point around the circumference of a pipe, rounded off to the next higher 0.1 mm.

Mean Wall Thickness (e_m)
The arithmetical mean of at least four measurements regularly spaced around the circumference and in the same cross-section of a pipe, including the measured minimum and the measured maximum values of the wall thickness in that cross-section and rounded off to the next higher 0.1 mm.

Tests

i. **Type Tests**

Tests carried out whenever a change is made in the composition or in the size/series in order to establish the suitability and the performance capability of the pipes.

ii. Acceptance Tests

Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

c) **CLASSIFICATION OF PIPES**

The pipes shall be classified by pressure ratings (working pressures) at 27℃ as follows:

Class of pipe	Working pressure (PN)
Class 1	0.25 MPa (2.5 kg/cm2)
Class 2	0.4 MPa (4.0 kg/cm2)
Class 3	0.6 MPa (6.0 kg/cm2)
Class 4	0.8 MPa (8.0 kg/cm2)
Class 5	1.0 MPa (10.0 kg/cm2)
Class 6	1.25 MPa (12.5 kg/cm2)

d) **COMPOSITION**

The material from which the pipe is produced shall consist substantially of unplasticized polyvinyl chloride to which may be added only those additives that are needed to facilitate the manufacture of the pipe and the production of sound and durable pipe of good surface finish, mechanical strength and opacity under conditions of use. None of these additives shall be used separately or together in quantities sufficient to constitute a toxic, organoleptic or microbial growth hazard, or materially to impair the fabrication or welding properties of the pipe, or to impair its chemical and physical or mechanical properties (in particular Long-term mechanical strength and impact strength) as defined in this Indian Standard. The additives to be used shall be selected from IS:10148 and shall be uniformly dispersed.

The monomer content (VCM content) in the resin shall be within the limits specified in 3.3.1 of IS:10151, when tested as per Annex A of IS:10151.

The composition shall be based on PVC resin having a K-value of 64 or greater when tested in accordance with IS:4669.

The addition of the manufacturer's own rework material is permissible. The quantity of the rework material used is to be declared by the manufacturer No. other rework material shall be used.

e) **SEALING RINGS**

These shall be in accordance with one of the types (Type 1 to Type-6) as per IS:5382. The manufacturer has to however specify the type of sealing ring (namely 1,2,3,4, 5 or 6) that is being offered. The design of the profile of the sealing ring is left to the manufacturer as long as the pipe with sealing ring meets the requirements of the specification.

f) **PHYSICAL AND CHEMICAL CHARACTERISTICS Visual Appearance**

The colour of the pipes shall be light grey. Slight variations in the appearance of the colour are permitted.

The internal and external surfaces of the pipe shall be smooth, clean and free from grooving and other defects. Slight shallow longitudinal grooves or irregularities in the pipe shall be permissible provided the wall thickness remains within the permissible limits.

Opacity
The wall of the plain pipe shall not transmit more than 0.2 percent of the visible light falling on it when tested in accordance with IS:12235 (Part 3).

g) **Effect on Water**

The pipes shall not have any detrimental effect on the composition of water flowing through them. When tested by the method described in IS:12235 (Part 4), IS:12235 (Part 10) and IS:12235 (Part 11), the quantities of lead, dialkyl tin C4 and higher homologues (measured as tin), and any other toxic substances extracted from the internal walls of the pipes shall not exceed the following concentrations (based on 'Guidelines for Drinking Water: Recommendations' — WHO, Geneva, 1984) in the test solution:

Lead (first extraction)	1.0 mg/1 (1.0 ppm by mass)
Lead (third extraction)	0.3 mg/1 (0.3 ppm by mass)
Dialkyl tin C4 and higher homologues measured as tin (third extraction)	0.02mg/l (0.02ppm by mass)

The manufacturer, for the purpose of these tests, shall disclose any other toxic substances present. The limit of all the 'other toxic substances', including the two mentioned in the above clause shall not exceed the specified limit of 0.01 mg/1.

h) **Reversion Test**

When tested by the immersion method prescribed in IS:12235 (Part 5), a length of pipe 200 ± 20 mm long shall not alter in length by more than 5 percent. In the case of socket end pipes, this test shall be carried out on the plain portion of the pipe taken at least 100mm away from the root of the socket.

i) **Vicat Softening Temperature**

When tested by the method prescribed in IS:6307, the Vicat softening temperature of the specimen shall not be less than 80°C.

j) **Density**
When determined in accordance with IS:13360 (Part 3/Sec 1), the density of the pipe shall be between 1.40 and 1.46.

k) **Sulphated Ash Content Test**

When tested, the sulphated ash content in the pipe shall not exceed 11 percent.

l) **Marking**

Each pipe shall be clearly and indelibly marked in ink/paint or hot embossed on white base at intervals of not more than 3 metres, in colour as indicated below. The markings shall show the following:

a) Manufacturer's name or trade-mark,
b) Outside diameter,
c) Class of pipe and pressure rating,
d) Batch or lot number, and
e) The word plumbing in the case of plumbing pipes.

The information according to above clause shall be marked in colour as indicated below for different classes of pipes:

Class of Pipe	Colour
Class 1	Red
Class 1	Blue
Class 1	Green
Class 1	Brown
Class 1	Yellow
Class 1	Black

In the case of plumbing pipes, the information given in marking shall be marked in pink colour. In the case of hot embossing, the pipes shall also be provided near the end with a circumferential colour band as indicated in marking so as to identify the class of pipe.

8.16.0 Finishing

A. **List of applicable codes**

Sl.No.	IS.No	Subject
1	IS:428	Distemper, Oil Emulsion, colour as required
2	IS:1200	Methods of measurement of building & civil engineering works
3	IS:2932	Enamel, synthetic, exterior
4	IS:2933	Enamel, exterior
5	IS:348	Specification for French polish
6	IS:427	Specification for distemper, dry colour as required
7	IS:2339	Specification for Aluminium Paints for general purposes in dual containers

B. CEMENT PLASTER

The cement plaster shall be 12 mm, 15 mm or 20 mm thick as specified in the item.

i. **Scaffolding**

For all exposed brick work or tile work double scaffolding independent of the work having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed. For all other work in buildings, single scaffolding shall be permitted. In such cases the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose.

Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars/columns less than one metre in width or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

Note: In case of special type of brick work, scaffolding shall be got approved from Engineer-in- charge in advance.

ii. **Preparation of Surface**

The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

iii. **Mortar**

The mortar of the specified mix using the type of sand described in the item shall be used. It shall be as specified in this specification. For external work and under coat work, the fine aggregate shall conform to grading IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

iv. **Application of Plaster**

a. Ceiling plaster shall be completed before commencement of wall plaster.
b. Plastering shall be started from the top and worked down towards the floor. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 × 15 cm shall be first applied, horizontally and vertically, at not more than 2 metres intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and sideways movements at a time. Finally the surface shall be finished off true with trowel or wooden float according as a smooth or a sandy granular texture is required. Excessive troweling or over working the float shall be avoided.
c. All corners, arises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, arises, provision of grooves at junctions etc. where required shall be done without any extra payment. Such rounding, chamfering or grooving shall be carried out with proper templates or battens to the sizes required.

d. When suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped cleaned and wetted with cement slurry before plaster is applied to the adjacent areas, to enable the two to properly join together. Plastering work shall be closed at the end of the day on the body of wall and not nearer than 15 cm to any corners or arises. It shall not be closed on the body of the features such as plasters, bands and cornices, nor at the corners of arises. Horizontal joints in plaster work shall not also occur on parapet tops and copings as these invariably lead to leakages. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.
e. No portion of the surface shall be left out initially to be patched up later on. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

v. **Thickness**

Where the thickness required as per description of the item is 20 mm the average thickness of the plaster shall not be less than 20 mm whether the wall treated is of brick or stone. In the case of brick work, the minimum thickness over any portion of the surface shall be not less than 15 mm while in case of stone work the minimum thickness over the bushings shall be not less than 12 mm.

vi. **Curing**

Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the Bidder's expense by such means as the Engineer- in-Charge may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

vii. **Finish**

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

viii. **Precaution**

Any cracks which appear in the surface and all portions which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer-in-Charge.

a. When ceiling plaster is done, it shall be finished to chamfered edge at an angle at its junction with a suitable tool when plaster is being done. Similarly when the wall plaster is being done, it shall be kept separate from the ceiling plaster by a thin straight groove not deeper than 6 mm drawn with any suitable method with the wall while the plaster is green.

b. To prevent surface cracks appearing between junctions of column/beam and walls, 150 mm wide chicken wire mesh should be fixed with U nails 150 mm centre to centre before plastering the junction. The plastering of walls and beam/column in one vertical plane should be carried out in one go. For providing and fixing chicken wire mesh with U nails payment shall be made separately.

C. POINTING ON BRICK WORK, TILE WORK AND STONE WORK

i. Scaffolding

For all exposed brick work, tile work or stone work independent double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong tied together with horizontal pieces over which scaffolding planks shall be fixed.

For all other work in building, single scaffolding shall be permitted. In such cases, the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose.

Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars/columns less than one metre in width, or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

Note: In case of special type of work, scaffolding shall be got approved from Engineer-in- Charge in advance.

ii. Preparation of surface

The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before pointing is commenced.

In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunken surface of the finished pointing or from the edge of the brick shall not be less than 12 mm.

iii. Mortar

Mortar of specified mix shall be used. It shall be as specified under clause “Mortar”.

iv. Application and Finishing

a. The mortar shall be pressed into the raked out joints, with a pointing trowel, either flush, sunk or raised, according to the type of pointing required. The mortar shall not spread over the corner, edges or surface of the masonry. The pointing shall then be finished with the proper tool, in the manner described below:

b. **Flush Pointing**: The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the bricks, tiles or stones so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge.

c. **Ruled Pointing :** The joints shall be initially formed as for flush pointing and then while the mortar is still green, a groove of shape and size as shown in drawings or as instructed, shall be formed by running a forming tool, straight along the centre line of the joints. This operation shall be continued till a smooth and hard surface is obtained. The vertical joints shall also be finished in a similar way. The vertical lines

shall make true right angles at their junctions with the horizontal lines and shall not project beyond the same.

d. **Cut or Weather Struck Pointing:** The mortar shall first be pressed into the joints. The top of the horizontal joints shall then be neatly pressed back about 3 mm or as directed, with the pointing tool so that the joints are sloping from top to bottom.

The vertical joints shall be ruled pointed. The junctions of vertical joints with the horizontal joints shall be at true right angles.

e. **Raised and Cut Pointing** : Raised and cut pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm raised and width 10 mm more as directed.

f. The superfluous mortar shall then be cut off from the edges of the lines and the surface of the masonry shall also be cleaned off all mortar. The finish shall be such that the pointing is to the exact size and shape required and the edges are straight, neat and clean.

v. **Curing**

The pointing shall be kept wet for seven days. During this period it shall be suitably protected from all damages.

The pointing lines shall be truly horizontal and vertical except where the joints are slanting as in rubble random masonry. Lines of joints from different directions should meet neatly at the junctions instead of crossing beyond.

D. **OIL EMULSION (OIL BOUND) WASHABLE DISTEMPERING**

i. **Materials**

Oil emulsion (Oil Bound) washable distemper (IS: 428) of approved brand and manufacture shall be used. The primers where used as on new work shall be cement primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's work shall be prepared.

The distemper and primer shall be brought by the Bidder in sealed tins in sufficient quantities at a time to suffice for a fortnight's work, and the same shall be kept in the joint custody of the Bidder and the Engineer-in-Charge. The empty tins shall not be removed from the site of work, till this item of work has been completed and passed by the Engineer-in-Charge.

ii. **Preparation of the Surface**

a. For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

b. In the case of old work, all loose pieces and scales shall be removed by sand papering.

The surface shall be cleaned of all grease, dirt etc.

Pitting in plaster shall be made good with plaster of Paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

iii. **Application**

a. **Priming Coat:** The priming coat shall be with distemper primer or cement primer, as required in the description of the item. The application of the distemper primer shall be as per specification.

Note: If the wall surface plaster has not dried completely, cement primer shall be applied before distempering the walls. But if distempering is done after the wall surface is dried completely, distemper primer shall be applied.

Oil bound distemper is not recommended to be applied, within six months of the completion of wall plaster. However, newly plastered surfaces if required to be distempered before a period of six months shall be given a coat of alkali resistant priming Paint conforming to IS: 109 and allowed to dry for atleast 48 hours before distempering is commenced. For old work no primer coat is necessary.

b. **Distemper Coat:** For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with brushes in horizontal strokes followed immediately by vertical ones which together constitutes one coat.

The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.

A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.

For old work the distemper shall be applied over the prepared surface in the same manner as in new work. One or more coats of distemper as are found necessary shall be applied to obtain an even and uniform shade. 15 cm double bristled distemper brushes shall be used. After each day's work, brushes shall be thoroughly washed in hot water with soap solution and hung down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

E. **WALL PAINTING WITH PLASTIC EMULSION PAINT**

The plastic emulsion Paint is not suitable for application on external, wood and iron surface and surfaces which are liable to heavy condensation. These Paints are to be used on internal surfaces except wooden and steel.

Plastic Emulsion Paint as per IS: 5411 of approved brand and manufacture and of the required shade shall be used.

i. **Painting on New Surface**

a. The wall surface shall be prepared as specification.

b. **Application:** The number of coats shall be as stipulated in the item. The Paint will be applied in the usual manner with brush, spray or roller. The Paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surfaces to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer's instructions.

The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

c. **Precautions**

(i) Old brushes if they are to be used with emulsion Paints, should be completely dried of turpentine or oil Paints by washing in warm soap water.
(ii) Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the Paint from hardening on the brush.
(iii) In the preparation of wall for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.
(iv) Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.
(v) Washing of surfaces treated with emulsion Paints shall not be done within 3 to 4 weeks of application.

d. Other details shall be referred relevant clauses as applicable.

8.17.0 Roadwork

A. List of applicable codes

Sl.No.	IS.No	Subject
1	IS:73	Paving bitumen
2	IS:702	Industrial bitumen
3	IS:1201- 1978 to IS:1220-1978	Method of testing tar and bituminous materials
4	IS:427	Specification for distemper, dry colour as required
5	IS:2339	Specification for Aluminium Paints for general purposes in dual containers
6	IRC 10	Recommended practice for borrow pits for road embankments constructed by manual operation
7	IRC-15	Standard Specification and code of practice for construction of concrete roads.
8	IRC-58	Guidelines for the design of plain jointed rigid pavement for highways

B. Stones for Kerb and Channels

Kerb and channel stones are provided on roads having raised berms for foot path etc. These shall be of selected hard stone, sound, durable free from laminations and other structural defects. The length of each kerb and channel stone shall be not less than

49.5 cm except that 29.5 cm long stones shall be permitted for closures and for curves. The other dimensions shall be 30 x 20 cm for kerb stones and 30x 10 cm for channel stones, unless specified otherwise. Kerb and channel stones shall be chisel dressed on exposed surface and edges. The dimensions of the exposed faces of kerb and channel stones shall be of sizes as specified with a tolerance of 10 mm in width and depth. In the case of kerb stones a tolerance of 5 cm shall be allowed in the dimensions of unexposed back and bottom faces and in the case of channel stones a tolerance of 10 mm shall be allowed in thickness.

C. **Boundary Stone**

The boundary stones shall be of either hard stone or sound and durable quality or precast R.C.C. These shall be in blocks of size 15 × 15 × 90 cm unless directed otherwise by the Engineer-in-Charge. A tolerance of 12.5 mm shall be permitted in the specified size. In the case of boundary stones of hard stone, the upper 30 cm shall be chiesel dressed on all the four sides and on the top.

The R.C.C. boundary stones shall be cast in cement concrete 1 : 1 ½ : 3 (1 cement : 1 ½ coarse sand :3 graded stone aggregate 20 mm nominal size), reinforced with 10 mm diameter tor steel bars or as directed and finished smooth with cement mortar 1 : 3 (1 cement : 3 fine sand). The specifications for R.C.C. work shall apply.

D. **SUB-GRADE : PREPARATION AND CONSOLIDATION**

In sub-grade composed of clay, fine sand or other soils that may be forced up into the coarse aggregate during rolling operation, an insulation layer of suitable thickness of granular materials or over size brick aggregate not less than 10 cm thick shall be provided for blanketting the sub-grade, which shall be paid for separately, unless otherwise specified.

In slushy soils or in areas that are water logged, special arrangements shall be made to improve the sub-grade and the total pavement thickness shall be designed after testing the properties of the subgrade soil. Necessary provision for the special treatment required shall be made in the project and paid for separately.

i. Preparation of Sub-Grade

The surface of the formation for a width of sub-base, which shall be 15 cm more on either side of base course, shall first be cut to a depth equal to the combined depth of sub-base and surface courses below the proposed finished level (due allowance being made for consolidation). It shall then be cleaned of all foreign substances. Any ruts or soft yielding patches that appear due to improper drainage conditions, traffic hauling or from any other cause, shall be corrected and the sub-grade dressed off parallel to the finished profile.

ii. Consolidation

The sub-grade shall be consolidated with a power road roller of 8 to 12 tonnes. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass (the roller shall pass a minimum of 5 runs on the sub grade). All undulations in the surface that develop due to rolling shall be made good with material or quarry spoils as the cases may be and the sub-grade is rerolled.

iii. Surface Regularity

The finished surface shall be uniform and conform to the lines, grades and typical cross section shown in the drawings, when tested with the template and straight edge, the variation shall be within the tolerances specified in codes.

8.18.0 Piling

A. List of applicable codes

Sl.No.	IS.No	Subject
1	IS:1200 (Part 23)	Method of measurement of building and Civil Engineering Works – Piling.
2	IS:2911 (Part 1/Sec. 1)	Code of practice for Design and Construction of pile foundation. Driven cast-in-situ piles
3	IS:2911 (Part 1/Sec. 2)	Code of practice of Design and Construction of pile foundation. Bored Cast-in-situ piles.
4	IS:2911 (Part 1/Sec. 3)	Code of practice for Design and Construction of pile foundation. Driven pre-cast concrete piles.
5	IS:2911 (Part 1/Sec. 4)	Code of practice for Design and Construction of pile foundation. Bored pre-cast concrete piles.
6	IS:2911 (Part 3)	Code of practice for Design and Construction of pile foundation. Under reamed piles.
7	IS:2911 (Part 4)	Code of practice for design and Construction of pile foundation. Load test on piles.
8	IS:5121	Safety Code for piling and other deep foundations.
9	IS:6426	Specification for pile driving hammer.
10	IS:6427	Glossary of terms relating to pile driving.
11	IS:6428	Specification for pile frame.
12	IS:9716	Guide for lateral dynamic load test on piles.
13	IS:14362	Pile boring equipments. General requirements.
14	IS:14893	Non-destructive integrity testing of piles (NDT) - Guidelines

B. Terminology

Allowable Load: It is load which is applied to a pile after taking into account its ultimate load capacity, pile spacing, Overall bearing capacity of the ground, the allowable settlement, negative skin friction including reversal of loads.

Bearing Pile: A pile formed in the ground for transmitting load of a structure to the soil by the resistance developed at its tips and or along its surface. It is either vertical or batter pile. It may be 'End bearing pile' or friction pile if it supports the load primarily along the surface.

Board Compaction Pile: It is bored cast-in-situ with or without bulb. In this compaction of surrounding ground and freshly filled concrete in pile, bore is simultaneously achieved by suitable method. A pile with a bulb is called an "under-reamed bored compaction pile". Under-reamed pile with more than one bulb is called Multi-under-reamed pile.

Constant Rate of Penetration (CRP) Test: The ultimate bearing capacity of preliminary piles and piles which are not used as working piles.

Constant Rate of Uplift (CRU) Test: The ultimate capacity in tension of preliminary piles and piles which are not used as working piles.

Cut of Level: It is the level where the installed pile is cut off to support the pile caps or beams.

Datum Bar: A rigid bar placed on immovable supports.

Draft Bolt: A metal rod driven into hole bored in timber, the hole being smaller in diameter than the rod.

Drop of Stroke: The distance through which the driving weight is allowed to fall for driving the piles.

Factor of Safety: It is the ratio of the ultimate load capacity of a pile to the safe load of a pile.

Follower Tube: A tube which is used following the main casing tube and it requires to be extended further. The inner diameter of the follower tube should be the same as the inner diameter of casing. The follower tube shall preferably be an outside guide and should be water tight when driven in water bearing strata or soft clays.

Initial Test: This test is carried out with a view to determine ultimate load capacity and safe load capacity.

Raker or Batter Pile: The pile which is installed at an angle to the vertical. Raker piles are normally provided where vertical piles cannot resist the required applied horizontal forces. The maximum rake to be permitted in piles shall not exceed –

1 in 8 for cast-in-situ piles of large diameter viz. 750 mm dia, and above.
1 in 5 for smaller dia. cast-on-situ piles.
1 in 4 pre-cast piles.

Routine Test: It is carried out with a view to check whether pile is capable of taking the working load assigned to it.

Safe Load: It is the load arrived at by applying a factor of safety to the ultimate load capacity of the pile.

Set: The net distance by which the pile penetrates in the ground due to stated number of blows of the hammer.

Spliced Pile: A pile composed of two or more lengths secured together, end to end to form one pile.

Test Pile: A pile which is selected for load testing and which is subsequently loaded for that purpose. This pile may form working pile itself if subjected to a routine load test with up to one and half time the safe load.

Total displacement (Gross): The total movement of the pile under a given load.

Total Elastic Displacement: This is the magnitude of the displacement of the pile due to rebound caused at the top after removal of given test load. This comprises two components as follows:

(a) Elastic displacement of the soil participating in load transfer; and
(b) Elastic displacement of the pile shaft.

Trial Piles: These are installed initially to assess the load carrying capacity, it is either tested to ultimate bearing capacity or twice the estimated safe load.

Ultimate Load Capacity: The maximum load which a pile can carry before failure of ground (when the soil fails by shear) or failure of pile materials.

Working Load: It is a load assigned to a pile as per design.
Working Pile: It is a pile forming part of foundation of a structural system.

C. **Driven Cast-in-situ Reinforced Cement Concrete Piles**

I. General

The pile formed within the ground by driving a casing of uniform diameter, permanent or temporary, and subsequently filling in the hole so formed with plain or reinforced concrete. For displacing the subsoil the casing is installed with a plug or a shoe at the bottom end. When the casing is left permanently, it is termed as cased pile and when the casing is taken out, it is termed as uncased pile.

II. Equipment and accessories

The equipment and accessories would depend upon the type of driven cast in-situ piles, job by job, and would be selected giving due consideration to the subsoil strata, ground-water conditions, type of founding material and the required penetration therein, wherever applicable.

Among the commonly used plants, tools and accessories, there exists a large variety; suitability of which depends on the subsoil conditions, manner of operations, etc. Brief definitions of some commonly used equipment are given below:

Dolly - A cushion of hardwood or some suitable material placed on the top of the casing to receive the blows of the hammer.

Drop Hammer (or Monkey) - Hammer, ram or monkey raised by a winch and allowed to fall under gravity.

Single or Double Acting Hammer-A hammer operated by steam compressed air or internal combustion, the energy of its blows being derived mainly from the source of motive power and not from gravity alone.

Kent ledge - Dead weight used for applying a test load to a pile.

Pile Frame (or Pile Rig) - A movable steel structure for deriving piles in the correct position and alignment by means of a hammer operating in the guides or (leaders) of the frame.

III. Reinforcement

i. The design of the reinforcing cage varies depending upon the driving and installation conditions, the nature of the subsoil and the nature of load to be transmitted by the shaft, axial, or otherwise. The minimum area of longitudinal reinforcement within the pile shaft shall be 0.4 percent of the sectional area calculated on the basis of outside area of the casing of the shaft.

NOTE - Where deformed bars are used, a minimum reinforcement of 0.4 percent of Sectional area should be the equivalent area of the bars used, compared to plain mild Steel bars.

ii. The curtailment of reinforcement along the depth of the pile, in general, depends on the type of loading and subsoil strata. In case of piles subject to compressive load only, the designed quantity of reinforcement may be curtailed at appropriate level according to the design requirements. For piles subjected to uplift load, lateral load and moments, separately or with compressive loads, it may be necessary to provide reinforcement for the full depth of pile. In soft clays or loose sands, or where there is likelihood of danger to green concrete due to driving of adjacent piles, the reinforcement should be provided up to the full pile depth, regardless of whether or not it is required from uplift and lateral load considerations. However, in all cases, the minimum reinforcement should be provided in the full length of the pile.

Piles shall always be, reinforced with a minimum amount of reinforcement as dowels keeping the minimum bond length into the pile shaft below its cut-off level and with adequate projection into the pile cap, irrespective of design requirements.

iii. Clear cover to all main reinforcement in pile shaft shall be not less than 50 mm. The laterals of a reinforcing cage may be in the form of links or spirals. The diameter and spacing of the same is chosen to impart adequate rigidity of the reinforcing cage during its handling and installations. The minimum diameter of the links or spirals shall be 6 mm and the spacing of the links or spirals shall be not less than 150 mm.

IV. Control of pile driving

i. **Control of Alignment** - Piles shall be installed as accurately as possible according to the designs and drawings either vertically or to the specified batter. Greater care should be exercised in respect of installation of single piles or piles in two-pile groups. As a guide, for vertical piles a deviation of 1.5 percent and for Raker piles a deviation of 4 percent should not normally be exceeded although in special cases a closer tolerance may be necessary.

Piles should not deviate more than 75 mm from their designed positions at the working level of the piling rig. In the case of a single pile in a column, positional tolerance should not be more than 50 mm. Greater tolerances may be prescribed for pile driven over water and for raking piles. For piles to be cut off at a substantial depth, the design should provide for the worst combination of the above tolerances in position and inclination. In case of piles deviating beyond these limits and to such an extent that the resulting eccentricity cannot be taken care of by a redesign of the pile cap or pile ties, the piles should be replaced or supplemented by one or more additional piles.

NOTE - In case of raker piles up to a rake of 1 in 6, there may be no reduction in the capacity of the pile.

ii. **Sequence of Piling**

a. In a pile group the sequence of installation of piles shall normally be from the centre to the periphery of the group or from one side to the other.

b. Consideration should be given to the possibility of doing harm to a pile recently formed by driving the tube nearby before the concrete has sufficiently set. The danger of doing harm is greater in compact soils than in loose soils.

c. **Driving a Group of Friction Piles** - Driving piles in loose sand tends to compact the sand which, in turn, increases the skin friction. Therefore, the order of installing of such a pile in a group should avoid creating a compacting block of ground into which further piles cannot be driven.

In case where stiff clay or compact sand layers have to be penetrated, similar precautions need be taken. This may be overcome by driving the piles from the centre outwards or by beginning at a selected edge or working across the group. However, in the case of very soft soils, the driving may have to proceed from outside to inside so that the soil is restrained from flowing out during operations.

iii. **Jetting**-Jetting of casings by means of water shall be carried out, if required, in such a manner as not to impair the bearing capacity of piles already in, place. The stability of the soil or the safety of any adjoining buildings.

iv. The top of concrete in a pile shall be brought above the cut-off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut-off level. The reinforcing cages shall be left with adequate protruding length above the cut-off level for proper embodiment into the pile cap.

v. Where cut-off level is less than 1.5 m below working level, the concrete shall be cast to a minimum or 300 mm above cut-off level. For each additional 0.3 m increase in cut-off level below working level, an additional coverage a minimum of 50 mm shall be allowed. Higher allowance may be necessary, depending on the length of the pile. In the circumstances, pressure on the unset concrete equal to or greater than the water pressure should be observed and accordingly length of extra concrete above cut-off level shall be determined.

vi. **Defective Pile**

a. In case defective piles are formed, they shall be removed or left place whichever is convenient without affecting the performance of the adjacent piles or the cap as a whole. Additional piles shall be provided to replace them as necessary.

b. If there is a major variation between the depths at which adjacent foundation piles in a group meet refusal, a boring shall be made nearby to ascertain the cause of this difference. If the boring shows that the soil contains pockets of highly compressive material below the level of the shorter pile, it may be necessary to take all the pile to a level below the bottom of the zone which shows such pockets.

Vii Any deviation from the designed location, alignment or load capacity of any pile shall be noted and adequate measures taken well before the concreting of the pile cap and plinth beam.

viii. During chipping of the pile top, manual chipping may be permitted after three days of pile easting; while pneumatic tools for chipping shall not be used before seven days after pile casting.

D. Bored Cast-in-situ Pile

a. General

The pile formed within the ground by excavating or boring a pile within it, with or without the use of a temporary casing and subsequently filling it with plain or reinforced concrete. When the casing is left permanently it is termed as cased pile and when the casing is taken out it is termed as uncased pile.

In installing a bored pile the sides of the borehole (when it does not stand by itself) is required to be stabilized with the aid of a temporary casing, or with-the aid of drilling mud of suitable consistency. For marine situations such piles are formed with permanent casing (liner).

b. Equipment and accessories

i. The equipment and accessories would depend upon the type of bored cast-in-situ piles chosen in a job and would be selected giving due consideration to the

subsoil strata, ground water conditions, type of founding material and the required penetration therein wherever applicable.

ii. Among the commonly used plants, tools and accessories, there exist a large variety; suitability of which depends on the subsoil conditions and manner of operations, etc. Boring operations are generally done by rotary or percussion type drilling rigs using direct mud circulation or reverse mud circulation methods to bring the cuttings out. In soft clays and loose sands bailer and chisel method, if used, should be used with caution to avoid the effect of suction. Rope operated grabbing tool or Kelly mounted hydraulically operated grab are also used. The grab method of advancing the hole avoids suction. Rope operated grabbing tool or Kelly mounted hydraulically operated grab are used. The grab method of advancing hole avoids suction. The size of the cutting tool should not be less than the diameter of the pile by more than 75 mm.

iii. Use of drilling mud in stabilizing sides of boreholes is also made where appropriate or necessary. Drilling mud should have certain basic properties which are defined codes.

iv. Permanent liner may be used to avoid the aggressive action of ground water or otherwise. In case, liner is used and the bore is filled with water or drilling fluid, the bottom part may be concreted using tremie method, so that the liner is effectively sealed against ingress of ground water and then upper part may be concreted in dry after proper inspection of the top surface of the concrete so placed under water.

c. Reinforcement

The design of the reinforcing cage vary depending upon installation conditions, the nature of the subsoil and the nature of load to be transmitted by the shaft, axial or otherwise.

i. The minimum area of longitudinal reinforcement within the pile shaft should be 0.4 percent of the sectional area calculated on the basis of outside area of the casing or the shaft.

ii. The curtailment of reinforcement along the depth of the pile, in general depends on the type of loading and subsoil strata. In case of piles subject to compressive load only, the designed quantity of reinforcement may be curtailed at appropriate level as per the design requirements. For piles subjected to uplift load, lateral load and moments, separately or with compressive loads, it may be necessary to provide reinforcement for the full depth of the pile. In soft clays or loose sands the reinforcement should be provided up to the full pile depth regardless of whether or not it is required from uplift and lateral load considerations. However in all cases, the minimum reinforcement should be provided in the full length of the pile. Piles shall always be reinforced with minimum reinforcement as dowels, keeping the minimum bond length into the pile shaft below its cut off level and with adequate projection into the pile cap irrespective of design requirement.

iii. The minimum clear cover to all main reinforcement in pile shaft shall be not less than 50 mm. The minimum clear distance between two adjacent main reinforcement should normally be 100 mm for the full depth of the cage. The laterals of a reinforcing cage may be in the form of links or spirals. The diameter and spacing of the same is chosen to impart adequate rigidity of the reinforcing cage during its handling and installation. The minimum diameter of the links or spirals shall be 6 mm and the spacing of the links or spirals shall be not less than 150 mm.

d. Workmanship

i. Control of Piling Installation

a. Bored cast-in-situ piles may be adopted by suitable choice of installation techniques; covering the manner of soil stabilization, that is use of casing and/or use of drilling mud; manner of concreting that is direct pouring and placing or by use of tremie and choice of boring tools in order to permit a satisfactory installation of a pile at a given site. Sufficient detailed information about the subsoil conditions is essential to predetermine the details of the installation technique.

b. **Control of Alignment** - Piles shall be installed as accurately as possible as per the designs and drawings either vertically or to the specified batter. Greater care should be exercised in respect of installation of single pile or piles m two pile groups. As a guide, for vertical piles a deviation of 1.5 percent and for raker piles a deviation of 4 percent should not normally be exceeded although in special cases a closer tolerance may be necessary.

Piles should not deviate more than 75 mm or D/10 whichever is more in case of piles having diameter more than 600 mm from their designed positions at the working level of the piling rig. In the case of a single pile in a column positional tolerance should not be more than 50 mm (100 mm in case of piles having diameter more than 600 mm). Greater tolerance may be prescribed for piles driven over water and for raking piles. For piles to be cut-off at a substantial depth, the design should provide for the worst combination of the above tolerances in position and inclination. In case of piles deviating beyond these limits and to such an extent that the resulting eccentricity cannot be taken care of by a redesign of the pile cap of pile ties, the piles should be replaced or supplemented by one or more additional piles. In case of piles, with non- circular cross section ‘D’ should be taken as the dimensions of pile, along which the deviation is computed. In such cases the permissible deviation in each direction should be different depending upon the dimension of the pile along that direction.

NOTE - In case of raker piles up to a rake of 1 in 6, there may be no reduction in the capacity of the pile unless otherwise stated.

Any deviation from the designed location, alignment or load capacity of any pile shall be noted and adequate measures taken well before the concreting of the pile cap and plinth beam.

c. A minimum length of one metre of temporary casing shall be inserted in each bored pile unless otherwise specifically desired. Additional length of temporary casing may be used depending on the condition of the strata, ground water level, etc.

Drilling mud of suitable consistency may, also be used instead of temporary casings for stabilizing sides of the holes.

For marine situations such piles may be formed with permanent casing (liner).

ii. In case, a bored pile is stabilized by drilling mud or by maintaining water heads within the hole, the bottom of the hole shall be handled very carefully before concreting work is taken up. The cleaning of the hole may be ensured by careful operation of boring tool and/or flushing of the drilling mud through the bottom of the hole. Flushing of bore holes before concreting with fresh drilling fluid/mud is preferred.

iii. In case a hole is bored by use of drilling mud, the specific gravity of the mud suspension near about the bottom of the hole shall, whenever practicable, be determined by suitable slurry sampler in a first few piles and at suitable interval of piles and recorded. Consistency of the drilling mud suspension shall be controlled throughout the boring as well as concreting operations in order to keep the hole stabilized as well as to avoid concrete getting mixed up with the thicker suspension of the mud.

The concreting operations should not be taken up when the specific gravity of bottom slurry is more than 1.2. Concreting shall be done by tremie method in all such cases. The slurry should be maintained at 1.5 m above the ground water level if casing is not used.

iv. Concreting under water may be done either with the use of tremie method or by the use of specially designed underwater placer to permit deposition of concrete in successive layers, without permitting the concrete within the placer to fall through free water.

e. **Defective Pile** - In case, defective piles are formed, they shall be removed or left in place whichever is convenient without affecting performance of the adjacent piles or the cap as a whole. Additional piles shall be provided to replace them as directed.

f. Any deviation from the designed location alignment or load capacity of any pile shall be noted and adequate measures taken well before the concreting of the pile cap and plinth beam if the deviations are beyond the permissible limit.

g. During chipping of the pile top manual chipping may be permitted after three days of pile casting; pneumatic tools for chipping shall not be used before seven days after pile casting.

h. After concreting the actual quantity of concrete shall be compared with the average obtained from observations actually made in the case of a few piles initially cast. If the actual quantity is found to be considerably less, special investigations shall be conducted and appropriate measures taken.

E. **Under-Reamed Pile a. General**

A bored cast in situ or bored compaction concrete pile with an enlarged bulb(s) made by either cutting or scooping out the soil or by any other suitable process.

b. Equipment and accessories

i. The selection of equipment and accessories will depend upon the type of under-reamed piles, site conditions and nature of strata. Also it will depend on economic considerations and availability of manually or power operated equipment.
ii. A typical list of equipment for manual construction is given in Appendix D of IS: 2911-Part-3.
v. Bore holes may be made by earth augers. In case of manual boring, an auger boring guide shall be used to keep the bores vertical or to the desired inclination and in position. After the bore is made to the required depth, enlarging of the base shall be carried out by means of an under-reaming tool.
iv. In ground with high water table having unstable pile bores, boring and under-reaming may be carried out using a suitable drilling mud. General guidelines for bentonite drilling mud are given in Appendix E of IS: 2911-Part-3. In normally met soil strata, drilling mud can be poured from top while boring and under-reaming can be done by normal spiral earth auger and under-reamer.

The level of drilling mud should always be about one metre above water table or the level at which caving in occurs. In case of very unstable strata with excessive caving in, continuous circulation of drilling mud using suitable pumping equipment and tripod, etc., along with modified auger and under- reamer may be used.

v. Sometimes permeable strata overlying a rim clayey stratum may be cased and normal boring and under-reaming operation may be carried out in clayey stratum.
vi. To avoid irregular shape and widening of bore hole in very loose strata at top, a casing pipe of suitable length may be used temporarily during boring and concreting.
vii. For improved control over the inclination of batter piles, a tripod hoist with fixed pulley should be used for lowering in of under-reaming tools.
viii. For placing the concrete in bore holes full of drilling mud or subsoil water, tremie pipe of not less than 150 mm diameter with flap valve at the bottom should be used.
ix. For batter under-reamed piles, the reinforcement cage should be placed guiding it by a chute or any other suitable method. If concreting is not done by tremie, it should be done by chute.
x. In under-reamed compaction piles, suitable devices should be used for guiding the movement of drop weight and specified core assembly for its vertical driving. For operating the drop weights of adequate capacity, suitable winch with hoisting attachment should be used.

c. Reinforcement in Piles

The provision of reinforcement will depend on nature and magnitude of loads, nature of strata and method of installation. It should be adequate for vertical load, lateral load and moments, acting individually or in combination. It may be curtailed at appropriate depth subject to provision given below,

a. The minimum area of longitudinal reinforcement in stem should be 0.4 percent of mild steel (or equivalent deformed steel). Reinforcement is to be provided in the full length irrespective of any other considerations and is further subject to the condition that a minimum number of three 10mm diameter mild steel or three 8mm diameter high strength steel bars shall be provided. The transverse reinforcement as circular stirrups shall not be less than 6mm diameter mild steel bars at a spacing of not more than the stem diameter or 30 cm whichever is less. In under-reamed compaction piles, a minimum number of four, 12mm diameter mild steel or four 10mm diameter high strength steel bars shall be provided. For piles of lengths exceeding 5 m and or 37.5 cm diameter, a minimum number of six 12mm diameter bars of mild or high strength steel shall be provided. For piles exceeding 40 cm dia, a minimum number of six 12mm diameter mild or high strength steel bars shall be provided. The circular stirrups for piles of lengths exceeding 5 m and diameter exceeding 37.5 cm shall be of 8 mm diameter bars.
b. For piles subjected to uplift loads, adequate reinforcement shall be provided to take full uplift which shall not be curtailed at any stage.
c. For piles up to 30 cm diameter, if concreting is done by tremie, equivalent amount of steel placed centrally may be provided.
d. The 5over the longitudinal reinforcement shall be 40 mm. In aggressive environment of sulphates, etc., it may be increased to 75 mm.

D. CONSTRUCTION

a. Under-reamed piles may be constructed by selecting suitable installation techniques at a given site depending on subsoil strata conditions and type of under-reamed pile and number of bulbs.
b. In construction with the equipment, initially boring guide is fixed with its lower frame levelled for making desired angular adjustment for piles at batter. Boring is done up to required depth and under-reaming is completed.

i. In order to achieve proper under-reamed bulb, the depth of bore hole should be checked before starting under-reaming. It should also be checked during under- reaming and any extra soil at the bottom of bore hole removed by auger before reinserting the under-reaming tool.
ii. The completion of desired under-reamed bulb is ascertained by (a> the vertical movement of the handle, and (6) when no further soil is cut.
iii. In double or multi-under-reamed piles, boring is first completed to the depth required for the first (top) under-ream only and after completing the under-reaming, boring is extended further for the second under- ream and the process is repeated.

c. **Control of Alignment**

The piles shall be installed as correctly as possible at the correct location and truly vertical (or at the specified batter). Great care shall be exercised in respect of single pile or piles in two-pile groups under a column. As a guide, for vertical piles a deviation of 1.5 percent and for raker piles a deviation of 4 percent shall not normally be exceeded. In special cases, a closer tolerance may be necessary. Piles shall not deviate more than 75 mm or one quarter the stem diameter, whichever is less (75 mm or D/ 10 whichever is more in case of piles having diameter more than 600 mm) from the designed position at the working level. In the case of single pile under a column, the positional deviation should not be more than 0 mm or one quarter of the stem diameter whichever is less (100 mm in case of piles having diameter more than 600 mm). For piles where cut-off is at substantial depths, the design should provide for the worst combination of the above tolerances in position and inclination.

In case of piles deviating beyond these limits, corrective measures where necessary may be taken in the form of increasing pile size, provision of extra reinforcement in the pile, redesign of pile cap and pile ties. If the resulting eccentricity cannot be taken care of by the above measures, the piles should be replaced or supplemented by one or more additional piles.

NOTE - In case of raker piles up to a rake of 1 in 6, there may be no reduction in the capacity of the pile unless otherwise stated.

d. Concreting shall be done as soon as possible after completing the pile bore. The bore hole full of drilling mud should not be left unconcreted for more than 12 to 24 hours depending upon the stability of bore hole.
e. For placing concrete in pile bores, a funnel should be used and method of concreting should be such that the entire volume of the pile bore is filled up without the formations of voids and/or mixing of soil and drilling fluid in the concrete.
   i. In empty bore holes for under-reamed piles a small quantity of concrete is poured to give about a 100 mm layer of concrete at the bottom. Reinforcement is lowered next and positioned correctly. Then concrete is poured to fill up the bore hole. Care should be taken that soil is not scrapped from sides if rodding is done for compaction. Vibrators shall not be used.
   ii. If the water is confined up to the bucket length portion at the toe and seepage is low, the water should be bailed out and concreting should be done as above.
   iii. In case the pile bore is stabilized with drilling mud or by maintaining water head within the bore hole, the bottom of bore hole shall be carefully cleaned by flushing it with fresh drilling mud, and pile bore will be checked for its depth immediately before concreting.

Concreting shall be done by tremie method. The tremie should have a valve at its bottom and lowered with its valve closed at the start and filled up with concrete. The valve is then opened to permit the flow of concrete which permits the upwards displacement of drilling mud. The pouring should be continuous and tremie is

gradually lifted up such that the tremie pipe opening remains always in the concrete. If the final stage the quantity of concrete in tremie should be enough so that on final withdrawal some concrete spills over the ground.

NOTE 1 - The concrete should be coherent, rich in cement (not less than 350 Kgf/m^3) and of slump not less than 150 mm.

NOTE 2- The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal of the pipe is surged to discharge the concrete

NOTE 3 - The pile should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile, to prevent the laitance from being entrapped within the pile.

NOTE 4 - All tremie tubes should be scrupulously cleaned before and after use.

NOTE 5 - Normally concreting of the piles should be uninterrupted. In the exceptional case of interruption of concreting, but which can be resumed within 1 or 2 hours, the tremie shall not be taken out of the concrete. Instead it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting should be resumed by introducing a little richer concrete with a slump of about 200 mm for easy displacement of the partly set concrete. If the concreting cannot be resumed before final set-up of concrete already placed, the pile so cast may be rejected, or used with modifications.

NOTE 6 - In case of withdrawal of tremie out of the concrete, either accidentally or to remove a choke in the tremie, the tremie may be re-introduced in a manner to prevent impregnation of laitance or scum lying on the top of the concrete already deposited in the bore.

iv. In inclined piles, the concreting should be done through a chute or by tremie method.

v. For under-reamed bore compaction piles, the pile bore is first filled up without placing any reinforcement. Concreting is done depending upon situation. Soon after, the specified core assembly shall be driven and extra concrete shall be poured in simultaneously to keep the level of concrete up to ground level. If hollow driving pipe is used in core assembly, the pipe-shall be withdrawn after filling it with fresh concrete which will be left behind.

NOTE - In under-reamed bored compaction piles, concreting should be uninterrupted and notes (5) and (6) mentioned above will not apply.

vi. The top of concrete in a pile shall be brought above the cut-off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut-off level for proper embedment into the pile cap.

vii. Where cut-off level is less than 1.5 metre below working level, concrete shall be cast to a minimum of 300 mm above cut-off level. For each additional O-3 m increase in cut off level below working level, additional coverage of 50 mm minimum shall be allowed.

Higher allowance may be necessary depending on the length of the pile. When concrete is placed by tremie method, it shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of one metre above cut-off level. In the circumstance where cut-off level is below ground water, the need

to maintain a pressure on the unset concrete equal to or greater than water pressure should be observed and accordingly length of extra concrete above cut-off level shall be determined.

viii. **Defective Pile** -In case, defective piles are formed, they shall be removed or left in place whichever is convenient without affecting performance of the adjacent piles or the cap as a whole. Additional piles shall be provided to replace them as directed.

ix. Any deviation from the designed location alignment or load capacity of any pile shall be noted and adequate measures taken well before the concreting of the pile cap and plinth beam if the deviations are beyond the permissible limit.

E. GRADE BEAMS

a. The grade beams supporting the walls shall be designed taking due account of arching effect due to masonry above beam. The beam with masonry due to composite action behaves as a deep beam.

For the design of beams, a maximum bending moment of $wl^2/150$, where w is uniformly distributed load per metre run (worked out by considering a maximum height of two storeys in structures with load bearing walls and one storey in framed structures) and 1 is the effective span in metres, will be taken if the beams are supported during construction till the masonry above it gains strength. The value of bending moment shall be increased to $wl^2/30$ if the beams are not supported. For considering composite action the minimum height of wall shall be 0.6 times the beam span. The brick strength should not be less than 30 kg f/cm^2. For concentrated loads and other loads which come directly over the beam, full bending moment should be considered.

b. The minimum overall depth of grade beams shall be 150 mm. The reinforcement at bottom should be kept continuous in all the beams and an equal amount may be provided at top to a distance of quarter span both ways from the pile centres. The longitudinal reinforcement both at bottom and top should not be less than three bars of 10 mm diameter mild steel (or equivalent deformed steel).

Stirrups of 8 mm diameter bars should be at a 300 mm spacing which should be reduced to 100 mm at the door openings near the wall edge up to a distance, of three times the depth of beam. No shear connectors are necessary in wall.

c. In expansive soil, the grade beams shall be kept a minimum of 80 mm clear off the ground. In other soils, the beams may rest on ground over a levelling concrete course of about 80 mm.

In this case, part load may be considered to be borne by the ground and it may be accounted for in the design of piles.

d. In case of exterior beams over piles in expansive soils, a ledge projection of 75 mm thickness and extending 80 mm into ground shall be provided on outer side of beam.

F. DESIGN OF PILE CAP

Pile caps are generally designed considering pile reaction as either concentrated loads or distributed loads. The depth of pile cap should be adequate for the shear for diagonal tension and it should also provide for necessary anchorage of reinforcement both for the column and the piles.

a. The pile caps may be designed by assuming that the load from column or pedestal is dispersed at 45° from the top of the cap up to the mid-depth of the pile cap from the

base of the column or pedestal. The reaction from piles may also be taken to be distributed at 45° from the edge of the pile, up to the mid-depth of the pile cap. On this basis, the maximum bending moment and shear forces should be worked out at critical sections.

b. When pile reactions are considered as point loads, the critical section for shear in diagonal tension is taken at a distance equal to half the depth of cap from the face of the column or pedestal. For bending moment and shear for bond, the critical section is taken at the face of the column or pedestal. In computing the external shear or the critical section the entire reaction of any pile of diameter D whose centre is located at D/2 or more outside the section shall be assumed as producing shear on the section; the reaction from any pile whose centre is located at D/2 or more inside the section shall be assumed as producing no shear on the section.

For intermediate positions of the pile centre, the portion of the pile reaction to be assumed as producing shear on the section shall be based on straight line interpolation between full value at D/2 outside the section and zero value inside the section.

c. The cap may also be designed as a solid slab carrying concentrated loads from piles. A square/rectangular pile cap can be divided in four triangular/trapezoidal areas by drawing diagonal lines at 45°from the corners. When the pile is cut by the line, the load on this pile is shared equally between the adjacent areas. The reaction of piles under an area will be taken towards producing shear. The bending moment are assumed to act from the centre of piles under an area at the face of the nearest pedestal or column.

d. Full dimension of the cap shall be taken as width to analyse the section for bending and shear in respective direction. Method of analysis and allowable stresses may be according to IS: 456-1978.

e. The clear overhang of the pile cap beyond the outer most pile in the group shall normally be 100 to 150 mm, depending upon the pile size.

f. The cap is generally cast over a 75 mm thick levelling course of concrete. The clear cover for main reinforcement in the cap slab shall be not less than 75 mm.

g. The pile should project 40 mm into the cap concrete.

G. LOAD TEST ON PILES

I. General

The bearing capacity of a single or group of piles shall be determined from test loading. It is most direct method for determining safe load on pile and it is more reliable on account of its being in-situ test. The load test on a concrete pile shall not be carried out earlier than 28 days of its casting. Initial test shall be carried on test pile which is not used as working pile and Routine tests shall be carried out as a check on working pile. Routine test shall be one-half percent to two percent of total number of piles or as specified, applicable to vertical and lateral load. Load Test shall generally conform to provision made in IS: 2911 (Part IV) which provides guidelines for determination of safe loads and conducting of different types of tests.

II. Types of loadings/tests

a. Vertical Load Test (Compression)
b. Cyclic Vertical Load Test
c. Lateral Load Test

III. Vertical Load Test

i. **General:** Compression load shall be applied to the pile top by means of a hydraulic jack against suitable load frame which is capable of providing reaction and settlement is recorded by suitable dial gauges. The Bidder shall apprise of Engineer-in-Charge before test is conducted.

ii. **Preparation of Pile Head:** Pile head shall be chipped off to horizontal plane, projecting steel shall be cut or bent and top finished smooth and levelled with plaster of Paris or similar synthetic material as specified to give a plane surface which is normal to the axis of the pile. A bearing plate with a hole at the centres shall be placed on the head of pile for the jacks to rest.

iii. **Loading Platform:** A proper loading platform is installed as specified. Bidder shall ensure that when the hydraulic jack and load measuring devices are mounted on pile head the whole system will be stable on the maximum specified load. For single pile two dial gauges shall be fixed to the pile and bear on surfaces on reference frame. The dial gauges shall be placed in diametrically opposite positions and be equidistant from the pile axis. Four dial gauges are used for groups, having 0.01 mm sensitivity. The arrangement shall be approved by the Engineer-in-charge.

iv. **Application of Load:** The test is carried out by applying a series of downward incremental load (20 per cent of safe loads on pile). In this method application of increment of test load and taking of measurement or displacement in each stage is maintained till the rate of displacement is either 0.1 mm in first 30 minutes or 0.2 mm in first one hour or 2 hours, whichever occurs first. The test load shall be maintained for 24 hours. This method is applicable for both initial and routine test. For testing of raker piles the loading shall be along its axis. Safe load on single pile for initial test is least of following:

   a. Two-thirds of the final load at which the total displacement attains a value of 12 mm unless otherwise stated, in such case the safe load should be corresponding to total displacement permissible.
   b. 50 per cent of the final load at which the total displacement equal 10 per cent of pile diameter and 7.5 per cent of bulb diameter in case of under-reamed piles.

Routine test shall be carried for a test load of one and half times the working load, maximum settlement not to exceed 12 mm or as stated.

Safe load on group of piles for initial test shall be least of the two

a. Final load at which total displacement is 25 mm or as stated.
b. Two-thirds of final load at which the total displacement is 40 mm.

Routine test shall be carried for a test load equal to not less than working load, the maximum settlement not to exceed 25 mm.

v. **Maintained Load Method:** This is applicable for both initial and routine test. In this method application of increment of test load and taking of measurement or displacement in each stage of loading is maintained till rate of displacement of the pile top is either 0.1 mm in first 30 minutes or 0.2 mm in first one hour or till 2 hours, whichever occurs first. If the limit of permissible displacement is not exceeded, testing of pile is not required to be continued further. The test load shall be maintained for 24 hours.

   Pile test data such as load, displacement and time shall be recorded in suitable prescribed tabular form. Results can be presented by suitable curves.

Test shall be carried out in proper manner and to the entire satisfaction of the Engineer- in-charge.

After the test is completed the test cap shall be dismantled and pile surface shall be resorted to original shape.

IV. Cyclic Vertical Load Testing

i. **General:** This process shall be used in case of initial test to find out separately skin friction and point bearing load on single piles of uniform diameter in conformity of provisions of IS Code 2911 (Part 4) for conducting of the test.

ii. **Preparatory Pile Head:** Refer preparatory pile head of Vertical Load Test mentioned above.

iii. **Loading Platform:** Refer loading platform of Vertical Load Test mentioned above.

iv. **Application of Load:** Relevant provision as per clause of application of load of Vertical Load Test mentioned above shall be applicable. The test may be continued up to 50 per cent over the safe load.

v. Test procedure given in Appendix E of IS: 2911(Part 4) shall be followed.

Test shall be carried out in proper manner and to the entire satisfaction of the Engineer- in-charge.

After the test is completed, the test cap shall be dismantled and pile surface shall be restored to original shape.

V. Lateral Load Testing

i. **Load Platform:** A proper loading platform shall be installed as specified. Hydraulic jack is mounted with gauge between two piles or pile groups under test. Dial gauge tips shall rest on central portion of glass plate fixed on the side of pile.

ii. **Application of Load:** Full load imposed by the jack shall be taken as lateral resistance on each pile or group. Load should be applied in increments of about 20 per cent of the estimated safe load. The next increment shall be applied after the rate of displacement is approximately equal to 0.1 mm per 30 minutes.

iii. The safe lateral load on pile; is least of the following:

a. Fifty per cent of the final load at which total displacement increases to 12 mm.
b. Final load when total displacement is 5 mm.
c. Load corresponding to any other specified displacement as per requirement. Pile group shall be tested as per actual conditions as far as possible.

iv. **Displacements:** Displacement is read by at least two dial gauges of 0.1 mm sensitivity spaced at 30 cm and kept horizontally one above the other and displacement is interpolated at cut off level. One dia gauge placed diametrically opposite to jack shall directly measure displacement. Where, it is not possible to locate one of the dial gauges in the line of the jack axes, then two dial gauge may be kept at a distance of 30 cm at a suitable height and the displacement interpolated at load point from similar triangles.

Note: One of the methods of keeping dial gauge on pile surface is to chip off uneven concrete on the side of the pile and to fix a piece of glass 20 to 30 mm square. The dial gauge tips shall rest on the central portion of the glass plate.

Arrangement and test procedure shall be duly approved by the Engineer-in-Charge.

VI. PULL-OUT TEST ON THE PILES

Uplift force may preferably be applied by means of hydraulic jack(s) with gauge using a suitable pullout set up.

The test pile shall have adequate steel to withstand pulling. In some cases, in order to allow for neck tension in a pull out test, it may be necessary to provide additional reinforcement in the piles to be tested.

The pull out load increments and consequent displacement readings shall be read as in the case of vertical load test.

Loading shall be continued till one of the following occurs :

i. Yield of soil pile system occurs causing progressive movement of pile exceeding 12 mm.

ii. The loading on the pile top equals three times the estimated safe load or as specified in the case of separate test pile.

The safe load shall be taken as the least of the following:

i. Two-third of the load at which the total displacement is 12 mm or the load corresponding to a specified permissible uplift,

ii. Half of the load at which the load-displacement curve shows a clear break (downward trend).

The initial test shall be carried out up to twice the estimated safe load or until the load displacement curve shows a clear- break (downward trend). Routine test shall be carried out to one-end-a-half times the estimated safe load or 12 mm total displacement whichever is earlier.

NOTE - One of the method for pull out the may be used is where hydraulic jack is made to rest on rolled steel joists resting on two supports on the ground. The jack reacts against a frame attached to the top of the test pile such that when the jack is operated, the pile gets pulled up and the reaction is transferred to the ground through the supports which are atleast 2·5 *D* away from the test pile periphery (where *D* is pile stem diameter of circular piles or diameter of the circumscribing circle in the case of square piles). The framework can be attached to the pile- top, with the reinforcement bar which may be threaded or to which threaded bolts may be welded. As an alternative if it sometimes preferable to use a central rod (designed to take pile load and embedded centrally in the pile to a length equal to the bond length load required. It will have thread at top for fixing it to the framework. For larger load, the number of rods may have to be more and depending on the set-up these may be put in a line or any other symmetrical pattern. For routine tests, the framework is normally attached to the reinforcing bars but a central rod may also be used in case the upper portion of the pile is required to be built up.

VII. Complementary tests

Complementary tests to the integrity test method is described below.

a. **Ultrasonic Pulse Velocity Test** — This test is carried out at the head of the pile in order to arrive at the speed of sound propagation through the cast concrete of the pile. This test is to be conducted in the foundation area.

b. **Penetration Test —** This test is used to assess the strength of the concrete at the pile head to ensure that the pile is sufficiently cured and ready for NDT.

c. **Density Testing of Cast Cubes —** In order to determine the density of concrete used each cube should be measured for density by weighing in air and water and using the calculation given in IS:14893.

All the above supporting tests can be used to check soundness of concrete at the test level and to assess the stress wave velocity of pile concrete depending on concrete density and its in-situ condition.

H. False Ceiling and Under Deck Insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the underside of the roof/floor slab of the air conditioned areas based on the functional requirement. Ceiling of air washer room shall also be provided with under deck insulation.

Aluminium false ceiling system shall comprise of 84mm wide 12.5mm 6deep closed type plain panels of approved colour, roll formed out of 0.5mm thick corrosion resistant aluminium alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, Ac ducts etc.

Permanent colour coated square panelled suitable size for electrical fixing aluminium false ceiling system shall be provided. The suspension system shall consist of 6mm dia galvanised steel rods suspended from ceiling supporting aluminium grid of 38x25x1.5mm and cross tie of 25x25x1.5mm and aluminium angle of 25x25x1.5mm.

Suitable MS channel (minimum ISMC 100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts, etc.

Bidder shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire protection sprinklers, etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the Owner approves the layout.

Under deck insulation shall comprise of 50 thick PUF material of density 36 kg/cubic meter. This mat shall be backed with 0.05mm thick aluminium foil and 24Gx25mm wire mesh netting. They shall be fixed to ceiling or wall as the case may be with 100x50x6 slotted mild steel plate welded to MS plate inserts embedded at the soffit of the slab at 600mm c/c and 14 G steel wire drawn through slots and fixed to wire netting.

9.0.0 ARCHITECTURAL WORKS

A. Architectural Concepts

a) Layout of the plant area shall have definite hierarchy of road network depending upon its usage, aesthetic, visual sensibilities for creating road vistas, focal points, building back drops, building frames. General layout shall be evolved taking over the basis of landform and local climate and due consideration shall be given to orientation and wind direction. The resulting built mass shall present a definite image width in distinct vocabulary in the form of landmarks, nodes and skyline.

b) Main Plant building shall be architecturally treated in such a way that it retains a monumental scale, yet presents a pleasing composition of mass and void with suitable and functionally designed projections and recesses. The overall impact of

the building shall be one of aesthetically unified architectural composition having a comprehendible scale, blending tonal values with the surroundings and taking full consideration of the climatic conditions, the building orientation and the existing structures nearby.

c) All other buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the main plant, surrounding structures and environment. Local architectural characters and materials may be judiciously imbibed. The building shall be designed initiating an architectural control common to all buildings. The architectural control shall be clearly spelt out in terms of scale, man and form.

d) Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into an account the mass and void of buildings, its facade, equipment, exposed structural elements, piping, trestles, bus ducts and other service elements. Minimum two numbers of colour schemes shall be proposed for approval of the owner.

e) Overall emphasis shall be on developing an eco-friendly architecture, merging with the nature. The scheme shall be conceptually finalised in totality including that of equipment so that the proper coordination with other agencies can be taken up at appropriate time.

B. Architectural Design

a) Natural light shall be used to the maximum extent, especially in the form of north light/sky light. For adequate light and ventilation, National Building code recommendations shall be followed.

b) Entrance canopies chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.

c) All the buildings shall be architecturally designed to meet the National Building Code (SP: 7) norms and local building bye laws, wherever applicable.

d) Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect. Statutory requirements may be required to be met with, wherever essential. The Architect shall be of National/ International repute having experience in similar kind of works. The Architect shall evolve the design philosophy based on Owner/Engineer guidelines and shall present it in the form of presentation drawings

e) Prospective views, 3-D Models and detail drawings.

f) Architectural components shall be designed for the conditions at the site for a minimum design life of 30 years.

C. General

a) All stairs shall have a maximum riser height of 180 mm and a minimum tread width of 250 mm. Minimum clear width of staircase shall be 1200 mm.
b) RCC staircase shall be provided for all RCC construction buildings and structural steel staircase for all structural steel buildings.
c) In all buildings, structures, suitable arrangement for draining out water collected from equipment blow downs, leakages, floor washings, firefighting, etc., shall be provided for each floor. All drains shall be covered with pre-cast RCC cover panels.
d) All fire exits shall be painted with post office red / traffic signal red colour shade which shall not be used anywhere except to indicate emergency or safety measure.

Fire safety norms shall be as per National Building Codes and the fire safety requirements for providing fire exits, escape stairs, and firefighting equipment. In detailing of all buildings, fire safety requirements conforming to IS: 1641 and IS: 1642 shall be followed.

D. Walls

All walls shall be non-load bearing infill panel walls. The function of all exterior walls is to provide enclosures for buildings. The exterior enclosure protects the enclosed system and personnel from adverse weather conditions and allows for a controlled interior environment.

a) External Walls

All external walls shall be one brick thick masonry work with 1:6 cement sand mortar. Masonry work facing transformer yard upto a required level shall be fire resistant. Minimum thickness of firewall shall be 350 mm for brick works and 200mm for concrete walls.

b) Internal walls

In plant building all internal walls shall be one brick thick masonry in cement mortar 1:6. Internal toilet walls, non-plant building walls and office walls shall be half brick thick masonry with 1:4 cement sand mortar. In control rooms and other specified areas as per requirement, aluminium glazed partition with aluminium box sections shall be used.

E. Painting

a) All painting on masonry or concrete surface shall be preferably be applied by roller. If applied by brush then it shall be finished off with roller. Minimum coats of paint shall be applied over a coat of primer.
b) External masonry surface of all building shall have decorative water proof cement paint over a coat of primer as per IS: 5410.
c) Acrylic plastic emulsion paint shall be provided for control room, control equipment room, computer room, UPS room. All other areas shall be painted with oil bound distemper.
d) Internal surface walls of room for pumps, machineries and maintenance shall be painted with washable painting of dark shade upto height of 1.5m above floor level.
e) Battery room and all other areas subject to chemical corrosion shall be painted with acid/alkali resistant epoxy paint over a suitable primer from top of dado.
f) Oil resistant paint shall be provided in oil equipment room, oil canal and fuel oil pump house etc.
g) Acrylic emulsion paint shall be as per IS: 5411 (Part 1), Acrylic washable distemper shall be as per IS: 428, White wash / Colour wash shall conform to IS: 627.
h) For painting on concrete, masonry and plastered surface shall be followed as per IS: 2395. For painting on wood work shall be followed as per IS: 2338. For painting on steel works and ferrous metals shall be followed as per IS: 1477.
i) All plastered areas above false ceiling shall be provided with one or more coats of white wash as per requirement.
j) All concrete surface coming in contact with sea water will be painted with 1.5mm thick polyuria coating meeting ASTM D-16, Type V (two component, chemical cure).

F. Anti-termite treatment

Anti-termite treatment shall be done with insecticide emulsion at the rate of 5 litres / m^2 as per IS: 6316 (Part II) for all structures.

G. Damp Proof Course

Damp Proof Course shall be provided over all masonry at plinth level as or directed by the engineer in charge. Unless otherwise specified, it shall consist of cement concrete 1:1.5:3 using 20mm down coarse aggregate and approved water proofing material in ratio as specified by the manufacturer and 40mm thick or as per drawing.

H. Metal wall cladding

Double skin insulated cladding made of 0.6 mm thick pre-coated galvalume high tensile steel sheet shall be provided for cladding. The outer and inner skin shall be of profile sheet of depth 28 mm. cold rolled steel of 550Mpa yield stress conforming to ASTM A 446 grade E with hot-dip metallic coating of Al-Zn alloy shall be used as substrate. Metallic coating thickness shall be minimum 150 gms/m^2 total. The surface shall be colour coated by oven baked paint system applied over substrate.

I. Plinth Protection

All buildings shall be provided with 1000 mm wide and 100 mm thick plain cement concrete paving all-round the outside. Plinth protection shall be laid over prepared subgrade and base formed with broken brick bats or rubble laid to a thickness of 150 mm.

J. Edge Protection

Edge protection angle of size 50x50x6 with lugs shall be provided for all concrete edges, where breakage of edge is expected. E.g.: All round the cut-outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable / pipe trenches / manholes supporting covers and supporting edges of pre-cast covers etc.

K. Roof

Roofs and floors shall be made of RCC slab.

For efficient disposal of rainwater, the run off gradient for the roof shall not be less than 1: 100 and the roof shall be provided with galvanized iron gutter, where ever required. Gutter shall be made water tight using suitable watertight treatment.

Roof of all buildings shall be provided with access / approach through staircase. Roof where equipment is mounted shall be provided with access through staircase.

L. Elastomeric water proofing treatment

Roof shall be provided with roof water proofing treatment using high solid content liquid applied elastomeric water proofing membrane with separate wearing course as per ASTM-C- 836 & 898. Thickness of the membrane shall be 1.5mm (min.). This treatment shall include application of polymerized mastic over the roof to achieve smooth surface and primer coat. Wearing course on the top of membrane shall consist of 25 mm thick PCC (1:2:4) cast in panels of maximum 1.2x1.2m size and reinforced with 0.56mm dia galvanized chicken wire mesh and sealing of joints using sealing compound/ elastomeric water proofing membrane. However, chequered concrete tile flooring 22mm (min.) thick of approved colour and shade conforming to

IS:13801 shall be provided for path way of 1m width for access of personnel and handling of equipment and for the entire area of the roof where equipment like A/C ventilation plant, cooling towers, etc. are provided in place of PCC wearing course. Equipment shall be installed on raised pedestal of minimum 30 cm height from the finished roof to facilitate maintenance of roof treatment in future.

M. Doors, Windows, Ventilators & Louvers

a) Main entrance doors of control room, control equipment room, computer room etc., shall be provided with air locked lobby with provision of aluminium doors with glazing. Doors shall be complete with all hardware fixtures like door closer, tower bolts, handles, stoppers, aldrops, locks etc.
b) Doors of wet areas like W.C., showers shall be hinged type single leaf shuttered FRP (fibre Reinforced Polyester) doors with heavy duty aluminium box section frame black powder coated.
c) Fire proof doors shall be provided on division walls of cable spreader rooms and at all fire exit points as per recommendation of Tariff Advisory Committee. These shall be as per IS: 3614. Fire resistance grade shall be as 2 hours. Fire doors shall be hollow metal steel flush door with appropriate filler to meet fire rating.
d) All outside doors shall have door closer as per IS: 3564. All exterior doors exposed to weather at all elevation shall swing out. Hardware of all doors shall be heavy duty.
e) All windows and ventilators of power house and other buildings shall be heavy duty extruded aluminium sections with fixed, sliding or swing shutters conforming to IS: 1948 and IS: 1949. All aluminium window shall have heavy gauge box sections with weather seals. Aluminium Windows with double glass fixed with vacuum shall be provided in air conditioning rooms.

N. Glazing

a) 6 mm thick float clear glass shall be provided for accessible level openable windows and 6 mm thick wired glass for fixed portion of high level windows and ventilators where frequent replacement is not feasible.
b) All windows shall be glazed and fully flashed and sealed for water tightness.
c) All glazing work shall conform to IS: 1083 and IS: 3548
d) In fire prone areas toughened glass of minimum thickness 6 mm as per IS: 5437 shall be used.

O. Rolling Shutters

Rolling shutters as per IS: 6248 with operating arrangement (manual, mechanical or electrical) according to the sizes shall be provided in buildings to facilitate handling and transportation of equipment.

M.S. rolling shutters shall be made of interlocking lath section formed from bright cold rolled, annealed M.S. strips not less than 0.90 mm thick for shutters up to 3.5m width & not less than 1.20 mm thick for shutters above 3.50 m width, with weather seals and wind lock and shall have grills for ventilation where necessary. Its components shall be factory galvanized, primed and field painted. They shall be manually or motor operated as required to meet functional requirement and operating convenience.

Rolling shutter with area upto 9 sq.m shall be push and pull type manually operated while for area above 9 sq.m. Rolling shutter will be mechanically / electrically operated, as per IS specifications.

P. Hand Railing

a) Minimum 1000 mm high (from floor/ roof level) hand railing shall be provided around all floor/roof openings, projections/balconies, walkways, platforms, steel stairs, etc. All handrails and ladder pipes shall be 50 mm nominal bore MS pipes (medium class) conforming to IS: 1161.
b) Spacing of handrail post shall be limited to 1200 mm as far as possible but can be adjusted to suit the length of railing.
c) For RCC stairs, except around all floor openings, 1000 mm high hand railing with 32 NB (polished) stainless steel pipe shall be provided.

Q. Lifts and Elevators

Refer Mechanical specification for detail.

R. Roof Drainage

The system shall be provided for removal of rainwater from roof surface without over flow to avoid damage to the roof structure of all buildings and shall consist of the following
a) Roof drain heads
b) Rain water down comers
c) Fixture

Multiple drains (minimum 2 No's) shall be provided for all roof areas. The roof drain shall be sized for the roof run off for a maximum rainfall per hour at site. Minimum 100 mm dia pipe shall be provided to drain out 40 sq.m of roof surface area and minimum 150 mm dia pipe to drain out 80 sq.m of roof surface area.

Rain water down take pipes and fitting shall be of PVC with sockets free from cracks and flaws. The pipe and fittings shall be fixed perfectly vertical, secured to wall or column with flat headed nails.

S. Parapets

Parapets shall be provided to all RCC roofs. All parapets wall shall be 750 mm high. 100 mm thick concrete parapet will be provided unless otherwise mentioned.

T. Paving

RCC paving minimum 150 mm thick of M20 over an under bed as specified here in shall be provided. RCC paving shall be designed as rigid reinforced concrete pavements for the crane / vehicular / equipment movement loads which the paving has to bear. The under bed for paving shall consist of preparation and consolidation of sub grade to the required level, laying of stone soling of 230 mm compacted thickness and down aggregate with interstices filled with selected sand followed by 100 mm thick 1:4:8 PCC with 40 mm nominal size aggregate.

U. Roads

Access within the project area shall be provided by a system of roadways.

All building in project area shall be approached by access road, which shall either be single or double lane road depending upon the functional requirement. Access roads shall also be provided to areas where access is necessary for inspection, operation and maintenance. Road level shall be higher than the FGL.

All the roads shall be of reinforced cement concrete. All shoulders shall be of raised type.

Type I roads shall consist of 7.5 metres wide RCC paved carriageway with 2.5m wide hard shoulders on both sides. All Type I roads shall have a minimum turning radius of 18 meters. Type I road shall be provided wherever necessary based on vehicle movement requirements.

Type II roads shall consist of one 4.5 metre wide RCC paved carriageway with 1.5m wide hard shoulders with drains on either side. A turning area at blind ends shall be provided. Plant areas where infrequent access is needed shall be served by Type II roads.

Top of all the shoulders shall be finished with 80mm thick interlocking tiles of M20 grade with 100 mm thick PCC. Minimum 100 mm thick screed sand cushion layer shall be provided below the interlocking tiles.

Sign Boards shall be provided for vehicle management and shall meet the Indian standards. All sign boards shall be dual worded in both English and the local Indian language. Finished top (crest) of roads shall be 250 mm above the surrounding grade level. Geometric design of road shall be in accordance with IRC:73. The ruling gradient for roads in longitudinal direction shall not exceed 1 in 25.

Main roads shall be designed for movement of heaviest equipment of the plant. The shoulder shall be laid with slope of 1 in 30.

Minimum clear width of drains shall be 600mm. The drains shall be designed and built using RCC. Drainage lines and other underground services shall be located at least 1m clear from the edge of the roads. All service and utility lines crossing the roads shall be taken through NP3 class RCC pipe designed for impact loading. All culverts carrying storm water shall be cast in place RCC box culverts.

No underground service piping except for drainage and sewage system shall run directly below the road (including upto 1 m from edge of road) along its longitudinal direction.

Surface drainage of roads shall be provided by giving proper longitudinal slopes and cross falls.

The Minimum thickness of RCC road pavement, Sub-base and minimum reinforcements shall be as follows.

Roads shall be designed for IRC and MOST standards (MORTH).

A Separation membrane shall be used between Concrete and sub-base. Membrane shall be impermeable. Plastic sheeting shall be 125microns thick laid flat without creases.

The drainage system shall be designed for precipitation intensity of minimum 80mm per hour.

The joints, dowel bars, tie bars, joint pillars, ceiling compounds tolerances curing shall be as per latest IRC MOST standards.

V. Surface Drainage

a) The surface drainage system shall be designed for surface washings and / or rain / fire water as the case may be. Unpaved open areas shall be drained through RCC drains and connected to main storm drains.

b) The paved area shall be sloped towards the drains with a minimum slope of 1 in 100. The maximum drainage travel extent shall be limited to 10 metres.

c) The surface drainage from uncontaminated area shall be connected to nearest open storm water drains through rectangular drains. Contaminated area surface drainage shall be collected through separate network.

d) The interconnecting pipes and rectangular drains shall be sized for carrying the design discharge when running full.

e) The rectangular drains shall be minimum 600 mm wide of RCC construction. The pipes for water drainage system shall be of RCC class NP2 conforming to IS:458 with minimum size of 150 mm NB. However, for road crossings etc., pipe of class NP3 shall be provided. For rail crossings, pipes conforming to railway loading standards shall be provided. If sufficient clearance cannot be provided between the top of the pipe and road top, the pipes shall be encased in RCC.

f) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8 m/sec respectively. However, minimum velocity for self-cleansing of 0.6m/sec shall be ensured. Slope of drain shall not be milder than 1 in 1000. The size & slope of open drain shall be fixed in consultation with BOP bidder.

g) Minimum earth cover of 450 mm shall be provided over drainage pipes in paved areas.

h) RCC Garland drains minimum 300mm wide shall be provided all-round the building to lead away roof drainage to plant drainage system. Plinth protection shall be provided as mentioned in chapter-VI of the specification.

W. Storm Water Drainage System

a) The plant storm water drainage system shall take into account the topography of the plant area, area drainage patterns and intensity of rainfall etc. The drainage system shall be designed for precipitation intensity equal to hourly rainfall for a return period of 1 in 50 years. These values shall be based on the recommendations of Indian metrological department (IMD).

b) All storm water drainage shall preferably be through open storm water drains. These shall be provided on both sides of the roads and shall be designed to drain the appropriate catchment area including road surface, open and covered area etc. The drains shall be minimum 600 mm wide at the base.

c) All open drains shall be rectangular in cross section & in RCC. In the main plant block, rectangular section RCC drains in minimum M25 grade concrete shall be provided. The thickness of side and bottom shall be minimum 150 mm or as per design considerations whichever is higher.

d) The pipes for water drainage system shall be concrete pipes of class NP2 conforming to IS:458. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. Diameter of pipes used for drainage / culverts shall be between 300 mm to 600mm. Beyond 600mm, box drains / culverts shall be provided. Water way RCC culvert shall not be less than 1m.

e) Surface drains shall normally have a bed slope not milder than 1 in 1000 along longitudinal direction and RCC pipes shall have such slopes so as to have effective discharge. The maximum velocity for pipe drains and open drains shall be limited to 2.4 m/sec and 1.8 m/sec respectively. However, minimum velocity for self cleansing of 0.6m/sec shall be ensured at peak flow condition (i.e. 3 times average flow) for pipes flowing at half full.

f) Suitable manholes shall be provided to piped drainage lines at every 30m intervals, at junctions and at change of gradient, alignment and diameter of pipe and shall be of masonry or RCC construction. Minimum size of manholes shall be 1.0m x 1.0m. All manholes shall be designed considering maintenance, inspection and cleaning of pipes. Easy accessibility and safety shall also be given due consideration.

g) The cushion over the pipes for storm culverts shall be minimum 600mm. Where less cushion is available, pipe shall been cased in RCC M15. Suitable RCC or masonry structures shall be provided at drops / falls to prevent scouring or damage to surface.

h) Invert of drainage pipe / drain shall be decided in such a way that the water can easily be discharged above the high water level in water course outside the plant boundary to which the storm water is to be led.

X. Floor finish and Skirting

For details, refer finishing schedule.

Y. Water Supply

Two numbers of roof water tanks (one for storing service water and another for potable water) of adequate capacities depending on the number of users and 8 hours storage capacity shall be provided for each building. Polyethylene water storage tanks conforming to IS: 12701 shall be used. The tanks shall be complete with all fittings including lid, float valve, stop cock, vent pipe, etc. PVC pipe shall be used for internal piping works for service water and potable water supply.

Z. Toilets

Toilets shall be provided near work areas, but isolated from main areas. Unless otherwise shown in drawings or specified, the dimension of the toilet blocks shall be decided by the number of sanitary fixtures, which shall be based on number of users in accordance with IS: 1172. Attached toilets shall be provided for all senior executive rooms and conference rooms. All other buildings shall have minimum one toilet block each.

Toilets shall be provided with all necessary approved Indian Standard fittings. Sufficient natural light and ventilation shall be provided as per requirement. Unless specified each toilet shall be provided with minimum one W.C. (Water closet), two urinal, one washbasin, towel rail, mirror and liquid soap dispenser, shelves etc. Western / Indian closets shall be provided as specified in the drawing.

Sewerage shall be connected to the nearest manhole of the power plant sewage network.

AA. Sanitary Fittings

Sanitary fittings shall be of Parry ware make or approved equivalent of the following sizes and specification

Indian Water Closet (IWC)	:	Orissa pan of size 600 mm x 400 mm conforming toIS: 2556 of 10 litres capacity.
European Water Closet (EWC)	:	Conforming to IS: 2556 with Bakelite seats of 10 litres capacity.
Urinals	:	Flat of size 610 mm x 410 mm x 380 mm urinal with flushing cistern and bottle trap.

Wash Basin	:	50 mm x 400 mm conforming to IS: 2556 with chromium plated bottle trap.

The exact number of fittings shall however be finalized during detail engineering stage.

BB. Rain Water Harvesting

Rain water harvesting is now an important component of wise resource use and environmental management. During operation of the plant following approach will be taken to implement the Rainwater harvesting plan.

Rain Water Harvesting should be implemented as per the scheme / design approved, Central ground water Authority / Board or State ground water authority or MoEF authorized agency shall be consulted for finalization of appropriate rain water harvesting technology. The necessary consultancy charges for the above agency for preparing rain water Harvesting method / scheme for the project to be borne by the Bidder.

CC. IS Codes & Standards

Indian Codes and Standards shall generally be used for design of structures/architectural works. In all cases, the latest revisions with amendments, if any shall be followed. Other International codes for specific requirements as insisted by Owner shall be followed.

DD. Master Key System for FGD area

An appropriate serviceable and functional master key system for the FGD area shall be installed. The elaboration of the system itself shall be made in close co-ordination with the Owner and only after obtaining Owner's approval in writing shall the order of production be placed.

The following requirements shall be met:

i. The general master key shall operate all locks

ii. The main key shall open all locks of one building

iii. The single key shall open the lock of a single room.

Necessary attention shall be paid to later extensions of the master key system, which shall be suitable for the FGD area including all final stages.

The profile cylinders shall be sea water resistant and shall suit plant requirements. The material of the cylinders shall be of massive brass, nickel-plated with six security pawl studs.

The keys shall be made of material approved by the Owner and shall have an engraved indication of the applicable key system and the building or door number.

Keys shall be supplied in the following numbers: General Master Key	10 nos.
Main keys	10 nos. per each building
Single keys	3 nos. per each door

EE. Architectural Finishing Works a) Doors and Window :

All main doors shall be made of aluminium (glazed). All control rooms shall have doors, windows and partitions made of glazed aluminium. PVC door shall be provided for all toilets.

Windows in ground floor of all buildings/structures in FGD area shall be provided with aluminium grill.

Windows & ventilators shall be provided 15% of the floor area to ensure natural ventilation & air flow in all buildings.

b) Finishing schedule

The minimum quality of finishes used for various building areas are furnished in the below table. The Bidder is at liberty to use superior finishes provided all specific requirements for the finish specified in this specification.

Description of Building/area	Wall (Internal)	Floor Finish	Ceiling	Roof Treatment	Wall (External)
Administrative Building :					
Ent. Lobby, Reception, Portico, staircase & Lift Area	Acrylic emulsion paint	20mm thick polished granite stone	Aluminium false ceiling in A/C areas & Acrylic washable Distemper in other areas.	-	Granular finish (Vineratex) or equivalent.
Office area	Acrylic emulsion paint	Glazed vitrified Ceramic tiles	Aluminium false ceiling in A/C areas & Acrylic washable Distemper in other areas.	-	Granular finish (Vineratex) or equivalent.
Roof	-	-	-	Elastomeric water proofing treatment	-
Workshop	Acrylic washable distemper in Workshop area and Acrylic emulsion paint in office area.	Granolithic flooring with non metallic floor hardener in workshop area and Heavy duty ceramic tiles in office area.	Acrylic washable Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Permanent Store	Acrylic washable Distemper	Granolithic flooring with non metallic floor hardener	Acrylic washable Distemper	Elastomeric water proofing treatment	Water proof cement based paint

Description of Building/area	Wall (Internal)	Floor Finish	Ceiling	Roof Treatment	Wall (External)
Chemical House	Acid/Alkali resistant tiles on wall up to 1500mm height & chemical resistant paint above.	Acid/Alkali resistant Tiles	Chemical resistant paint	Elastomeric water proofing treatment	Water proof cement based paint
Pump Houses	Acrylic emulsion paint in control room and Acrylic washable distemper in other areas.	Granolithic flooring with non metallic floor hardener in pump house area and Vitrified tiles AC areas.	Aluminum false ceiling in control room/AC Areas and acrylic distemper in other areas.	Elastomeric water proofing treatment	Water proof cement based paint
Electrical / Control Room	Acrylic emulsion paint	Vitrified ceramic tiles	Aluminum false ceiling	Elastomeric water proofing treatment	Granular finish
Toilet	Dadoing for 2100 mm high & Acrylic distemper above	Heavy duty ceramic tiles	Acrylic washable Distemper	--	Water proof cement based paint

Note:

a. The quality, colour & size of all materials shall be got approved by the engineer.
b. The selection of size of tiles/granite slab shall be such that to have minimum number of joints while laying.
c. All steel structures shall be finished with chemical resistant paint on account of marine environment.

10.0.0 QUALITY CONTROL

A. Equipment and Materials

i. Bidder shall provide and maintain at the site necessary number and type of machinery and equipment including survey instruments in good working condition for proper setting out and timely completion of the works covered under this specification. All arrangements for transporting the equipment to and from the site shall be done by the Bidder at his own expense. Bidder shall have at the site accredited and qualified engineers and foreman/ supervisors with adequate number of years of experience in execution of similar works and operators of machinery and equipment for satisfactory progress and timely completion of the works.

ii. It shall be ensured by the Bidder that work shall proceed uninterrupted even in the event of power failures. As such, adequate number of diesel operated equipment (such as concrete mixers, vibrators, etc.) shall be provided by the Bidder, as an alternative arrangement, in case, electrically operated equipment are proposed to be brought to site.

iii. All materials supplied by the Bidder shall be of the best quality and shall conform to this specification. Approval in writing shall be obtained from Engineer, before any alternative or equivalent material is proposed to be used by the Bidder.
iv. Bidder shall furnish Manufacturer's test certificate for the materials supplied by him. Where such certificates are not available, and where the Engineer so desires the specimen from the materials supplied to site shall be got tested at a recognized and approved testing laboratory at Bidder's cost.
v. Climbing or slip-forms shall be controlled by linked hydraulically operated jacks that are reversible, driven by an electrically operated pump and with provision for manual operation in the event of a break down.
vi. For slip-form operation two level platforms shall be provided on the inner as well as outer side. All safety requirements shall be met by provision of handrails, lighting etc. Safety nets shall also be provided below the platforms.
vii. Whenever defects in concrete is noticed after any particular left, work shall be stopped and non-destructive testing shall be carried out to verify the strength and soundness of concrete. Reputed agencies as approved by the Engineer shall be entrusted with the work. Additional destructive tests on concrete cores taken from the affected areas shall also be carried out, if found necessary. All costs towards these tests shall be borne by the Bidder.
viii. One hoist for passengers/supervisory staff and one for transport of goods shall be provided by the Bidder. These hoists shall be operational not later than the time when construction first reaches 30 m and should be available throughout the construction period. Access between various working levels shall be provided by an approved system of ladders. Under no circumstances shall staging or scaffolding be relied upon to provide such access.

B. **Physical Checks**

Some of the mandatory physical checks which shall be carried out by the Bidder are as under:

i. The twist or rotation of the slip-form every 15 minutes.
ii. Level of top of jacks every thirty minutes.
iii. Verticality with the help of lasers atleast once in 4 hours.
iv. Inside and outside diameters/dimensions and wall thickness, once in each shift of 8 hours.
v. Level of top of form panels once initially and subsequently after each shift.
vi. Level of working platforms once initially and subsequently after each interruption.
vii. Batter of the form panels and yoke legs once on erection and subsequently after each interruption.
viii. Condition of jack rods for ovality, indentation, buckling, moving out of alignment, etc., before fixing each rod.
ix. Bracing of jack rods passing through openings.
x. Live load on working deck to avoid accidental overloads.
xi. Workability of concrete at mixer and at point of placement, once an hour.
xii. Temperature of concrete, once in 4 hours.

11.0.0 DISMANTLING AND DEMOLITION

The work envisaged under this sub-head is for dismantling and demolition of brick masonry in cement/lime mortar, reinforced cement concrete works, removing wooden chowkhats of doors, wooden or steel windows. Blasting is not allowed in the plant area. Retrieved materials, if any shall be handed over to Owner’s store at NCTPS.

A. **General:**

The term Dismantling implies carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of the building as specified or shown on the drawings.

The term Demolition implies taking up or down or breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or shown on drawings.

B. **Precautions:**

Necessary propping, shoring and/or underpinning shall be provided for the safety of the adjoining work or property, which is to be left intact, before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property, Wherever required, temporary enclosures or partitions shall also be provided. Necessary precautions shall be taken to keep the dust- nuisance down as and when necessary.

Dismantling shall be commenced in a systematic manner. The dismantled articles shall be passed by hand/equipment/crane where necessary and lowered to the ground and not thrown. The materials shall then be properly stacked as directed by the Engineer-in-charge.

All materials obtained from dismantling or demolition shall be the property of the Owner unless otherwise specified and shall be kept in safe custody until handed over to the Engineer-in-charge. Any serviceable material, obtained during dismantling or demolition shall be separated out and stacked properly as indicated by the Engineer-in-charge/Owner or as specified in the item. All under- serviceable materials, rubbish etc. shall be disposed off as directed by the Owner/Engineer-in- charge.

C. **Treatment:**

All the dismantled area shall be rendered clean off all debris, dust etc.

VOLUME – II

SUB-SECTION – 5.2

SPECIFICATION FOR CHIMNEY LINING

A. BOROSILICATE GLASS BLOCK LINING OF FLUE CAN

1.0.0 GENERAL PROJECT INFORMATION

1.1.0 INTRODUCTION

This specification covers the technical details of the borosilicate glass flake lining for chimney with respect to its preliminary check requirements, surface preparations, coating applications & atmospheric condition requirements.

Tamil Nadu Generation and Distribution Co Ltd (TANGEDCO) is setting up the 1 x 800 MW North Chennai Thermal Power Project Stage III. One Concrete Chimney with single flue steel can of height 275 m is under construction. In order to comply with the MOEF norms for flue gas emission, a Flue gas desulphurization plant (Wet FGD) is proposed to be installed. Hence TANGEDCO is proposing to carry out Borosilicate Glass Block Lining or 2 mm thick Titanium (Grade 2 as per ASME B265) or 2 mm thick C-276 alloy of inner surface of flue can of the single flue chimney as protection from wet flue gas. The EPC contractor upon finalsaition of order shall take up the Chimney lining as a first priority and it shall be completed in 6 months.

1.2.0 INTENT OF SPECIFICATION

The intent of this technical specification is to provide a complete Chimney Lining system to protect the flue cans from wet flue gas of Flue gas desulphurization system.

The bidder shall study the specification and satisfy himself thoroughly regarding the workability and suitability of the equipment and system offered by him. He shall take full responsibility for guaranteed and satisfactory operation of the system as regards its performance and smooth and reliable working of supplied equipments

All work to be carried out as per the above guidelines shall be read in conjunction with the drawings and annexure. The bidder shall be responsible for providing all material, equipment and services, which are required to complete the project and fulfill the objective of safe and trouble free operability, maintainability and the reliability of the complete work covered under this specification.

The bidder shall fulfill all the features of their work as per the relevant codes and standards and adhere to all the local regulations, as applicable. Design, manufacture, supply, construction, erection, and commissioning will be as per the state of the art technology and satisfy all the statutory and mandatory laws and regulations to its fullest extent.

2.0.0 SCOPE OF WORK

2.1.0 The Scope of work for providing Borosilicate Glass Block Lining of the steel flue can , in the single flue chimney includes the following.

The flue shall be internally protected with a lining system consisting of borosilicate glass blocks of 51mm thick, applied with a flexible, chemically resistant adhesive membrane applied over epoxy primer and the scope of works also include modifications required if any on flue to accommodate expansion joints, providing additional support structures, lining in the inspection door area, soot hopper area. All the items, though not specifically mentioned but

needed to make the system complete and for reliable performance and safe working, shall also be included, unless otherwise specifically excluded elsewhere.

i) Complete engineering, procurement and installation of Borosilicate Glass Block Internal Lining

ii) Wet Stack design study

iii) Supervision of complete installation by the OEM's QA Inspector to perform comprehensive QA program for the requirements of this project

iv) Submission of comprehensive QA documentation after the completion of the lining process in the flue can

2.2.0 The bidder shall be responsible for the quality of the material, manufacturing, transport, storage, handling, erection and documentation.

2.3.0 The bidder shall also provide all required equipment and services which may not be specifically stated herein but are required to meet the intent of ensuring completeness, operability, maintainability and reliability of the total work covered under this specification within his quoted price.

2.4.0 The successful bidder shall be responsible for providing qualified personnel to collect the required data from Purchaser by way of hard copy, drawings, soft copy etc.

2.5.0 The bidder shall be responsible for bringing the required tools, tackles, machines, erection spares to make up for the damages during execution etc for completing the scope of the work as per this specification.

2.6.0 It may be noted that the requirements, conditions, annexures, appendices etc. stated in Technical Specification shall be read together in conjunction with the volumes Vol-I & Vol-II while interpreting the specification.

2.7.0 In the event of conflict between requirements of any two clauses of specification documents, the more stringent requirements shall apply unless otherwise confirmed by the Purchaser in writing before the award of this contract, based on a written request from the Bidder for such clarification.

2.8.0 In case Bidder is getting qualified through an Associate as per Volume-IA of this Tender Specification the work division between Bidder and the Associate shall be as per the Deed of Joint Undertaking (DJU) as stipulated in the above-referred clauses.

3.0.0 SCOPE OF SUPPLY

3.1.0 The bidder or his Associate shall design, manufacture and furnish equipment / system including but not limited to the following.

a) Borosilicate Glass Block Internal lining material on the flue can made of ''COR-TEN-B'' Steel for the entire height.

i) Borosilicate Cellular Glass Block, 51 mm thick, as required
ii) Epoxy Primer
iii) Adhesive membrane

b) Modifications to Flue can equipment's

i) Acid resistant material like Elastomeric for the Expansion bellow
ii) Acid resistant material like Hastalloy for Flue gas Sample points / sampling ports

iii) Acid resistant material or borosilicate glass block lining for Manhole / access door
iv) Suitable Condensate drain arrangement at the bottom of the flue can

c) Documentation shall, as a minimum, comprise the following.

i) All drawings for the above works and supply
ii) O&M Manual & Instruction Manual
iii) Submission of comprehensive QA documentation after the completion of the lining process in the flue can.

d) All other miscellaneous equipment and accessories required for a complete functional system which meets the intent and requirements of this specification shall also be furnished by the bidder.

4.0.0 TECHNICAL SPECIFICATIONS

4.1.0 Specification of borosilicate blocks

The lining system shall use closed cell borosilicate glass blocks with the following physical properties:

i) A coefficient of linear thermal expansion not greater than 5.5 x 10(¬6)/℃, as per ASTM E228
ii) Compressive strength of at least 1.38 Mpa / 1.1 N/Sq.mm as per ASTM C.165
iii) Flexural strength of at least 0.62 Mpa / 0.8N/Sq.mm as per ASTM C.203/C.240
iv) Thermal conductivity of 0.087 W/m℃K at a mean temperature of 38 ℃ as per ASTM C177 and ASTM C518
v) The block shall be 6 by 9 inches and 2 inches thick

4.2.0 Specification of adhesive membrane

The adhesive membrane shall be a 2-component urethane asphalt mastic having excellent elastomeric properties and be acid & heat resistant. The adhesive membrane shall be applied in between and behind the blocks in a 3 mm thick layer ensuring a proper bond and adhesion. The adhesive membrane shall have the following properties.

i) Tensile strength at 23° C of 1.0 N/mm2 as per ASTM D.412
ii) Elongation at 23° C of 147.0 % as per ASTM D.412
iii) Moisture vapor transmission of 0.0048 Perm inches as per ASTM C.96 Method E
iv) The adhesive shall show no slump after 5 hours conditioned at 60ºC with a film thickness of 3/32" as per ASTM 6511, standard test methods for solvent bearing bituminous compounds, section 12 behavior at 60ºC.

4.3.0 Specification of primer

Primer to be applied on steel substrate receiving borosilicate glass block lining system shall have the following properties including thickness, physical & chemical properties.

i) The primer shall be a high performance epoxy primer. The primer shall be applied in 1 layer with a WFT of 3 to 5 mils
ii) The primer shall be applied either by rolling or spray gun Welds and joints shall receive an additional layer of primer by brush prior to rolling or spraying
iii) The solids by volume of the high performance epoxy primer shall be no less than 50%
iv) The bonding of the primer to the steel shall be at least 1400 psi. as per ASTM D4541

4.4.0 Specification for surface preparation of steel substrate

- The steel surface shall be grit blasted to a cleanliness of SA 2 1/2 and approved by the supplier of the lining system
- The substrate shall thereafter be primed using a high performance epoxy primer within a short time window approved by the supplier

4.5.0 Wet stack properties of the lining system

The lining system (borosilicate glass block and adhesive) shall be tested for its wet stack surface properties by an independent approved institute, subject to acceptance by the Purchaser, and has during such testing been shown to allow, without any significant re-entrainment of flue gas condensate, a flue gas velocity of at least 18.3 m/s.

Bidder shall provide a project specific "Wet Stack" study, performed by an independent approved institute, subject to acceptance by the Purchaser, indicating the correct placement and design of liquid collection gutters and liquid drains to ensure minimization of liquids and condensates entering the chimney.

5.0.0 DETAILS OF CHIMNEY FLUE

5.1.0 Following are the brief details of chimney flue and other associated systems without borosilicate lining.

a)	Maximum inlet flue gas temperature	:	140 Deg. C
b)	Exit Velocity in flue	:	25 to 30 m/s
c)	Number of Wind Shields	:	1 No. made of concrete
d)	Number of Steel flue	:	1 No.
e)	Height of steel flue from Finished Floor Level (FFL)	:	275.00 m
f)	Material of Construction	:	Top 14.40 meters is made of stainless steel, remaining is made of Corten steel
g)	No. of Expansion Joints per flue	:	5 Nos. at different elevations
h)	Intermediate supports per flue	:	6 Nos. at different elevations
i)	Manhole/Access doors per flue	:	6 Nos. at different elevations.
j)	Bottom supports per flue	:	4 Nos. at El. 0. 00 (FFL)
k)	Centre line of Inlet flue gas duct	:	El. + 17.00 m from FFL
l)	Disposal of ash flue bottom ash	:	From soot hopper located below flue can
m)	Interface with SG package contractor flue gas duct	:	Outside the wind shield

5.2.0 The approximate estimated Surface area for Chimney flue and Borosilicate Lining including inlet flue gas duct, transition piece for flue duct, soot hopper etc. is furnished below. However, the surface area required for chimney lining shall be calculated by the bidder from the drawings furnished along with this tender and the lining shall be provided accordingly.

- Surface Area for one flue – 10,300 m2 { indicative minimum}

6.0.0 INSTALLATION OF BOROSILICATE BLOCK LINING SYSTEM

6.1.0 Surface Preparation & Surface Cleaning

The bidder shall carry out the following as a minimum to prepare the steel flue surface for the lining.

- Sandblasting of flue for surface preparation. Near-white metal blast finish shall be provided by the bidder for preparing the steel surfaces to receive the lining.
- All surfaces must be free from dust, dirt, and grease. Any foreign material which will interfere with adhesion must be removed.
- All weld spatter slag and old anchor welds shall be removed from the substrate, and the area ground flush with the parent metal.
- All edges and fillets and similar abrupt contours shall be rounded off smoothly.

6.2.0 Mixing of Adhesive Membrane

- The Adhesive membrane shall be mixed according to the direction for the product use in the correct mixing ratio.
- The temperature for mixing the main material and hardener shall be about 24 degC.
- Appropriate mixing method shall be used for equal mixing and should be blended for the required appropriate time.
- Sufficient time shall be allowed for curing

6.3.0 Mixing machine

Mixing machine shall be used for preparing the 2 component Adhesive Membrane on site.

- In order to ensure consistent, high quality mixing of the components of the lining system adhesive, (an) automated mixing machine(s) should be provided using a 3,200W mixer motor, with fail-safe protection against the operator error of mixing the main adhesive component without its hardener.
- The mixing machine must be CE – approved.
- The mixing machine shall have thermal motor protection to minimize failure and fire risk.
- Adequate number of mixing machines shall be employed for completion of the installation works for the two units within the scheduled time.

6.4.0 Mixing of Epoxy Primer

- Epoxy Primer shall be mixed according to the direction for the product use
- Mixing ratio shall be as recommended by OEM
- Epoxy Primer shall be blended by using Mechanical Mixer for the required minimum time.

6.5.0 Installation of Borosilicate Block

- The Adhesive membrane shall be applied as per the instructions of OEM.
- Arrange the borosilicate glass blocks such that there is no black space between the block and surface. The adhesive should fill the side joint and flow out to the edge. The block shall completely stick to adhesive applied on the surface.
- Block whose edge is broken shall not be used.
- All the equipments and tools required to install Borosilicate Glass Block lining system including Polyethylene film, Rag, Wire brush, Plastic sink, Electric drill, Jiffy Mixer Blade, Insulated saw, Float, Paint brush, hand cleaner, Cleansing glove, Hygrometer, Surface thermometer, white chalk, white spray etc as required shall be arranged by the bidder.

6.6.0 Inspection

- Inspection and testing including adhesion shall be as per approved QAP.
- The mixing, curing and adhesion characteristics of the adhesive membrane shall be evaluated by applying it onto a test area of the same material and surface preparation of the substrate. Work life and initial set time may be visually observed. Cure shall be uniform.
- The installation procedure of the lining system shall be verified by installing the system on a transparent panel. Visual inspection shall be made of back, end and side joints.

6.7.0 Heat cycling resistance

- The lining system shall, through documented testing, have been proven resistant to thermal shock, for a minimum of 1000 cycles, where each cycle results in the lining surface temperature to rise from ambient temperature to 180 ℃, and back to ambient temperature.
- The lining system shall also withstand occasional excursion of flue gas temperature of more than 200℃.

6.8.0 On site supervision and QA/QC services

- The lining system (borosilicate glass block and adhesive) supplier shall provide on-site technical support and QA/QC supervision, and shall employ QA/QC supervisors with a demonstrated experience of at least 5 years in technical support and QA/QC supervision of the subject lining system.

6.9.0 Performance, safety and fire risk

- The lining system (borosilicate glass block and adhesive) shall be tested and certified for fire risk by an approved institute subject to acceptance by the Purchaser, and through testing as per relevant ASTM standards.

7.0.0 MODIFICATIONS REQUIRED IN THE FLUE (UNDER CONSTRUCTION)

7.1.0 Sample Point

- Borosilicate block primer and high nickel steel bar will be applied to sample points to make it acid resistant.
- The nozzle (Pipe tube) shall be of suitable alloy steel to withstand design operating environment.
- Nozzle shall be fully seal-welded both inside and outside of the steel duct plate. The inside weld shall be ground smooth.
- The nozzle shall be flanged and not threaded.
- The Glass Blocks shall be Cut and shaped as required to fit. The block shall be fully bonded to the exterior surface of the nozzle with adhesive membrane.
- The bidder shall coordinate with the BOP package contractor in order to ensure that the sample point is matching with the requirements for installing the flue gas analyser probes/equipments.

7.2.0 Manhole and Access doors

- Manholes/Access doors shall be modified by application of borosilicate blocks.
- High nickel alloy stop bars of 2mm thickness for protection from acidic condensate.
- Fibre gaskets shall be used for sealing.

7.3.0 Collection gutter

- The condensate generated in flue gas while FGD is under operation, shall be collected and discharged from bottom of the flue can.
- The material of gutter including drain and base plates shall be made of suitable alloy steel to withstand design operating environment.
- All welds shall be full seal welds.
- The surfaces of the alloy materials which will be in contact with the lining system shall be blasted and primed with Epoxy Primer.
- The Glass Blocks shall be fully bonded to the alloy steel.

7.4.0 Soot Hopper

- Acid proof brick lining in soot hopper is not be required and instead borosilicate lining shall be provided resistant to acids.

7.5.0 Puddle Flange

- Puddle flange located at the bottom of soot hopper shall be lined with High nickel alloy material for protection from acidic ash.

7.6.0 Expansion Joints

- Expansion joints cannot withstand the acidic flue gas during FGD operation and hence shall be replaced by acid resistant elastomeric fabric bellows.

8.0.0 BATTERY LIMITS

Following are the battery limits. a) Chimney Flue: Entire system from inlet flue gas duct to flue top. b) Inlet flue gas duct: 1 meter from the shell outer surface. c) Soot Hopper: Entire system up to puddle flange.

9.0.0 EXCLUSIONS

Following are the exclusions from the scope of the bidder.

a) Disposal of condensate from soot hopper to condensate collection pit
b) Pumps and piping system for condensate disposal from condensate Collection pit to ETP.

10.0.0 CHIMNEY DRAWINGS

The following drawings of the chimney are enclosed along with this tender specification.

Sl.No.	Drawing Number	Drawing description
1	GID-244-CV-UHN-RC-30201	275 M High RC Chimney- General Arrangement

11.0.0 WARRANTY

Ten (10) year warranty for the Borosilicate glass Block Lining System of the chimney flue shall be provided. Under this warranty, the bidder shall repair or replace the lining system {Both application and material} at his own cost, if the lining system should fail to protect the chimney flue from internal deterioration.

12.0.0 TIME SCHEDULE

The completion time of the Package shall be 12 months from the date of LOA.

B. TITANIUM OR C-276 ALLOY LINING OF FLUE CAN

The chimney flue liner cladding to be made of 2 mm thick Titanium (Grade 2 as per ASME B265) or C-276 alloy.

Installation shall be as per applicable standards

Tamil Nadu Generation and Distribution Corporation Ltd.

Flue Gas Desulphurisation System & Auxiliaries for North Chennai TPP-Stage-III - 1x800 MW Supercritical Thermal Power Station Project

TENDER ENQUIRY DOCUMENT
FOR
EPC CONTRACT

[TENDER SPECIFICATION No. SE/E/PROJ-II/OT.NO.2/2018-2019]

VOLUME II

SECTION 6

TENDER DRAWINGS

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India

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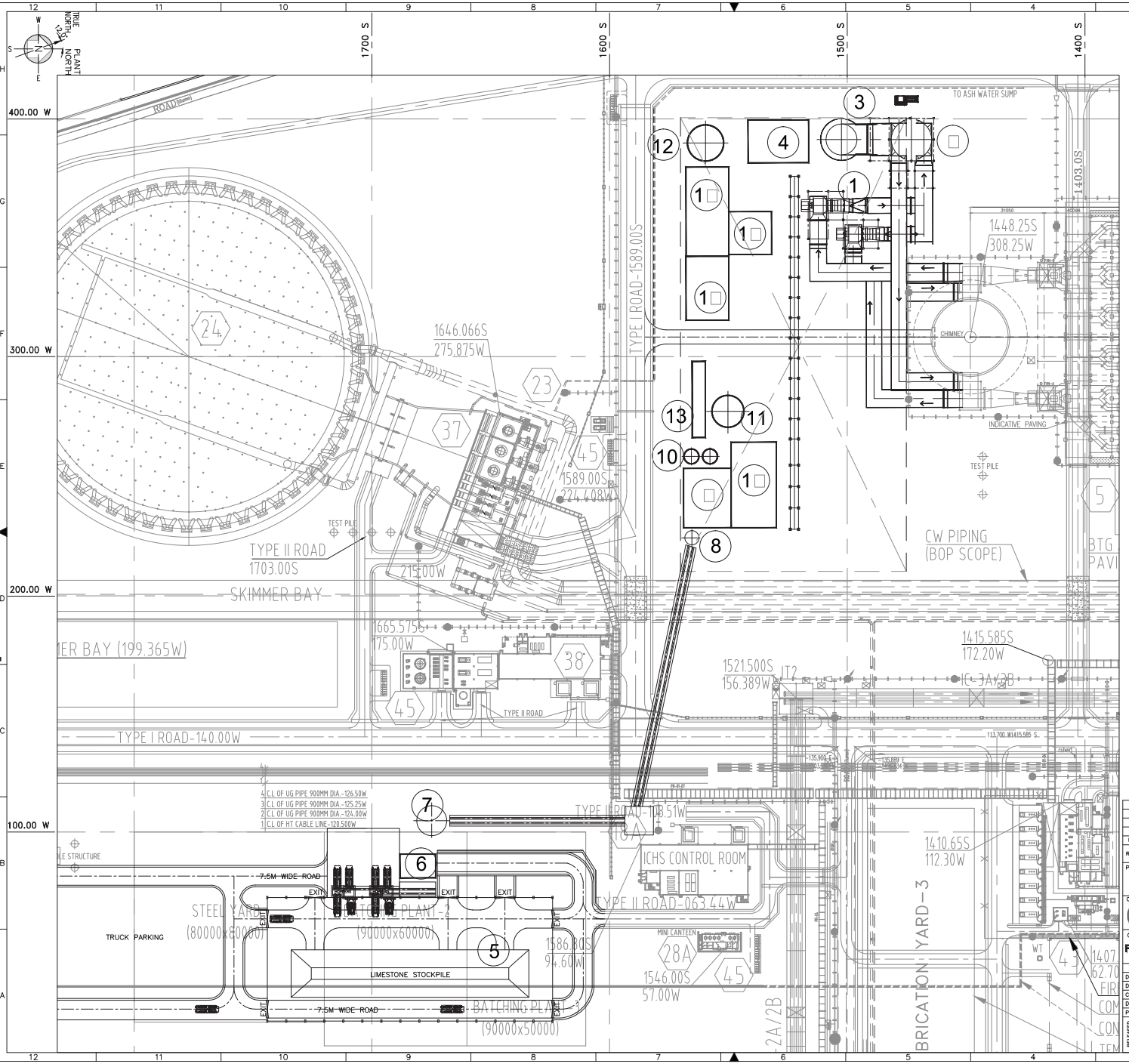
SECTION – 6

TENDER DRAWINGS

The following list of drawings/ documents are enclosed with the specification.

Sl. No.	Drawing No.	Rev.	Drawing Title
A	**MECHANICAL**		
1	FCE-1116127-GE-DWG-LAY-3000-001	R0	General Layout – FGD Area
2	FCE-1116127-GE-DWG-LAY-3000-002	R0	Terminal Point
3	FCE-1116127-ME-DWG-PFD-3000-001	R0	Flow Diagram for Lime Stone Handling System
4	FCE-1116127-ME-DWG-PFD-3000-002	R0	Flow Diagram for Limestone Unloading and Slurry Preparation System
5	FCE-1116127-ME-DWG-PFD-3000-003	R0	Flow Diagram for Desulphurisation System
6	FCE-1116127-ME-DWG-PFD-3000-004	R0	Flow Diagram for Process Water Distribution System
7	FCE-1116127-ME-DWG-PFD-3000-005	R0	Flow Diagram for Gypsum Recovery System
8	FCE-1116127-ME-DWG-PFD-3000-006	R0	Flow Diagram for Gypsum Handling System
9	FCE-1116127-ME-DWG-PFD-3000-007	R0	Flow Diagram for Compressed Air System
10	FCE-1116127-ME-DWG-PFD-3000-008	R0	Flow Diagram for Equipment Cooling Water system
11	FCE-1116127-ME-DWG-PFD-3000-009	R0	Flow Diagram for Waste Water Treatment system
12	FCE-1116127-ME-DWG-PFD-3000-010	R0	Flow Diagram for Potable water distribution system
13	FCE-1116127-ME-DWG-PFD-3000-011	R0	Flow Diagram for Service Water distribution system
B	**ELECTRICAL**		
1	FCE-1116127-EL-DWG-2800-001	R0	Single Line Diagram
2	FCE-1116127-EL-DWG-3800-002	R0	Schematic Diagram for UPS System

Sl. No.	Drawing No.	Rev.	Drawing Title
C	**CONTROL & INSTRUMENTATION**		
1	ANNEXURE-1	R0	Flue Gas Desulphurization PLC System Configuration
2	ANNEXURE-2	R0	Typical Wiring arrangement in Junction Box
3	ANNEXURE-3	R0	GA for Operator Work Station Table
4	ANNEXURE-4	R0	GA for Printer Table
5	ANNEXURE-5	R0	GA for Local Instrument Enclosure
6	ANNEXURE-6	R0	GA for Local Instrument Rack
7	ANNEXURE-7	R0	Typical Instrument Hookup Diagram
8	ANNEXURE-8	-	Drive Control Philosophy



NOTES:–

1. ALL ELEVATION ARE REFERRED TO THE TOP OF FINISHED FLOOR LEVEL OF ELECTRICAL BUILDING AS EL.(±)0.00M, WHICH CORRESPONDS TO RL.(+)10.0 M
2. THE LAYOUT SHOWN HERE IS INDICATIVE ONLY. BIDDER TO OPTIMISE THE LAYOUT BASED ON THEIR STANDARD PRACTICE AND ACCOMMODATE IN THE EARMARKED SPACE.
3. BATCHING PLANT SHALL BE REMOVED BY BOP CONTRACTOR.

Sl. No.	DESCRIPTION	REMARKS
1	BOOSTER FAN	
2	GAS TO GAS HEAT EXCHANGER	
3	ABSORBER	
4	SLURRY RECIRCULATION PUMP AND OXIDATION AIR BLOWER HOUSE	
5	LIMESTONE UNLOADING SHED	
6	LIMESTONE CRUSHER HOUSE	
7	BULK LIMESTONE SILO	
8	DAY LIMESTONE SILO	
9	LIMESTONE SLURRY PREPARATION BUILDING	
10	LIMESTONE SLURRY TANK	
11	PROCESS WATER TANK	
12	EMERGENCY SLURRY TANK	
13	PROCESS WATER PUMPS HOUSE/ AIR COMPRESSOR	
14	WASTE WATER BUILDING	
15	GYPSUM DEWATER BUILDING	
16	GYPSUM STORAGE SHED	
17	ELECTRICAL & CONTROL BUILDING	

FOR TENDER PURPOSE ONLY

REV.	DATE	DESCRIPTION	DRN.	STR.	MECH.	ELEC.	INST.
R0	28.02.19	FOR TENDER PURPOSE	MV		VS		
				APPROVED BY			

PROJECT :

FGD FOR 1 x 800MW NORTH CHENNAI TPP STAGE -III

OWNER :

TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED
CHENNAI-600 002, TAMILNADU, INDIA

OWNER'S ENGINEER

FICHTNER INDIA

FICHTNER C□□□□□□E□□□□r□l□d□□
Pr□□□ L□ □d
Chennai

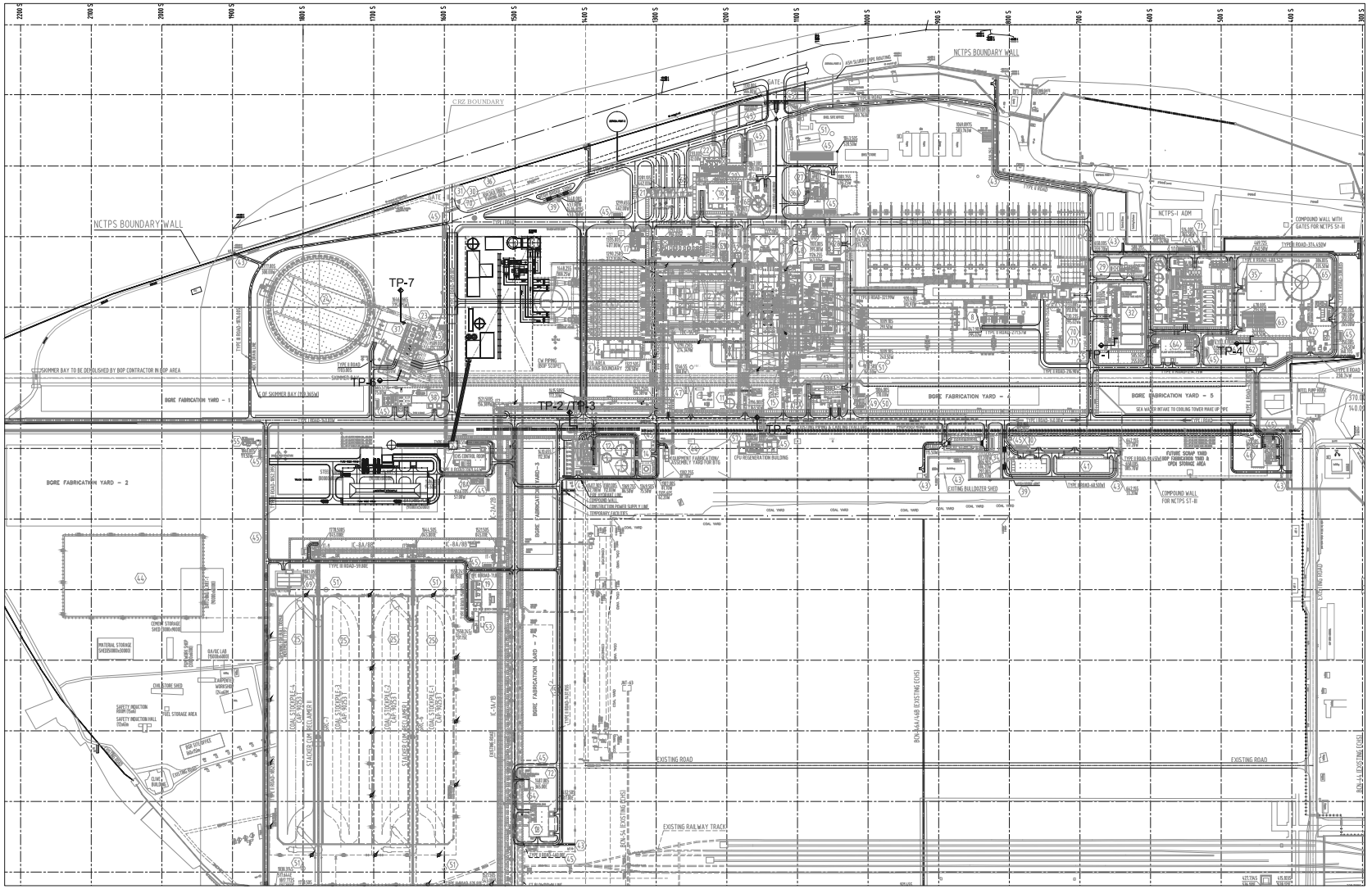
	SIGNATURE	DATE
DRAWN	BASS	10.05.17
DESIGNED	PS	10.05.17
CHECKED	VR	10.05.17
DEPT.HEAD	VS	10.05.17
PROJ.MGR.	SSR	10.05.17

GENERAL LAYOUT
FGD AREA

RELEASED FOR		
	PRELIMINARY	
	TENDER	✓
	ENGINEERING	
	CONSTRUCTION	

DEPT. MECH | JOB NO. 1116127 | SCALE: 1:750 | REV.

DWG.NO. FCE-1116127-GE-DWG-LAY-3000-001 R0



NOTES:-

1. ALL ELEVATION ARE REFERRED TO THE TOP OF FINISHED FLOOR LEVEL OF ELECTRICAL BUILDING AS EL.(±)0.00M, WHICH CORRESPONDS TO RL.(+)10.0 M
2. THE LAYOUT SHOWN HERE IS INDICATIVE ONLY. BIDDER TO OPTIMISE THE LAYOUT BASED ON THEIR STANDARD PRACTICE AND ACCOMMODATE IN THE EARMARKED SPACE.

TERMINAL POIT LIST:

TP SNo.	DESCRIPTION	NORTH/SOUTH	EAST/WEST	REMARKS
TP–1	SERVICE WATER	S 648.595M	W 256.085M	
TP–2	POTABLE WATER	S 1412.303M	W 130.700M	
TP–3	AUX. STEAM	S 1412.303M	W 129.900M	
TP–4	WASTE WATER	S 420.000M	W 248.500M	
TP–5	DM WATER	S 1153.500M	W 125.181M	
TP–6	ACW WATER SUPPLY	S 1661.582M	W 209.615M	
TP–7	ACW WATER RETURN	S 1657.438M	W 275.290M	
TP–8	FIRE WATER	–	–	NEAR BY HEADER

FOR TENDER PURPOSE ONLY

REV.	DATE	DESCRIPTION	DRN.	STR.	MECH.	ELEC.	INST.
				APPROVED BY			
R0	28.02.19	FOR TENDER PURPOSE ONLY	MV	VS			

PROJECT :

FGD FOR 1 x 800MW NORTH CHENNAI TPP STAGE -III

OWNER :

TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED
CHENNAI- 00 00 , TAMILNADU, INDIA

OWNER'S ENGINEER

FICHTNER INDIA

FICHTNER C[illegible] E[illegible] Pr[illegible] L[illegible]d
Chennai

	SIGNATURE	DATE
DRAWN	BASS	10.05.17
DESIGNED	PS	10.05.17
CHECKED	VR	10.05.17
DEPT.HEAD	VS	10.05.17
PROJ.MGR.	SSR	10.05.17

GENERAL LAYOUT FOR FGD TERMINAL POINT

ISSUED FOR		
	PRELIMINARY	
	TENDER	✓
	ENGINEERING	
	CONSTRUCTION	

DEPT. MECH | JOB NO. 1116127 | SCALE: 1:2000 | REV.

DWG.NO. **PCE-1116127-GE-DWG-LAY-3000-002** R0

SIZE–A0

Tamil Nadu Generation and Distribution Corporation Ltd.

Flue Gas Desulphurisation System & Auxiliaries for North Chennai TPP-Stage-III - 1x800 MW Supercritical Thermal Power Station Project

TENDER ENQUIRY DOCUMENT
FOR
EPC CONTRACT

[TENDER SPECIFICATION No. SE/E/PROJ-II/OT.NO.2/2018-2019]

VOLUME II

SECTION 7

SCHEDULES

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India

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SCHEDULE - 1

FUNCTIONAL GUARANTEES - FGD

A. Category- I : Performance Guarantees [Acceptable short fall limit with penalty]

The Performance Guarantees which attract Liquidated Damages are as follows:

Sl. No.	Particular	Value inclusive of design, manufacture and all other Toleranc es	Acceptable Shortfall limit with Penalty	Applicable Test Codes
1.0	a. SO_2 removal efficiency to meet the stack outlet SO_2 level of <100 mg/Nm^3 @ 6% O_2 on dry basis at 100% TMCR load		(-)0.25% point from the guaranteed SO2 removal efficiency.	PTC 40 (1991)
2.0	Limestone consumption of the FGD unit at 100% TMCR condition on firing worst coal. The value shall be provided for the following cases: a. Design / performance coal b. Best coal c. Worst coal	.....TPH .....TPH .....TPH	(+) 10% points from the guaranteed values.	
3.0	Total Auxiliary power consumption (as per Schedule 2) for the FGD unit at 100% TMCR condition on firing worst coal, for the FGD unit with auxiliary facilities. The value shall be provided for the following cases: a. Design / performance coal b. Best coal c. Worst coal	.....kW .....kW .....kW	(+) 5% from the guaranteed auxiliary power consumption	

B Guarantees under Category- II

SO2 removal in treated flue gas: Maximum concentration of SO2 in treated flue gas at the exit of FGD for the unit shall not exceed the guaranteed values.

C. Guarantees Under Category-III

The parameters/capabilities shall be demonstrated for various systems/ equipment shall include but not limited to the following:- (Refer Volume I for the Parameters Under these categories and Guaranteed values shall be indicated in the below table by the Bidder).

Sl. No.	Particular	Value inclusive of design, manufacture and all other Tolerances	Acceptable Shortfall limit	Applicable Test Codes
1.	Minimum SO2 removal efficiency of scrubber corresponding to the design conditions of the FGD plant			
2.	Mist Outlet Droplet Content			
3.	Maximum pressure drop of flue gas across the FGD system, corresponding to the guarantee conditions of the FGD plant, mmwc (g)			
4.	Permissible range of plant load variation for design SO2 removal efficiency of the FGD plant (MW or % of unit MCR)			
5.	Permissible maximum SO2 concentration in the inlet flue gas for design SO2 removal efficiency of the FGD plant, mg/Nm3.			
6.	SO2 removal efficiency with one spray level out of service corresponding to guarantee conditions of FGD plant*(for multi spray tower systems)			
7.	Gypsum purity.			
8.	Noise			
9.	Wet ball Mill capacity at rated fineness	Bidder to provide.		
10.	Wet ball Mill wear parts guarantee	Bidder to provide.		
11.	Wet ball Mill ball consumption	Bidder to provide.		
12.	Vacuum Belt Filter Capacity	Bidder to provide.		

Sl. No.	Particular	Value inclusive of design, manufacture and all other Tolerances	Acceptable Shortfall limit	Applicable Test Codes
13.	Waste water from FGD	Bidder to provide.		
14.	Performance characteristics of booster fans (capacity, head developed, etc.).	Bidder to provide.		
15.	Margin in Booster fans	Bidder to provide.		
16.	GGH Leakage	Bidder to provide.		
17.	Passenger cum Goods Elevator for FGD absorber & Limestone Grinding Building:	Bidder to provide.		
18.	Availability of FGD plant	Bidder to provide.		
19.	Air Conditioning system	Bidder to provide		
20.	Ventilation system	Bidder to provide		
21.	Equipment Cooling Water System	Bidder to provide		
22.	Particulate matter in flue gas			
23.	Capacity of limestone handling system and Gypsum Handling System	Bidder to provide		
24.	Make-up water for FGD	Bidder to provide		
25.	Equipment Vibration	Bidder to provide		

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 2

GUARANTEED AUXILIARY POWER CONSUMPTION - FGD

Complete list of auxiliary power consumption at input to motor including design, manufacture and all other tolerances shall be guaranteed by the Contractor as given below:

SCHEDULE OF AUXILIARY POWER CONSUMPTION

Sl. No.	Particulars	Total number provided (Working + Standby) for each unit	Power consumption for each motor / equipment at 100 % TMCR condition	Total Power consumption in kW at 100% TMCR condition for each unit	Total Power consumption in kW at 100% TMCR condition for The FGD and auxiliaries
(1)	(2)	(3)	(4)	(5)	(6)
1.0	**Total auxiliary power consumption of the following HT and LT drives for the FGD Plant at 100 % TMCR while firing worst coal**				
a)	Flue gas booster fans including its lube oil pumps.				
b)	Limestone mills including its lube oil pumps.				
c)	Gas to Gas Heater				
i)	Power Consumption for Main drive				
ii)	Power Consumption for Sealing, Purge, Heaters, Cleaning system etc				
iii)	Total Power consumption				
d)	Slurry re-circulation pumps				
e)	Oxidation Compressors/blowers				
f)	Absorber oxidation tank agitator.				
g)	Gypsum Bleed Pumps				
h)	Vacuum Belt Filter, Vacuum Pump and its integral auxiliaries				
i)	Void				
j)	Limestone bucket elevator				
k)	Gypsum bucket elevator				

Sl. No.	Particulars	Total number provided (Working + Standby) for each unit	Power consumption for each motor / equipment at 100 % TMCR condition	Total Power consumption in kW at 100% TMCR condition for each unit	Total Power consumption in kW at 100% TMCR condition for The FGD and auxiliaries
(1)	(2)	(3)	(4)	(5)	(6)
I)	Any Other Items (Bidder to list any other continuously running equipment) 1 2 3				
	Grand total value (Sum of Items for 1.0 above)	-	-		

1 Bidders to note that the grand total value as above will be considered for evaluation, Performance Guarantees and levy of Liquidated Damages (L.D).

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 3

TECHNICAL DATA SHEET

(TO BE FILLED IN BY BIDDER))

MECHANICAL

Sr.No	Description	Units	Data
A.	**WET FGD**:		
	Flue gas Parameters at FGD inlet		
	Flue gas flow rate	TPH.	
	Flue gas temperature (including temperature rise in ID fan & Booster fan)	°C	
	Baseline SO_2 value	mg/Nm^3	
	Dust Load	mg/Nm^3	
	FGD Equipment Design Data		
	1. Booster Fan		
	- Numbers	Nos.	
	- Capacity	m^3/s	
	- Total developed Head	mmWC	
	- Power consumption	kW	
	2. Absorber		
	- Type		
	- Numbers		
	- Material of Construction		
	- Absorber efficiency	%	
	- Absorber gas velocity	m/s	
	- Absorber diameter & height	M	
	- Reagent flow	TPH	
	- L/G ratio	L / Nm^3	
	1. **Limestone Crusher**		
	- Type		
	- Numbers		
	- Material of Construction		
	- Output		
	- Capacity		
	4. Lime Stone Mill		
	- Type		

Sr.No	Description	Units	Data
	- Numbers		
	5. Slurry Recirculation Pumps		
	- Type		
	- Numbers	Nos.	
	- Capacity of each pump	TPH	
	6. Limestone Data		
	- Lime Stone purity	%	
	- Lime Stone consumption for the FGD system	TPH	
	7. FGD Make Up water Data		
	- Make up water quality		
	- Make up water for the FGD system	TPH	
	8. FGD system Auxiliary power consumption		
	- Auxiliary power consumption for the FGD	kW	
	9. Other Utilities		
	- Steam requirement	TPH	Indicate the pressure and temperature requirement
	- Service water / Potable water	m^3/s	Indicate the pressure requirement
	- Instrument air / Service air	m^3/s	Indicate the pressure requirement
B.	**Duct Sizing**		
1.	Normal Gas flow Rate through Duct	m3/hr	
2.	Maximum Gas Flow rate through the duct	m3/hr	
3.	Inlet Gas Temperature	°C	
4.	Inlet Gas Pressure	mmwc	
5.	Duct size (L X B)	m	
6.	MOC of the Flue gas Duct		
8.	Type of Dampers		
9.	Type of Dampers		
10.	MOC of the Dampers		
11.	Velocity of the Gas in the Duct	m/s	
12.	Sealing Air		
13.	Sealing Air fans		
14.	Quantity of Seal air fans	Nos	
15.	Capacity	Nm3/hr	
16.	Head	mmwc	

Sr.No	Description	Units	Data
17.	BKW	KW	
18.	Motor Rating	KW	
19.	Range of Operation	%	
C.	**GGH**		
1.	Type		
2.	Number		
3.	Mounting (Horizontal / Vertical)		
4.	Rotational speed	rpm	
5.	Maximum handling capacity	Nm3/h	
6.	Flue gas temperature		
	Untreated flue gas temperature at GGH entrance	^{o}C	
	Untreated flue gas temperature at GGH outlet	^{o}C	
	Treated flue gas temperature at GGH entrance	^{o}C	
	Treated flue gas temperature at GGH outlet	^{o}C	
7.	Total effective heating surface		
	Heating surface Material and thickness		
	Heating surface coating thickness		
8.	Pressure drop (untreated / treated)	mmWc	
9.	Leakage loss	%	
10.	Treated gas	Kg/h	
11.	Untreated gas	Kg/h	
12.	Heating element type		
13.	On load cleaning		
	• Type of blower		
	• Pressure of steam	Kg/cm2(g)	
	• Flow	Kg/h	
	• Numbers		
14.	Off load cleaning		
	• Medium		
	• Pressure		
	• Quantity		
15.	GGH fire preventive measure details		
16.	Motor		
	• Emergency motor	kW	

Sr.No	Description	Units	Data
	• Air motor	kW	
D.	**Booster Fans**		
1.	Type of fan		
2.	Type of fan blade		
3.	Blade material and thickness		
4.	Fan critical speed		
5.	Fan component design		
6.	Fan casing material and plate thickness		
7.	Fan housing design pressure		
8.	Mode of Operation		
9.	Quantity	Nos	
10.	Capacity	Nm3/hr	
11.	Head	mmwc	
12.	BKW	KW	
13.	Motor Rating	KW	
14.	Range of Operation	%	
E.	**Scrubber/Absorber**		
1.	MOC of the Scrubber		
2.	Normal Gas flow Rate through scrubber	m3/hr	
3.	Maximum Gas Flow rate through the Scrubber	m3/hr	
4.	Velocity of the Gas in the Scrubber	m/s	
5.	Air Liquid Ratio		
6.	Air Temperature Drop in Scrubber	°C	
7.	Maximum Allowable Temperature across the Scrubber.		
8.	Maximum Time allowed for High Temperature gas to flow through Scrubber		
9.	Pressure Drop across the scrubber	mmwc	
10.	Number of Spray header in Scrubber		
11.	MOC of Spray Header		
12.	Velocity of Liquid in Spray header	m/s	
13.	MOC of Drift Eliminator		
14.	Number of layers Drift Eliminators		
15.	Facility of Mist washing		
16.	MOC of the Slurry tank		

Sr.No	Description	Units	Data
17.	Concentration of Lime in Slurry tank		
18.	pH of Slurry		
19.	Slurry Density		
20.	Provision of Online pH meter, Density meter, Level, Temperature in the Slurry Sump		
21.	Hold up Volume	m3	
22.	Minimum Water Level	m	
23.	Maximum Water Level	m	
24.	Retention Time	Minutes	
25.	Air Injection system		
26.	Number of Agitators in Slurry sump		
27.	Agitator MOC		
F.	**Lime Stone Unloading system**		
1.	Unloading Hopper Capacity		
2.	Vibratory Screens and Feeder		
3.	Bucket Elevator Capacity		
4.	Quantity		
5.	Feed Chute Capacity		
6.	MOC of the Bucket Elevator, Buckets		
7.	Capacity and Size of the Bucket		
8.	Height of lift		
9.	Bucket Spacing		
10.	Chain MOC		
11.	Top Pulley and Bottom Pulley Width		
12.	Discharge Chute		
13.	Dust Proofing/Sealing of Joints		
14.	Type of Gear Box		
15.	Reduction ratio		
16.	Service factor of Gear Box		
17.	Make of Gear Box		
18.	Type of Drive		
19.	Silo for Limestone		
20.	MOC of Silo		
21.	Capacity of Silo		
22.	Number of Days of Storage		

Sr.No	Description	Units	Data	
23.	Limestone Particle size			
24.	Bulk Density			
25.	Size of Silo			
26.	Compatibility for Future Dense Phase Unloading system.	Yes/No		
G.	**Accessories for Silo**		**Bulk storage Silo**	**Day Storage Silo**
1	Target Boxes			
2	Bag type vent filter with fan at the top of storage silo			
3	Pressure relief vent			
4	Unloading spout with all accessories such drive equipments, rotary feeder, and discharge chute with canvass, limit switches, dust suppression unit etc for unloading into conveyors.			
5	Dust conditioning equipment with all accessories such as isolation/shut off gate, drive equipments, rotary feeder, associated water piping, valves etc. to make the system complete in all respects.			
6	Silo level indicator with all accessories.			
7	Ceramic fluidizing pads to fluidize silo.			
8	Fluidizing Blowers			
H.	**Belt Conveyors**			
	General			
1	Type of belt			
2	Capacity (Design)	T/h		
3	Belt Width	mm		
4	Belt Speed	m/s		
5	Ratio of working tension to allowable tension			
6	Pulley			
7	Type			
8	Lagging			
9	Bearing life (minimum)	h		
10	Bearings			
11	Idlers			
12	Carrying idlers			
13	Return idlers			

Sr.No	Description	Units	Data	
14	Impact idlers			
15	Self aligning carrying and return idlers			
16	Bearings			
17	Testing of rollers			
18	Lubrication			
19	Technological structures			
20	Stringers/Short supports			
21	Deck plate			
22	Seal plate			
23	Safety switches			
a)	Pull cord switches			
b)	Belt sway switches			
c)	Zero speed switch			
24	Tensioning arrangement			
25	Accessories			
a)	Size of chutes			
b)	Type and No. of belt cleaners			
c)	Skirt board			
d)	Chute blockage switch			
e)	Cross over			
I.	**Bucket Elevator**		**Bulk Lime handling**	**Crushed Lime handling**
1.	Capacity			
2.	Numbers (W+S)			
3.	Type			
4.	Lifting Height			
5.	Centre Distance between Shafts			
6.	Material of Construction			
7.	Max Conveying speed			
8.	Type of filling (Bucket) - Direct filling / Scooping			
9.	Bucket Volume			
10.	Number of Buckets			
11.	Make			

Sr.No	Description	Units	Data
J.	**Wet Ball Mill**		
1.	Quantity		
2.	Capacity		
3.	Orientation		
4.	MOC of Shell		
5.	Ball MOC		
6.	Drive		
7.	Accessories		
8.	Trunnion Fitted with Trunnion bearing and bearing Housing		
9.	Girth gear, pinion fitted with pinion shaft		
10.	Pedestal and Pedestal bearing with pinion shaft		
11.	Size of balls used		
K.	**Gear Box**		
1	Type		
2	Service Factor		
3.	Reduction ratio		
4.	Motor RPM		
5.	Motor Rating		
6.	Any Auxiliary Motor required		
7.	Details of Aux motor if any		
L.	**Mill Separation Tank**		
1.	Effective Capacity		
2.	Number of tank		
3.	Number of Compartments		
4.	MOC of tank		
M.	**Mill Circuit Pumps**		
1.	Quantity		
2.	Capacity		
3.	Type		
4.	Material of Construction		
5.	Casing/Housing		
6.	Shaft , Rotor and sleeve		
7.	Foundation Bolts & nuts		
8.	Gear Box		

Sr.No	Description	Units	Data
9.	Service Factor		
10.	Motor Rating		
N.	**Lime Slurry Day tank**		
1.	MOC		
2.	Quantity		
3.	Capacity		
4.	Accessories		
a)	Agitator		
b)	Level Measurements		
c)	Inlet, Outlet, Overflow, Drain,		
O.	**Lime Slurry transfer Pumps**		
1.	Quantity		
2.	Capacity		
3.	Material of Construction		
4.	Casing/Housing		
5.	Shaft , Rotor and sleeve		
6.	Foundation Bolts & nuts		
7.	Gear Box		
8.	Service Factor		
9.	Motor Rating		
P.	**Slurry Re-circulation Pumps**		
1.	Quantity per Unit		
2.	Capacity		
3.	Type		
4.	Material of Construction		
a)	Casing		
b)	Shaft , Rotor, sleeve and Wetted Parts		
c)	Gear Box		
5	Service Factor		
	Motor Rating		
Q.	**Slurry Bleed Pumps**		
1.	Quantity per Unit		
2.	Capacity		
3.	Type		
4.	Material of Construction		

Sr.No	Description	Units	Data
a)	Casing		
b)	Shaft , Rotor, sleeve and Wetted Parts		
c)	Gear Box		
d)	Service Factor		
e)	Motor Rating		
R.	**Hydro Cyclones**		
1.	Quantity		
2.	Capacity		
3.	MOC		
4.	Efficiency		
5.	Inlet Flow		
6.	Up flow		
7.	Down flow		
8.	% Solids		
S.	**Vacuum Belt Filter**		
1.	Quantity		
2.	Capacity		
3.	Gypsum Purity		
4.	Moisture Content		
5.	Gypsum generation Rate Guaranteed		
6.	MOC of the Vacuum belt filter		
7.	Rated Vacuum		
T.	**Service Water Pumps**		
1.	Quantity		
2.	Capacity		
3.	Location		
4.	Type		
5.	RPM		
6.	Material of construction		
a)	Casing		
b)	Impeller		
c)	Shaft		
d)	Service Water Piping to FGD Plant from Comprehensive Pump House		
7.	Pipe Routing		

Sr.No	Description	Units	Data
8.	Coating and Wrapping		
9.	Road Crossings		
U.	**Process Water Tank**		
1.	Effective Capacity	m3	
2.	MOC		
3.	Type		
V.	**Emergency Water Tank**		
1.	Effective Capacity	m3	
2.	MOC		
3.	Type		
W.	**Process Water Transfer Pumps**		
1.	Quantity		
2.	Capacity		
3.	Type		
4.	RPM		
5.	Material of construction		
a)	Casing		
b)	Impeller		
c)	Shaft		
d)	Wetted Parts		
X.	**Mist Eliminator Washing Pumps**		
1.	Quantity		
2.	Capacity		
3.	Type		
4.	RPM		
5.	Material of Construction		
a)	Casing		
b)	Impeller		
c)	Shaft		
d)	Wetted Parts		
Y.	**Effluent Water Pumps**		
1.	Quantity		
2.	Capacity		
3.	Location		
4.	Type		

Sr.No	Description	Units	Data
5.	RPM		
6.	Material of construction		
a)	Casing		
b)	Impeller		
c)	Shaft		
d)	Wetted Parts		
Z.	Effluent Piping from FGD Plant to Bottom ash slurry sump		
1.	Pipe Routing		
2.	Coating and Wrapping		
3.	Road Crossings		
AA.	**Run off Pit**		
1.	Service		
2.	Capacity		
3.	Sump Pumps		
4.	Quantity per sump		
5.	Type		
6.	MOC		
BB.	Piping with in FGD area (make up/ Service/ Potable/ACW/ Auxiliary Steam/ Effluent)		
CC.	Sewage (urinals from Toilet) from FGD area to Main Sewer Network		
DD.	**Air Compressor**		
1.0	**General**		
1.1	Designation		
1.2	Number offered		
	- Instrument air compressor		
1.3	Type		
1.4	Duty mode		
1.5	Control mode		
1.6	Lubrication bearing		
1.7	Location		
1.8	Type of drive-compressor connection		
1.9	Galvanization of interconnecting piping		
2.0	**Material of construction**		
2.1	Casing		

Sr.No	Description	Units	Data
2.2	Rotor body		
2.3	Shaft seal		
2.4	Inlet throttle valve		
2.5	Housing of valve		
2.6	Bull gear		
2.7	Pinion gear		
2.8	Timing gear		
2.9	Gear box		
2.10	Blow of valve		
2.11	Unloading cylinder head		
2.12	Tube of blow off cooler / oil cooler.		
2.13	Outer casing of coolers		
	Note : Equivalent material for screw compressor shall be acceptable subject to approval		
EE.	**Inter Cooler and After Cooler**		
1.0	**General**		
1.1	Designation		
1.2	Nos. required		
1.3	Type		
1.4	Location		
2.0	**Equipment parameters**		
2.1	Outlet air temperature	°C	
2.2	Design pressure	$kg/cm^2(g)$	
2.3	Hydrostatic test pressure	$kg/cm^2(g)$	
2.4	Allowable pressure drop of air	$kg/cm^2(g)$	
2.5	Minimum corrosion allowance	mm	
3.0	**Material of Construction**		
3.1	Tube		
3.2	Shell		
3.3	Tube sheet		
3.4	Tube support plates		
3.5	Auto-drain trap body & Trim		
4.0	**Intake Air Filter**		
4.1	**General**		
4.1.1	Designation		

Sr.No	Description	Units	Data
4.1.2	Nos. Required		
4.1.3	Location		
4.1.4	Type		
4.2.0	**Performance Required**		
4.2.1	Air flow rate		
4.2.2	Filtering efficiency		
4.3.0	**Special Feature**		
4.3.1	Operating sound level		
4.3.2	Filtering element equivalent		
5.0	**Air Receiver**		
5.1	**General**		
5.1.1	Designation		
5.1.2	Type		
5.1.3	Location		
5.1.4	Receiver design code		
5.1.5	Number		
5.2.0	**Equipment Parameter**		
5.2.1	Design pressure		
5.2.2	Hydraulic test pressure		
5.2.3	Relief valve set		
5.3.0	**Material of Construction**		
5.3.1	Shell		
5.3.2	End plates		
5.3.3	Relief valve body		
5.3.4	Relief valve spring		
FF.	**Air Drying Plant**		
1.0	**General**		
1.2	Designation		
1.3	Type		
1.4	Duty		
1.5	Nos. required	Nos.	
1.6	Location		
2.0	**Operating Data**		
2.1	Air flow rate	Nm^3/min	
2.2	Dew point (atmospheric)	°C	

Sr.No	Description	Units	Data
2.3	Maximum allowable pressure drop	Kg/cm^2	
3.0	**Tests**		
3.1	Noise level		
3.2	Capacity at rated discharge pressure of compressors		
3.3	Negative tolerance on guaranteed values of specific power consumption, air dryer dew point of air, air dryer pressure drop and water pressure drop.		
3.4	Performance test for air dryer – Rated dew point temperature		
	Note: Design, MOC, annunciations, trips for compressor (within the compressor and Air drying Plant skid) as per manufacturer standard will be subjected to approval by owner. Manufacturer shall be as per approved vendor list.		
GG.	**Crane & Hoist**		
	Crane		
1.0	GENERAL		
1.1	Type of control proposed		
2.0	**Hoisting System**		
2.1	Rope		
a)	Rope construction		
b)	Rope quality (material)		
c)	Factor of safety		
2.2	Rope drum		
a)	Drum material		
b)	Whether stress relieved		
2.3	Bearing type		
2.4	Hook		
a)	Hook type		
b)	Hook material		
c)	Safety latches provided		
d)	Hook suspension		
2.5	Sheave material		
2.6	Hoist Brake		
a)	Type		

Sr.No	Description	Units	Data
b)	Torque		
2.7	Gear box		
a)	Material of gears		
b)	Material of pinions		
c)	Type of gears & pinions		
2.8	Limit Switch type		
3.0	**Cross Travel**		
3.1	CT brake		
a)	Type		
b)	Torque	Nm	
3.2	Gear box		
a)	Material of gears		
b)	Material of pinion		
c)	Type of gears & pinion		
3.3	Wheels		
a)	Materials		
b)	Hardness	BHN	
c)	Type		
d)	Wheel bearing type		
3.4	Type of limit switches		
4.0	**Long Travel**		
4.1	CT brake		
a)	Type		
b)	Torque	Nm	
4.2	Gear box		
a)	Material of gears		
b)	Material of pinion		
c)	Type of gears/pinion		
4.3	Wheels		
a)	Materials		
b)	Hardness	BHN	
c)	Type		
d)	Wheel bearing type		
4.4	Type of limit switches		
5.0	Type of Buffer Stoppers		

Sr.No	Description	Units	Data
6.0	**Electrical**		
6.1	Power supply		
6.2	Rating		
6.3	Number of starts/hour		
HH.	**Electric Hoist**		
1	**GENERAL**		
1.1	Design according to standard service class/ load class		
1.2	Location (Indoor/ Outdoor)		
1.3	Type of control		
2	**HOISTING SYSTEM**		
2.1	Wire Rope		
a)	Rope construction		
b)	Rope quality (material)		
c)	Factor of safety		
2.2	Rope drum		
a)	Drum material		
b)	Whether stress relieved		
c)	Bearing type		
2.3	**Hook**		
a)	Hook type		
b)	Hook material		
c)	Safety latches provided		
d)	Hook suspension		
e)	sheave material		
2.4	**Hoist Brake**		
a)	Type		
b)	Torque	Nm	
2.5	**Gear box**		
a)	Material of gears		
b)	Material of pinions		
c)	Type of gears & pinions		
2.6	Type of Limit Switch		
3	**Travel**		
3.1	**CT brake**		
a)	Type		

Sr.No	Description	Units	Data
b)	Torque	Nm	
c)	Gear box		
i)	Material of gears		
ii)	Material of pinion		
iii)	Type of gears & pinion		
d)	**Wheels**		
i)	Materials		
ii)	Hardness	BHN	
iii)	Type		
iv)	Wheel bearing type		
e)	Type of Limit switches		
4	Rating		
5	Number of starts/hour		
II.	**Manual Hoist**		
1	Standards		
2	Application		
3	Trolley and hoist operation		
4	Material of construction		
4.1	Trolley frame		
4.2	Gears (Trolley)		
4.3	Lifting hook (Swivel)		
4.4	Gears		
5	Trolley wheel		
6	Brake		
JJ.	**Fire Protection System**		
1.0	**Under Ground Piping (Normally Filled with Water)**		
a)	Pipe specification		
b)	Pipe to pipe joint		
c)	Pipe to valve joint		
d)	Pipe fittings		
e)	Bolts, nuts & washers		
f)	Corrosion protection		
2.0	**Above Ground Piping (Normally Filled with Water)**		
a)	Pipe specification		

Sr.No	Description	Units	Data
b)	Pipe to pipe joint		
c)	Pipe to valve joint		
d)	Pipe fittings		
e)	Bolts, nuts & washers		
f)	Corrosion protection		
3.0	**Above Ground Piping (Normally Empty)**		
a)	Pipe specification		
b)	Pipe to pipe joint		
c)	Pipe to valve joints		
d)	Pipe fittings		
e)	Bolts nuts & washers		
f)	Pipe protection		
4.0	**C.I Gate Valves**		
a)	Type		
b)	Sizes		
c)	Rating		
d)	End connection		
e)	Code / Standard		
f)	Material of construction		
g)	Body		
h)	Bonnet		
i)	Stem		
j)	Wedge disc		
k)	Body seat ring		
l)	Back sheet		
m)	Stem packing		
n)	Hand wheel		
o)	Bonnet bolts & nuts		
p)	Bonnet gasket		
q)	Testing		
r)	Test pressure		
s)	Approval		
t)	Reference to the manufacturers technical leaflet		

Sr.No	Description	Units	Data
5.0	**Gun Metal Globe Valves**		
a)	Type		
b)	Sizes		
c)	Rating		
d)	End connection		
e)	Code / Standard		
f)	Material of construction		
g)	Body		
h)	Bonnet		
i)	Disc		
j)	Stem		
k)	Seat ring		
l)	Gasket (Bonnet)		
m)	Packing		
n)	Hand wheel / lever		
o)	Testing		
p)	Test pressure		
q)	Approval		
r)	Reference to the manufacturers technical leaflet		
6.0	**C-I Check Valves**		
a)	Type		
b)	Size		
c)	Rating		
d)	End connection		
e)	Code / Standard		
f)	Material of construction		
g)	Body		
h)	Cover		
i)	Disc		
j)	Hinge bracket		
k)	Body seat ring		
l)	Flap seat ring		
m)	Hinge pin		
n)	Gasket		
o)	Bolt, nut & studs		

Sr.No	Description	Units	Data
p)	Testing		
q)	Test pressure		
r)	Approval		
s)	Reference to the manufacturers technical leaflet		
7.0	**Butterfly Valves**		
a)	Type		
b)	Sizes		
c)	Rating		
d)	End connection		
e)	Code / Standard		
f)	Material of construction		
g)	Body		
h)	Shaft		
i)	Disc		
j)	Disc retaining ring		
k)	Body seat “O” ring		
l)	Bush		
m)	Hand wheel / lever		
n)	Studs		
o)	Nuts		
p)	Testing		
q)	Test pressure		
r)	Approval		
s)	Reference to the manufacturers technical leaflet		
8.0	**Deluge Valve**		
a)	Type		
b)	Size		
c)	Design data		
d)	End connection		
e)	Type of operation		
f)	Trim description		
g)	Accessories		
h)	Material of construction		

Sr.No	Description	Units	Data
i)	For Diaphragm type		
j)	Housing		
k)	Cover		
l)	Clapper		
m)	Clamp ring		
n)	Seat		
o)	Diaphragm		
p)	Seat rubber		
q)	Valve disc		
r)	NRV, ball		
s)	Bolts		
t)	Testing		
u)	Approval		
v)	Reference to the manufacturers technical leaflet		
9.0	**HVWS Spray Nozzles**		
a)	Model		
b)	Mounting		
c)	Material		
d)	K factor/Orifice size(mm)		
e)	Bulb size		
f)	Approval		
g)	End connector		
h)	Finish		
i)	Reference to the manufacturers technical leaflet		
10.0	**Quartzoid Bulb Detector**		
a)	Material		
b)	Sensitive element		
c)	Set temperature		
d)	Response time		
e)	End connector		
f)	Approval		
11.0	**Y-Strainers**		
a)	Manufacture		
b)	Sizes		

Sr.No	Description	Units	Data
c)	End connector		
d)	Screen open area to pipe room sectional area ratio		
e)	Material of construction		
f)	Body		
g)	Screen		
h)	Screen mesh		
i)	Testing pressure		
j)	Reference to the manufacturers technical leaflet		
12.0	**Hydrant Valve**		
a)	Type		
b)	Code / Standard		
c)	End connection		
d)	Inlet		
e)	Outlet		
f)	Size		
g)	Flow		
h)	Testing		
i)	Test pressure		
j)	Working pressure		
k)	Design pressure		
l)	Material of construction		
m)	Body		
n)	Female outlet		
o)	Stop valve		
p)	Blank cap		
q)	Bonnet		
r)	Gland		
s)	Gland packing		
t)	Gland nut		
u)	Check nut		
v)	Seat		
w)	Spindle		
x)	Hand wheel		
y)	Spring		

Sr.No	Description	Units	Data
z)	Washer & rubber seat		
aa)	Approval		
bb)	Reference to the manufacturers technical leaflet		
13.0	**Branch Pipe & Nozzle**		
a)	Size		
b)	Nozzle Type		
c)	Code / standard		
d)	Material of construction		
e)	Branch pipe / nozzle		
f)	Spanner		
g)	Testing		
h)	Approval		
i)	Reference to the manufacturers technical leaflet		
14.0	**Hose Coupling**		
a)	Type		
b)	Size		
c)	Code / standard		
d)	Material of construction		
e)	Female half coupling		
f)	Male half coupling		
g)	Seal washer		
h)	Outer disc		
i)	Self-locking nut		
j)	Locking latch		
k)	Spring		
l)	Guide disc		
m)	Knob		
n)	Testing		
o)	Approval		
p)	Reference to the manufacturers technical leaflet		
15.0	**Fire Hose**		
a)	Type		
b)	Size		

Sr.No	Description	Units	Data
c)	Code / standard		
d)	Length		
e)	End fittings		
f)	Testing		
g)	Hose weight (gm/m)		
h)	Bursting pressure		
i)	Proof pressure		
j)	Kink test pressure		
k)	Change in length test pressure		
l)	Change in diameter test pressure		
m)	Approval		
n)	Reference to the manufacturers technical leaflet		
16.0	**Hose Cabinet**		
a)	Type		
b)	Size		
c)	Mounting		
d)	Special requirement		
e)	Accessories		
f)	Reference to the manufacturers technical leaflet		
17.0	**MVWS Spray Nozzles**		
a)	Model		
b)	Mounting		
c)	Material		
d)	K factor/Orifice size(mm)		
e)	Bulb size		
f)	Approval		
g)	End connector		
h)	Finish		
i)	Reference to the manufacturers technical leaflet		

Sl.No.	Description	Unit	Data
KK.	**PORTABLE FIRE EXTINGUISHERS**		
1.0	**CARBON DI-OXIDE TYPE**		
1.1	Type		
1.2	Design standard		
1.3	Quantity	Nos.	
1.4	Guaranteed performance		
a	Capacity	kg	
b	Max. effective range when tested in still air	m	
c	Min. period during which the continuous jet shall be maintained.	S	
d	Maximum period for discharge of 95% of the charge	S	
1.5	Constructional features		
1.6	Material of construction		
1.7	Physical data		
1.8	Accessories		
a	Chemical charge		
b	Mounting Brackets complete with all hardware		
c	Carrying handle		
d	Liquid level indicator		
e	Any other as per design code		
1.9	Approvals		
1.10	Painting and testing		
2.0	**DRY CHEMICAL POWDER TYPE**		
2.1	Type		
2.2	Design standard		
2.3	Quantity	Nos.	
2.4	Guaranteed performance		
a	Capacity	kg	
b	Max. effective range when tested in still air	m	

Sl.No.	Description	Unit	Data
c	Min. period during which the continuous jet shall be maintained.	S	
d	Maximum period for discharge of 95% of the charge	S	
2.5	Constructional features		
2.6	Material of construction		
2.7	Physical data		
2.8	Accessories		
a	Chemical charge		
b	Mounting brackets complete with all hardware		
c	Carrying handle		
d	Liquid level indicator		
e	Any other as per design code		
2.9	Approvals		
2.10	Painting and testing		
3.0	**FOAM TYPE**		
3.1	Type		
3.2	Design standard		
3.3	Quantity	Nos.	
3.4	Guaranteed performance		
a	Capacity	lts	
b	Max. effective range when tested in still air	m	
c	Min. period during which the continuous jet shall be maintained	S	
d	Maximum period for discharge of 95% of the charge	S	
3.5	Constructional features		
3.6	Material of construction		
3.7	Physical data		
3.8	Accessories		
a	Chemical charge		
b	Mounting brackets complete with all hardware		

Sl.No.	Description	Unit	Data
c	Carrying handle		
d	Liquid level indicator		
e	Any other as per design code		
3.9	Approvals		
3.10	Painting and testing		
LL.	**TROLLEY MOUNTED (MOBILE) FIRE EXTINGUISHERS**		
1.0	**DRY CHEMICAL POWDER TYPE**		
1.1	Type		
1.2	Design standard		
1.3	Quantity	Nos.	
1.4	Guaranteed performance		
a	Capacity	kg	
b	Max. effective range when tested in still air	m	
c	Min. period during which the continuous jet shall be maintained at length not less than 6 m	S	
d	Maximum period for discharge of 95% of the charge	S	
1.5	Constructional features		
1.6	Material of construction		
1.7	Physical data		
1.8	Accessories		
a	Chemical charge		
b	Mounting brackets complete with all hardware		
c	Carrying handle		
d	Liquid level indicator		
e	Any other as per design code		
1.9	Approvals		
1.10	Painting and testing		
2.0	**CARBON DI-OXIDE TYPE**		
2.1	Type		

Sl.No.	Description	Unit	Data
2.2	Design standard		
2.3	Quantity	Nos.	
2.4	Guaranteed performance		
a	Capacity	kg	
b	Max. effective range when tested in still air	m	
c	Min. period during which the continuous jet shall be maintained	S	
d	Maximum period for discharge of 95% of the charge	S	
2.5	Constructional features		
2.6	Material of construction		
2.7	Physical data		
2.8	Accessories		
a	Chemical charge		
b	Mounting brackets complete with all hardware		
c	Carrying handle		
d	Liquid level indicator		
e	Any other as per design code		
2.9	Approvals		
2.10	Painting and testing		

MM.HVAC SYSTEM

A. AIR COOLED DUCTABLE SPLIT TYPE AIR CONDITIONING UNITS

Sl.No.	Description	Unit	Data
A	**GENERAL**		
1	Standard		
2	Type		
3	Overall weight	kg	
B	**COMPRESSOR SECTION**		
1	Type		

Sl.No.	Description	Unit	Data
2	No. of Compressor		
3	Capacity	TR	
4	Refrigerant		
5	Condensing Temp.	Deg C	
6	Evaporating		
7	Compressor speed	RPM	
8	Energy Efficiency Ratio		
9	Power consumption	kW	
10	Motor rating	kW	
11	Power Supply		
12	Protection Devices		
	High/low pressure protection		
	Oil Pressure Switch		
	Single phase protection		
	Overload protection		
13	Controls		
	Adjustable thermostatic switch		
	Automatic unloader		
14	Accessories		
	External Crankcase heater		
	Vibration Isolator		
	Suction gas strainer		
C	**COOLING COIL**		
1	Coil Type		
2	No. of Rows		
3	Coil Tube dia	mm	
4	Tube thickness	mm	
5	Fin thickness	mm	
6	Fin spacing	mm	
7	Coil face area	m^2	
8	Coil face velocity	m/s	
9	Air side fouling factor		

Sl.No.	Description	Unit	Data
10	Expansion valve		
D	**BLOWER FAN**		
1	Fan Type		
2	No. of fans		
3	Fan capacity	m^3/hr	
4	Fan static pressure	mm of WC	
5	Fan static efficiency	%	
6	Fan shaft power	kW	
7	Fan rated speed	RPM	
8	Fan drive		
9	Fan drive motor type		
10	Power Supply		
11	Motor rating	kW	
E	**CASING**		
1	Type		
2	Frame		
3	Acoustic Insulation		
4	Evaporator drain pan		
5	Inlet RA Grille		
F	**REFRIGERANT PIPING & VALVES**		
1	Piping		
2	Valve		
G	**CONDENSER**		
1	Type		
2	Refrigerant Inlet temperature	Deg C	
3	Refrigerant outlet temperature	Deg C	
4	Number of passes		
5	Number of tube bundles		
6	Heat exchange rate		
7	LMTD (including correction factor)		
8	Fouling factor		
9	Surface area		

Sl.No.	Description	Unit	Data
H	**TESTING & INSPECTION**		
1	Material Testing		
2	Pressure testing		
3	Compressor		

B. AIR DISTRIBUTION SYSTEM

Sl.No.	Description	Unit	Data
1.0	Service		
2.0	Ducting		
	a) Material		
	b) GI Coating	gms/m²	
	Supply air diffusers / grilles		
	a) Type		
	b) Shape		
	c) Material & thickness		
	- Frame		
	- Louvres		
	d) Volume control dampers		
3.0	Return air diffusers / grilles		
	a) Type		
	b) Shape		
	c) Material & Thickness		
	- Frame		
	- Louvres		
	d) Volume control dampers		
4.0	Acoustic insulation		
	a) Materials		
	b) Thickness	mm	
	c) Finish		
	d) Quantity	m²	
	Fire dampers		
	a) Rating		
	b) Type of actuation		

Sl.No.	Description	Unit	Data
5.0	Air Intake Louvres		
	a) Material & thickness		
	- Frame	mm	
	- Louvres		
6.0	Splitter dampers, turning and elbow vanes, balancing dampers, duct supports etc.		

C. VENTILATION SYSTEM

Sl.No.	Description	Unit	Data
A	**AXIAL FLOW FANS**		
1.0	General		
1.1	Standard		
1.2	Mounting		
1.3	Service		
1.4	Type		
2.0	**OVERALL WEIGHT**	kg	
2.1	Performance		
2.2	Capacity	m^3/hr	
2.3	Air density	kg/m^3	
2.4	Total pressure	mmWC	
2.5	Static pressure	mmWC	
2.6	Static efficiency	%	
2.7	Total efficiency	%	
2.8	Rated speed	RPM	
2.9	Critical speed		
2.10	Fan shaft power		
2.11	Motor power rating		
3.0	**NO. OF BLADES**		
3.1	Construction		
3.2	Fan impeller		
3.3	Fan shaft		
3.4	Fan casing		
3.5	Fan Hood & Cowl		
3.6	Bird Screen		

Sl.No.	Description	Unit	Data
3.7	Conned Inlet		
3.8	Inlet screen		
4.0	**BOLTS & NUT**		
4.1	Fan Drive		
4.2	Type		
4.3	Drive Motor		
4.4	Power supply		
4.5	Motor ambient temp.		
4.6	Motor Insulation		
5.0	**MOTOR ENCLOSURE**		
5.1	Fan Accessories		
5.2	Exhaust Hood		
5.3	Cowl		
5.4	Conned inlet		
5.5	Inlet screen		
5.6	Flexible connection		
5.7	Fan supporting frame		
5.8	Grouting frame		
5.9	Vibration isolator		
5.10	Backdraft damper		
5.11	Air Filters		
6.0	**DISCONNECT SWITCH**		
6.1	Testing and Inspection		
6.2	Material Testing		
6.3	Dynamic balancing		
6.4	Performance testing		
	Notes :		
	1) Fan motor shall be suitable for DOL starting.		
B	**BELT DRIVEN AXIAL FLOW FANS (SPARK RESISTANT CONSTRUCTION)**		
1.0	**General**		
1.1	Standard		
1.2	Type		
1.3	Special requirement		
1.4	Arrangement		

Sl.No.	Description	Unit	Data
1.5	Overall weight	kg	
2.0	**Performance**		
2.1	Capacity		
2.2	Air Density		
2.3	Static pressure		
2.4	Total pressure		
2.5	Rated Speed		
2.6	Static Efficiency		
2.7	Total Efficiency		
2.8	Fan Shaft power		
2.9	Critical Speed		
2.10	No. of Blades		
2.11	Recommended Motor Rating		
3.0	**Fan Drive**		
3.1	Type		
3.2	Drive Motor		
3.3	Power Supply		
3.4	Motor ambient temp.		
3.5	Motor Insulation		
3.6	Motor Enclosure		
4.0	**Fan Accessories**		
4.1	Exhaust cowl		
4.2	Bird screen		
4.3	Backdraft damper		
4.4	Inlet case		
4.5	Inlet screen		
4.6	Fan supporting frame/Grouting frame		
4.7	Vibration Isolator		
4.8	Sliding rail for fan motor		
4.9	Disconnect switch		
5.0	**Material Of Construction**		
5.1	Impeller		
5.2	Fan shaft		
5.3	Shaft sleeve		
5.4	Casing		

Sl.No.	Description	Unit	Data
5.5	Inlet Case		
5.6	Cowl		
5.7	Bolts & Nut		
5.8	Inlet Screen		
5.9	Bird Screen		
6.0	**TESTING & INSPECTION**		
6.1	Material Testing		
6.2	Dynamic Balancing		
6.3	Performance testing		
	Notes:		
	1) Fan motor shall be suitable for DOL Starting.		

NN. Equipment Cooling Water System

Description	Unit	Data	
ACW booster & DMCW Pumps PUMPS		**ACW booster pumps**	**DMCW Pumps**
General			
Manufacturer			
Design Standard			
Number (W+S)	No.		
Type			
No. of Stages			
Capacity	m^3/s		
Total Head	m		
Discharge pressure at design capacity	bar (a)		
Discharge pressure at no flow	bar (a)		
Speed	rpm		
Power required at duty point	kW		
Rated Power of Motor	kW		
Pump Efficiency at duty point	%		
Overall efficiency at duty point	%		
Specific Speed	Ns		
Radial Bearing Lubrication			
Thrust Bearing Lubrication			
Type of glands or seal			

Description	Unit	Data	
Pump casing design pressure	bar (a)		
Hydrostatic test pressure	bar (a)		
Type of coupling			
Connections			
Suction flange diameter	mm		
Discharge flange diameter	mm		
Flange Specification / Rating			
Materials			
Casing			
Impeller			
Shaft			
Other wetted parts			
Motors			
Note: For motors of each type and rating technical data shall be furnished by the Tenderer as per the format given in Electrical section.			
PLATE HEAT EXCHANGERS			
General			
Number of plate heat exchangers being supplied.	Nos.		
Manufacturer			
Model Number / Type			
Whether single or double pass			
Design			
Design Pressure	bar (a)		
Design Temperature	°C		
Heat Load	KW		
LMTD (Corrected)	°C		
Guaranteed Performance for Each Heat Exchanger		**Primary Side (Hot Fluid)**	**Secondary side (Cold Fluid)**
Flow rate	m^3/hr		
Inlet temperature	°C		
Outlet temperature	°C		
a) In fouled conditions			
b) In clean conditions			
Total pressure drop across heat	bar (a)		

Description	Unit	Data	
exchanger from inlet to outlet			
a) For design flow			
b) For 110% design flow rate			
Heat Transfer & Fluid flow data			
Film heat transfer co-efficient	Kcal/hrm^2 °C		
Fouling factor	m^{2}hr°C/kcal		
Overall fouling	m^{2}hr°C/kcal		
Overall heat transfer coefficient	Kcal/hrm^2 °C		
a) In clean conditions			
b) In fouled conditions			
Total effective heat transfer area per heat exchanger	m^2		
Pressure drop in channels	bar (a)		
a) In clean condition			
b) In fouled conditions			
Maximum differential pressure between hot and cold fluids in plate channels (Operating)	bar (a)		
Heat Transfer Plates			
Area of each plate	m^2		
Dimension (width x height)	mm x mm		
Thickness	mm		
Material & chemical composition			
Number of plates per heat exchanger	Nos.		
Maximum number of plates that can be accommodated in the heat exchanger frame	Nos.		
Type of corrugation			
Maximum plate pack length	mm		
Average spacing between two plates	mm		
Hold up volume of each passage	m^3		
Port size (diameter)	mm		
Plate Gaskets			
Type			
Material and composition			
Thickness of gasket	mm		

Description	Unit	Data	
Carrying Bar (a)			
Type of construction			
Number per heat exchanger			
Material			
Guide Bar (a)			
Type of construction			
Number per heat exchanger			
Material			
Frame Plate			
Type of construction			
Material			
Pressure Plate			
Type of construction			
Material			
Supporting columns			
Type of construction			
Material			
Clamping / Gasket Compression Arrangement			
Type of arrangement			
Bolts size and material			
Nuts size and material			
Inlet & outlet Connection Nozzles		**Primary Side (Hot Fluid)**	**Secondary Side (Cold Fluid)**
Size	mm		
Rating			
Facing & drilling standard			
Flange material			
Are all nozzles counter-flanges, bolts, nuts, gaskets etc., are included in the offer?		Yes / No	
Cleaning frequency of the heat exchanger for assumed fouling factor	months		
Is backwash necessary		Yes / No	
Are all auxiliaries and accessories included in the offer?		Yes / No	

OO. FGD Waste Water Treatment System

Sl.No.	Description	Unit	Data
1.0	**Waste water collection tank**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	Size(Length x Width x Height)	m x m x m	
2.0	**Lime preparation cum dosing tank (For waste water collection tank)**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	MOC of Agitator		
	i) Impeller		
	ii) Shaft		
	iii) Hardwares(Wetted parts)		
f)	MOC of Dissolving basket		
g)	Size(Dia x Ht)	m x m	
h)	Type of Agitator		
i)	Agitator motor rating	kw	
3.0	**Lime Dosing Pump(For waste water collection tank)**		
a)	Type		
b)	MOC		
	i) Stator		
	ii) Rotor		
	iii) Shaft		
	iv) Hardwares (Wetted parts)		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	

Sl.No.	Description	Unit	Data
d)	Dosing Concentration	%	
e)	Capacity	LPH	
f)	Head	mwc	
g)	Motor rating	kw	
h)	Dosing rate	ppm	
4.0	**Hypo preparation cum dosing tank**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	Size(Dia x Ht)	m x m	
5.0	**Hypo dosing pump**		
a)	Type		
b)	MOC		
	i) Head		
	ii) Diaphragm		
	iii) Shaft		
	iv) Hardwares		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	
d)	Capacity for each pump	LPH	
e)	Head	mwc	
f)	Motor rating	Kw	
g)	Dosing rate	ppm	
h)	Dosing Concentration	%	
6.0	**Air scouring blowers for Waste water collection tank and Sludge pit**		
a)	Type		
b)	Quantity	Nos	
c)	Capacity	m^3/hr	
d)	Head	mwc	

Sl.No.	Description	Unit	Data
e)	MOC		
	i) Casing		
	ii) Lobes		
	iii) shaft		
	iv) Hardwares		
	v) base frame		
	vi) Foundation bolts		
f)	Motor rating	kw	
7.0	**Clarifier feed pump**		
a)	Type		
b)	MOC		
	i) Casing		
	ii) impeller		
	iii) Shaft		
	iv) Hardwares(Wetted parts)		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	
d)	Capacity	m^3/hr	
e)	Head	mwc	
f)	Pump BKW	kw	
g)	Motor rating	kw	
8.0	**Flash mixer**		
a)	Qty	Nos	
b)	MOC of tank		
c)	MOC of Agitator		
	i) Impeller		
	ii) Shaft		
	iii) Hardwares(Wetted parts)		
d)	Retention time	mins	
e)	Capacity	m^3	
f)	Agitator Motor rating	kw	

Sl.No.	Description	Unit	Data
9.0	**Flocculation tank**		
a)	Qty	Nos	
b)	MOC of tank		
c)	Retention time	mins	
d)	MOC of Agitator		
	i) Impeller		
	ii) Shaft		
	iii) Hardwares(Wetted parts)		
e)	Capacity	m^3	
g)	Agitator Motor rating	kw	
10.0	**Clarifier(Tube settler)**		
a)	Qty	Nos	
b)	MOC		
	i) Super structure		
	ii) Plates/Tubes		
	iii) Launder		
c)	Rise rate	m^2/m/hr	
d)	Design sludge consistency	%	
e)	Outlet Turbidity	NTU	
f)	Angle of Hopper	Deg	
g)	Capacity	m^3/hr	
11.0	**Lime preparation cum dosing tank(For Clarifier)**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	MOC of Agitator		
	i) Impeller		
	ii) Shaft		
	iii) Hardwares(Wetted parts)		
f)	MOC of Dissolving basket		
g)	Size(Dia x Ht)	m x m	

Sl.No.	Description	Unit	Data
h)	Type of Agitator		
i)	Agitator motor rating	kw	
12.0	**Lime Dosing Pump(For Clarifier)**		
i)	Type		
j)	MOC		
	i) Stator		
	ii) Rotor		
	iii) Shaft		
	iv) Hardwares(Wetted parts)		
	v) Base frame		
	vi) Foundation bolts		
k)	Quantity	Nos	
l)	Dosing Concentration	%	
m)	Capacity for each pump	LPH	
n)	Head	mwc	
o)	Motor rating	kw	
p)	Dosing rate	ppm	
13.0	**Ferric chloride preparation cum dosing tank**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	MOC of Agitator		
	i) Impeller		
	ii) Shaft		
	iii) Hardwares(Wetted parts)		
f)	MOC of Dissolving basket		
14.0	**Ferric chloride dosing pump**		
a)	Type		
b)	MOC		
	i) Head		

Sl.No.	Description	Unit	Data
	ii) Diaphragm		
	iii) Shaft		
	iv) Hardwares		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	
d)	Capacity for each pump	LPH	
e)	Head	mwc	
f)	Motor rating	Kw	
g)	Dosing rate	ppm	
h)	Dosing Concentration	%	
14.0	**Poly preparation cum dosing tank**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	MOC of Agitator		
	i) Impeller		
	ii) Shaft		
	iii) Hardwares(Wetted parts)		
f)	MOC of Dissolving basket		
15.0	**Poly dosing pump**		
a)	Type		
b)	MOC		
	i) Head		
	ii) Diaphragm		
	iii) Shaft		
	iv) Hardwares		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	
d)	Capacity for each pump	LPH	

Sl.No.	Description	Unit	Data
e)	Head	mwc	
f)	Motor rating	Kw	
g)	Dosing rate	ppm	
h)	Dosing Concentration	%	
16.0	**Clarified water storage tank**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	Size(Length x Width x Height)	m x m x m	
17.0	**Clarified water transfer pumps**		
a)	Type		
b)	MOC		
	i) Casing		
	ii) impeller		
	iii) Shaft		
	iv) Hardwares(Wetted parts)		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	
d)	Capacity	m^3/hr	
e)	Head	mwc	
f)	Pump BKW	kw	
g)	Motor rating	kw	
18.0	**Sludge pit**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	Size(Length x Width x Height)	m x m x m	
19.0	**Centrifuge feed pump**		
a)	Type		

Sl.No.	Description	Unit	Data
b)	MOC		
	i) Casing		
	ii) impeller		
	iii) Shaft		
	iv) Hardwares(Wetted parts)		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	
d)	Capacity	m^3/hr	
e)	Head	mwc	
f)	Pump BKW	kw	
g)	Motor rating	kw	
20.0	**Centrifuge**		
a)	Type		
b)	MOC		
	i) Basket		
	ii) Bowl		
	iii) Hardwares		
	iv) All wetted parts		
c)	Quantity	Nos	
d)	Capacity	m^3/hr	
e)	Design outlet sludge consistency	%	
f)	Efficiency	%	
g)	Motor rating	kw	
21.0	**Poly preparation cum dosing tank(For Centrifuge)**		
a)	Type		
b)	MOC		
c)	Quantity	Nos	
d)	Capacity(Each), min	m^3	
e)	MOC of Agitator		
	i) Impeller		
	ii) Shaft		

Sl.No.	Description	Unit	Data
	iii) Hardwares(Wetted parts)		
f)	MOC of Dissolving basket		
22.0	**Poly dosing pump (For Centrifuge)**		
a)	Type		
b)	MOC		
	i) Head		
	ii) Diaphragm		
	iii) Shaft		
	iv) Hardwares		
	v) Base frame		
	vi) Foundation bolts		
c)	Quantity	Nos	
d)	Capacity for each pump	LPH	
e)	Head	mwc	
f)	Motor rating	Kw	
g)	Dosing rate	ppm	
h)	Dosing Concentration	%	
23.0	**Piping**		
a)	Waste water/sludge pipe/Clarified water		
b)	Lime solution		
c)	Ferric chloride/Poly/Hypo		
24.0	**Plant Capacity of FGD WWTP**	m^3/hr	

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

ELECTRICAL

Bidder shall furnish technical data in the following schedules along with the offer.

The schedule for data to be submitted for approval after award of contract will be issued to the successful Bidder during detail engineering.

HT Switchgear

Sl. No.	Description	Unit	Data
1.0	**SWITCHGEAR ASSEMBLY**		
1.1	Make		
1.2	Type		
1.3	Reference Standard		
1.4	Voltage (Nom. / Max.)	kV	
1.5	Phase, Frequency	No, Hz	
1.6	**Short Circuit Rating**		
	a. Interrupting MVA (sym.) for 3 sec	MVA	
	b. Short-time for 3 sec.	kA (rms)	
1.7	**Insulation Level**		
	a. Impulse Withstand	kV (peak)	
	b. 1-min. 50 Hz. Voltage withstand	kV (rms)	
1.8	Metal-clad construction?	Yes / No	
1.9	Degree of Protection		
1.10	Minimum thickness of sheet metal used	mm	
1.11	Switchgear completely assembled, wired and tested at factory	Yes / No.	
2.0	**CONSTRUCTION**		
2.1	Draw-out feature provided for :		
	a. Circuit breaker with service, test and disconnected position	Yes / No.	
	b. Voltage Transformer	Yes / No.	
2.2	**Breaker Cubicle**		
	a. Cubicle door can be closed with breaker in TEST position	Yes / No.	
	b. Working zone limits from floor level	mm	
2.3	All meters, switch & relays flush mounted type	Yes / No	
3.0	**BUSBAR**		
3.1	Make		
3.2	Material & Grade		

Sl. No.	Description	Unit	Data
3.3	Reference, Standard		
3.4	Cross sectional area	Sq. mm	
	Size	mmxmm	
3.5	Continuous Current rating at ambient of 50°C		
3.6	Current density	A / mm²	
3.7	Maximum temperature rise over 50°C	°C	
3.8	Short time current for 3 sec.	kA (rms)	
4.0	**CIRCUIT BREAKER**		
4.1	Make		
4.2	Type		
4.3	Reference Standard		
4.4	Rated voltage	KV	
4.5	Rated frequency	Hz.	
4.6	No. of poles	No.	
4.7	**Rated Current**		
	a. Continuous (at site condition, 50°C ambient & within cubicle)	Amp.	
	b. Short-time current for 3 sec.	kA (rms)	
4.8	Maximum temperature rise over 50°C ambient	°C	
4.9	Rated operating duty		
4.10	Interrupting capacity at rated voltage and operating duty		
	a. Symmetrical	kA (rms)	
	b. DC component	%	
4.11	Rated making current	kA (peak)	
4.12	Maximum over voltage factor when switching off		
	a. Unloaded transformer		
	b. Loaded transformer		
	c. Unloaded Lines		
	d. Induction Motor		
4.13	**At 100% interrupting capacity**		
	a. Opening time (max.)	ms	
	b. Arcing time (max.)	ms	
	c. Total tripping time (max.)	ms	

Sl. No.	Description	Unit	Data
4.14	Total closing time (max.)	ms	
4.16	No. of breaker operations permissible without requiring inspection, replacement of contacts and other main parts		
	a. At 100% rated current		
	b. At 100% rated interrupting current		
4.17	Type of contacts		
	a. Main		
	b. Arcing		
4.18	Material of contacts		
	a. Main		
	b. Arcing		
	c. Whether contacts silver plated		
	d. Thickness of silver plating		
4.19	Type of arc control device provided		
4.20	**Operating Mechanism**		
	a. Type		
	b. No. of breaker operations stored		
	c. Trip free or fixed trip		
	d. Anti-pumping features provided		

Auxiliary Power Transformer

S.No	DESCRIPTION	Rating-1	Rating-2
1.	Name & Place of Manufacturer		
2.	Service		
3.	Reference Standards		
4.	MVA rating at ONAN cooling		
5.	Rated no load voltage ratio		
6.	Rated frequency		
7.	Number of phases		
8.	Connections		
	a. HV winding		
	b. LV windings		
9.	Vector group		
10	Direction of Power flow		

S.No	DESCRIPTION	Rating-1	Rating-2
11	Off load tap Changer		
	a. Type		
	b. Tap Range		
	c. Tap step		
12	Type of Transformer Neutral earthing for LV		
13	Type of Cooling		
14	Temperature rise over 50 deg C ambient .		
	a. Top oil by Thermometer method		
	b. Windings by Resistance method		
15	Hot spot temperature at weighted reference ambient temperature		
16	Efficiency at 75 Deg. C at 0.8 Power factor at full load		
17	Component losses		
	a. No load loss at rated voltage on principal tapping & at rated frequency		
	b. Load loss at rated current at principal tapping at 75 Deg. C excluding auxiliary loss		
	c. Auxiliary losses (Cooler loss)		
18	Impedance voltage at rated current HV-LV (Nominal tap)		
19	Rated HV current at rated voltage and rated frequency		
20	Rated LV current at rated voltage and rated frequency		
21	Short circuit withstand Duration		
22	Short circuit withstand Current (kA)		
	a)HV		
	b)LV		
23	Type of Termination		
	a) HV		
	b) LV		
24	Total Weight		
25	Oil quantity required for first filling		
26	Overall dimensions		
	a) Length		

S.No	DESCRIPTION	Rating-1	Rating-2
	b) Breath		
	c) Height		
27	Type of windings		
	a. HV windings		
	b. LV windings		
28	Winding Current density		
	a. HV		
	b. LV		
29	Vacuum withstand capability of tank only		
30	Thickness of transformer tank		
	a. side plates		
	b. bottom plate		
	c. Top plate		
31	Core		
	a. Material & grade of core laminations		
	b. Thickness of core laminations		
32	Type of Oil preservation system		
33	Cooling Fans		
	a. No.of working fans		
	b. No.of standby fans		
	c. Motor rating		

Dry Type Transformers

Sl. No.	DESCRIPTION	Rating-1	Rating-2
1.	Name & Place of Manufacturer		
2.	Type, Service		
3.	Reference Standards		
4.	MVA rating		
5.	Rated no load voltage ratio (kV)		
6.	Rated frequency		
7.	Number of phases		
8.	Connections		
	a. HV winding		
	b. LV windings		

Sl. No.	DESCRIPTION	Rating-1	Rating-2
9.	Vector group		
10.	Direction of Power flow		
11.	Off load tap Changer		
	a. Type		
	b. Tap Range		
	c. Tap step		
12.	Type of Transformer Neutral earthing for LV		
13.	Type of Cooling		
14.	Temperature rise over 50 deg C ambient .		
15.	Efficiencies at 75 Deg. C at 0.8 Power factor at full load		
16.	Component losses		
	a. No load loss at rated voltage on principal tapping & at rated frequency		
	b. Load loss at rated current at principal tapping at 75 Deg. C excluding auxiliary loss		
17.	Impedance voltage at rated current HV-LV (Nominal tap)		
18.	Rated HV current at rated voltage and rated frequency		
19.	Rated LV current at rated voltage and rated frequency		
20.	Short circuit withstand Duration		
21.	Short circuit withstand current (kA)		
	a)HV		
	b)LV		
22.	Type of Termination		
	a) HV		
	b) LV		
23.	Total Weight		
24.	Overall dimensions		
	a) Length (mm)		
	b) Breath (mm)		
	c) Height (mm)		
25.	Type of windings		

Sl. No.	DESCRIPTION	Rating-1	Rating-2
	a. HV windings		
	b. LV windings		
26.	Winding Current density		
	a. HV		
	b. LV		
27.	Core		
	a. Material & grade of core laminations		
	b. Thickness of core laminations		

Neutral Grounding Resistor (NGR)

SL.No	DESCRIPTION	UNITS	RATING 1	RATING 2
1.	Make			
2.	Type			
3.	Reference Standard			
4.	Rated Voltage	V		
5.	Frequency	Hz		
6.	Degree of protection			
7.	**Insulation Level**			
	a) 1 min power frequency withstand Voltage	kV rms		
	b) Basic Impulse Voltage	kV peak		
8.	Rated short time current & time	Amps, Sec		
9.	**Maximum temperature rise over 50°C ambient**			
	a) Resistor	Deg C		
	b) Enclosure	Deg C		
10.	**Resistor**			
	a) Material			
	b) Resistivity			
	c) Resistance per resister element			
	d) Net resistance of unit			
	e) No. of parallel paths			
	f) No of resistor elements per path			
	g) Total no. of resistor elements			

SL.No	DESCRIPTION	UNITS	RATING 1	RATING 2
	h) Method of connecting elements			
	i) Temperature coefficient of resistor			
	j) Type of grids			
11.	**Enclosure**			
	a) Material			
	b) Thickness			
	c) Overall Dimensions			
	d) Phase to earth clearance			
	e) Weight	Kg		
	f) Overall Dimension (L x B x H)	mm		
12.	Maximum span between bus support insulators	mm		
13.	**Enclosure Finish**			
	a) Exterior surface			
	b) Interior surface			
14.	Phase to Earth clearance provided(minimum value)	mm		
15.	**Support Insulator**			
	a) Make			
	b) Type			
	c) Reference Standard			
	d) Material			
	f) Voltage class	kV		
	g One Minute power frequency withstand voltage			
	h) Creepage Distance	mm		
16.	**Space heater**			
	a) Make			
	b) Type			
	c) Voltage Rating	V		
	d) Power	W		
	e) No.of Space heater			
	f) Thermotat control range			
	g) Total heater load			
17.	**Supporting Steel Structure**			
	a) Height of support structure	M		

SL.No	DESCRIPTION	UNITS	RATING 1	RATING 2
	b) Thickness of galvanizing	Micron		
18.	**Grounding**			
	a) Material and size of ground bus for Neutral grounding			

Segregated Phase Busduct

Sl.No.	Description	Units	Data
1.	Make		
2.	Type		
3.	Reference Standard		
4.	Voltage Class	V	
5.	Rated Voltage	V	
6.	Degree of protection		
7.	**Insulation Level**		
	a) 1 min power frequency withstand Voltage	kV rms	
	b) Basic Impulse Voltage	kV peak	
8.	Rated Continuous Current at 50°Cambient temperature	Amps	
9.	**Maximum temperature rise over 50°C ambient**		
	a) Bus Conductor	Deg C	
	b) Bus Enclosure	Deg C	
	c) Bus joint-Plain	Deg C	
10.	**Rated Short Time Current**		
	a) Symmetrical kA for 3 sec	kA	
	b) Momentary	kA Peak	
11.	**Material & Grade**		
	a) For Conductor		
	b) For Enclosure		
12.	**Conductivity**		
	a) For Conductor		
	b) For Enclosure		
13.	Conductor Shape		
14.	Conductor Size		
15.	Conductor weight / metre	kg	

Sl.No.	Description	Units	Data
16.	**Enclosure Data**		
	a) Phase Spacing		
	b) Overall Dimensions		
	c) Thickness		
	d) Phase to earth clearance		
17.	**Interphase Barrier plate for Segregated Busduct**		
	a) Material		
	b) Thickness		
18.	**D.C. Resistance of conductor at (in micro Ohms / meter / phase)**		
	a) 20°C		
	b) 90°C		
19.	**A.C. Resistance of conductor at (in micro Ohms / meter / phase)**		
	a) 20°C		
	b) 90°C		
20.	50 Cycle Reactance in Ohm/meter/phase		
21.	Weight per meter run of Busduct	Kg	
22.	Guaranteed loss per 3phase per metre	Watts	

415V Non-Segregated Phase Busduct

Sl.No.	Description	Units	Rating-1	Rating-2
1.	Make			
2.	Type			
3.	Reference Standard			
4.	Shape & Size of Busduct			
5.	Voltage Class	V		
6.	Rated Voltage	V		
7.	Degree of protection			
8.	**Insulation Level**			
	a) 1 min power frequency withstand Voltage	kV rms		
9.	Rated Continuous Current at 50°Cambient temperature	Amps		
10.	**Maximum temperature rise over 50°C ambient**			
	a) Bus Conductor	Deg C		

Sl.No.	Description	Units	Rating-1	Rating-2
	b) Bus Enclosure	Deg C		
	c) Bus joint-Plain / tinned	Deg C		
	d) Bus joint-Silver plated	Deg C		
11.	**Rated Short Time Current**			
	a) Symmetrical kA for 1 sec	kA		
	b) Momentary	kA Peak		
12.	**Material & Grade**			
	a) Conductor			
	b) Enclosure			
13.	**Conductivity**			
	a) for Conductor			
14.	Conductor Shape			
15.	Conductor Size	mm		
16.	Conductor weight / metre	kg		
17.	**Enclosure Data**			
	a) Phase Spacing	mm		
	b) Phase to phase clearance	mm		
	c) Phase to earth clearance	mm		
	d) Overall Dimensions	mm		
	e) Thickness of sheet steel	mm		
18.	**D.C. Resistance of conductor at**	μΩ/M/ph		
	a) 20°C			
	b) 90°C			
19.	**A.C. Resistance of conductor at**	μΩ/M/ph		
	a) 20°C			
	b) 90°C			
20.	50 Cycle Reactance in Ohm/meter/phase	Ω/M/ph		
21.	Weight per meter run of Busduct	kg		
22.	Guaranteed loss per 3phase per metre	watts		

LV SWITCHGEAR

(Data to be furnished for each Switchboard)

Sl. No.	Description	Unit	PCC	MCC	DB
1.	**SWITCHGEAR ASSEMBLY**				
a)	Make				
b)	Reference standard(s)				
c)	Rated voltage & frequency	V & Hz			
d)	Short circuit rating				
	Short circuit withstand rating for 1 second	kA(rms)			
	Dynamic short circuit withstand rating	kA(peak)			
e)	One minute power frequency withstand voltage	kV(rms)			
f)	Degree of Protection				
g)	Type of steel				
h)	Sheet steel thickness for load bearing member	mm			
i)	Sheet steel thickness for enclosure & door	mm			
j)	Thickness for gland plate	mm			
k)	Construction of PCC-Form 4b, Drawout	Yes / No			
l)	Construction of MCC-Form 4b, Drawout	Yes / No			
m)	Construction of DB-Form 4b, Fixed	Yes / No			
n)	Overall dimension of each switchboard (Separate list to be furnished)	mm x mm x mm			
2.	**BUS BAR**				
a)	Material & grade of main horizontal bus bar				
b)	Material & grade of Earth bus bar				
c)	Maximum temperature rise over 50°C	°C			
d)	Short circuit withstand rating for 1 second	kA(rms)			
e)	Dynamic short circuit withstand rating	kA(peak)			
f)	Bus bar provided with				
	• Insulating sleeve	Yes / No			
	• Phase barriers	Yes / No			
	• Cast resin shrouds for joint	Yes / No			

Sl. No.	Description	Unit	PCC	MCC	DB
g)	Bus connections silver plated / made with anti-oxide grease				
3.	**CIRCUIT BREAKER**				
a)	Make				
b)	Rated voltage & frequency	V & Hz			
c)	In-panel rating of following IEC rated breakers at 50°C design ambient temperature				
	• 4000A breaker	A			
	• 3200A breaker	A			
	• 2500A breaker	A			
	• 2000A breaker	A			
	• 1600A breaker	A			
	• 1250A breaker	A			
	• 1000A breaker	A			
	• 800A breaker	A			
	• 630A breaker	A			
d)	Short circuit withstand rating for 1 second	kA(rms)			
e)	Short circuit breaking current	kA(rms)			
f)	Short circuit making current	kA(peak)			
g)	Maximum temperature rise over 50°C ambient	°C			
h)	Rated operating duty				
i)	Total tripping time (max.)	ms			
j)	Total closing time (max.)	ms			
k)	No. of breaker operations permissible without requiring inspection, replacement of contacts and other main parts				
	At 100% rated current				
	At 100% rated interrupting current				
l)	Material of contacts				
	Main				
	Arcing				
m)	Thickness of silver plating	mm			
n)	Type of operating mechanism				
o)	VA burden & rated voltage for				
	• Spring charging motor	VA & V			

Sl. No.	Description	Unit	PCC	MCC	DB
	• Closing coil	VA & V			
	• Trip coil	VA & V			
4.	**Isolating Switch**				
a)	Make				
b)	Type				
c)	Rated voltage	V			
d)	Utilization category				
5.	**MCCB**				
a)	Make				
b)	Type				
c)	Rated voltage	V			
d)	Current rating				
e)	Short circuit current rating				
6.	**Power Contactors**				
a)	Make				
b)	Rated voltage	V			
c)	Coil voltages	V			
d)	Utilization category				
	• Reversible motor				
	• Non-reversible motor				
	• DC application				
7.	**Multi-function Meter**				
a)	Make				
b)	Type				
c)	Accuracy class				
d)	Measuring functions				
8.	**Energy Meter**				
a)	Make				
b)	Type				
c)	Accuracy class				
d)	Measuring functions				
9.	**Relays**				
a)	Type & make of motor protection relay				
b)	Type & make of feeder protection relay				
c)	Type & make of voltage relay				

Sl. No.	Description	Unit	PCC	MCC	DB
d)	Type & make of check synchronizing relay				
10.	**Local Push Button Stations**				
a)	Enclosure material & thickness				
b)	Degree of protection of enclosure				
11.	**Local Push Button Stations (Flame-proof Type)**				
a)	Enclosure material & thickness				
b)	Degree of protection of enclosure				
12.	**Local Motor Starters**				
c)	Enclosure material & thickness				
d)	Degree of protection of enclosure				
13.	**MPCB**				
e)	Make				
f)	Type				
g)	Rated voltage	V			
h)	Current rating				
i)	Short circuit current rating				
14.	**MCB**				
j)	Make				
k)	Type				
l)	Rated voltage	V			
m)	Current rating				
n)	Short circuit current rating				

Battery

S.No	Description	Unit	Data for Lead Acid Plante Battery
1	Manufacturer of battery		
2	Quantity	Nos.	
3	Applicable standard		
4	DC System Voltage	V	
5	Battery type		
6	Type of Container		
7	Type of the cell		
8	Cell designation as per IS		

S.No	Description	Unit	Data for Lead Acid Plante Battery
9	Cell dimensions	mmxmmx mm	
10	Weight of complete cell • Without electrolyte • With electrolyte	Kg	
11	Plates • No.of positive plates per cell • Types of positive plates • Types of negative plates		
12	No. of Cells per battery		
13	Rated cell voltage		
14	Ampere Hour rating	AH	
15	Battery capacity referred to a cell end voltage of 1.85	AH	
16	Load cycle duration	Hours	
17	10 hour rating at 27°C to 1.85V per cell	A	
18	Minimum cell voltage during duty cycle	1.85 V	
19	WH efficiency	>75 %	
20	AH efficiency at 10 hour discharge rate	> 90%	
21	Float charging (Volt / cell , Amp)	V,Amp	
22	Boost charging in 10 hours (Volt / cell , Amp) • Start • Finish	V,Amp	
23	Maximum short circuit current for a dead short across terminals	KA	
24	Internal resistance of • Battery • Each cell of battery	Ohm	
25	Taps provided of cell No.		
1	Internal resistance of each cell of battery	Ohm	
2	Mounting arrangement		
3	Racks • Material • No.of racks • Overall dimension of rack		

Battery Charger

S.No	Description	Unit	Data for Battery Charger
1	Manufacturer's name and address		
2	No. of Chargers	Nos.	
3	Type		
4	Battery charger rating (Current & Voltage) • Float • Boost	A / V	
5	Reference Standard		
6	Ambient temperature	°C	
7	DC System Voltage	V	
8	Degree of Protection of Panel		
9	AC Input rating		
	• Voltage	V	
	• Frequency	HZ	
	• AC input current –float mode	A	
	• AC input current –boost mode	A	
10	DC output rating		
	• Voltage - float mode	V	
	• Voltage - Boost mode	V	
	• c)current –float mode	A	
	• d)current –boost mode	A	
11	Percentage DC output voltage variation of the float charger for the corresponding input variation.		
12	Percentage DC output voltage variation of the Boost charger for the corresponding input variation.		
13	Ripple content in the DC output peak to peak • Float Charger • Boost Charger	%	
14	Battery charging current • Float mode • Boost Mode	A	
15	Maximum Boost Charging Current of Battery	A	

S.No	Description	Unit	Data for Battery Charger
16	Maximum Boost Charging Voltage of Battery	V	
17	Maximum time for Boost Charging of Battery	Hours	
18	Type of load limiting feature		
19	**Rectifier Transformer**		
	• Make		
	• Rating		
20	**Blocking diode**		
	• Make		
	• Current rating	A	
21	**SCR**		
	a) Make		
	b) Current rating	A	
22	**AC MCCB**		
	• Make		
	• Current Rating	A	
	• Breaking capacity		
23	**DC MCCB**		
	• Make		
	• Current Rating	A	
	• Breaking capacity		
24	Type of cooling		
25	Heat dissipation	W	
26	Efficiency of complete charger	%	
27	Type of sheet steel & Thickness of sheet metal	mm	
28	Dimensions in mm (LxDxH)	mxmxm	
29	Weight of complete panel	kg	
30	Paint shade • inside • Outside		

UPS Battery

S.No	Description	Unit	Discharge Resistor Data for Main Plant Battery
1	Make & Type		
2	Quantity		
3	Rating	A	
4	Resistor Material		
5	Temperature rise	ºC	
6	Degree of Protection		
7	Thickness of sheet metal	mm	
8	Dimensions in mm (LxDxH)	mxmxm	
9	Weight of complete panel	kg	

UPS Battery

S.No	Description	Unit	Data
1.	Manufacturer of battery		
2.	Quantity	Nos.	
3.	Applicable standard		
4.	DC System Voltage	V	
5.	Battery type		
6.	Type of Container		
7.	Type of the cell		
8.	Cell designation as per IS		
9.	Cell dimensions	mmxm mxmm	
10.	Weight of complete cell • Without electrolyte • With electrolyte	Kg	
11.	Plates • No.of positive plates per cell • Types of positive plates • Types of negative plates		
12.	No. of Cells per battery		
13.	Rated cell voltage		

S.No	Description	Unit	Data
14.	Ampere Hour rating	AH	
15.	Battery capacity referred to a cell end voltage	AH	
16.	Load cycle duration	Hours	
17.	10 hour rating at 27°C to 1.85V per cell / 5 hour rating at 27°C to 1.1V per cell	A	
18.	Minimum cell voltage during duty cycle		
19.	WH efficiency		
20.	AH efficiency		
21.	Float charging (Volt / cell , Amp)	V,Amp	
22.	Boost charging (Volt / cell , Amp) • Start • Finish	V,Amp	
23.	Maximum short circuit current for a dead short across terminals	KA	
24.	Internal resistance of • Battery • Each cell of battery	Ohm	
25.	Taps provided of cell No.		
26.	Internal resistance of each cell of battery	Ohm	
27.	Mounting arrangement		
28.	Racks • Material • No.of racks • Overall dimension of rack		

Discharge Resistor

S.No	Description	Unit	Discharge Resistor Data
1	Make & Type		
2	Quantity		
3	Rating	A	
4	Resistor Material		
5	Temperature rise	ºC	
6	Degree of Protection		

S.No	Description	Unit	Discharge Resistor Data
7	Thickness of sheet metal	mm	
8	Dimensions in mm (LxDxH)	mxmxm	
9	Weight of complete panel	kg	

UPS

Sl.No	Description	Unit	Data
1.	General		
a)	UPS rating	kVA/kW	
b)	Make		
c)	Make & place of manufacture		
d)	No. of UPS		
e)	Type		
f)	Reference Standard		
g)	In put AC Voltage with variation	V	
h)	Input Frequency , Hz with variation	Hz	
i)	Output Voltage with variation	V	
j)	Out put Frequency , Hz with variation	Hz	
k)	Design Ambient temperature		
l)	Efficiency of complete UPS (AC to AC)	%	
m)	DC System voltage	V	
n)	Total Harmonic distortion		
o)	Voltage regulation	%	
p)	Frequency regulation	%	
q)	Transient voltage regulation	%	
r)	Over load response of UPS		
s)	Dynamic response		
t)	Noise level	dB	
u)	Cooling		
v)	Communication interface		
w)	Heat dissipation	kW	

Sl.No	Description	Unit	Data
x)	Thickness of sheet metal		
y)	Dimensions in mm (LxDxH)		
z)	Weight of complete panel(kg)		
aa)	Paint shade – inside – out side		
bb)	List of protections/ indications/ metering/annunciations provided in UPS		
2.	**UPS Enclosure**		
a)	Material		
b)	Thickness of sheet		
c)	Degree of protection		
3.	**Charger/Rectifier**		
a)	Make		
b)	Type		
c)	Current rating		
d)	Voltage rating		
4.	**Static inverter**		
a)	Make		
b)	Type		
c)	Current rating		
d)	Voltage rating		
e)	AC output voltage variation		
f)	Guaranteed efficiency		
g)	Total harmonic content at rated load		
5.	**Static transfer switch**		
a)	Make		
b)	Type		
c)	Current Rating	A	
d)	Voltage rating	V	
e)	Transfer time	m.sec	
6.	**Manual by-pass switch**		
a)	Make		

Sl.No	Description	Unit	Data
b)	Type		
c)	Current Rating	A	
d)	Voltage rating	V	
7.	**Voltage stabilizer**		
a)	Make		
b)	Type		
c)	Capacity	kVA	
e)	Input voltage & no. of phase		
h)	Type of cooling		
i)	Class of insulation		
o)	Voltage regulation for input variation of +/- 10% and 0 to 100% load variation and PF 0.6 to 1.0		
p)	Servomotor drive details		
q)	Output Current at Rated voltage	A	
8.	**Input Transformer**		
a)	Make		
b)	KVA rating	kVA	
c)	Voltage ratio, frequency & no. of phase		
d)	Vector group		
e)	Insulation class		
f)	Rated current		
	Output Transformer		
a)	Make		
b)	KVA rating	kVA	
c)	Voltage ratio, frequency & no. of phase		
d)	Vector group		
e)	Insulation class		
f)	Rated current		
9.	**MCCB**		
a)	Make		

Sl.No	Description	Unit	Data
b)	Rating	A	
c)	Type		
10.	**HRC and Semiconductor Fuses**		
- a	Make		
b)	Type		
c)	Rating	A	
11.	**Cables**		
a)	Make		
b)	Type		
c)	Conductor material		
d)	Insulation material		
f)	Cable size between UPS-A & UPS-B	Sq.mm	
g)	Cable size between UPS & SCVS	Sq.mm	

HIGH VOLTAGE POWER CABLE

(Data shall be furnished for each voltage grade, each type and size of cable)

Sl.No	Description	Units	Data
1.	Make		
2.	Applicable standard		
3.	Cable size	Sq.mm	
4.	Rated voltage	V	
5.	Earthed/Unearthed grade		
6.	Continuous current rating at 50°C air ambient temperature (For single core cables rating shall be based on bonding screen at both the ends in trefoil form)	A	
7.	Continuous current rating at 40°C ground ambient temperature	A	
8.	Short circuit withstand current for 1 sec duration for		
a)	Conductor	kA rms	
b)	Metallic screen	kA rms	
9.	Conductor		
a)	Material		
b)	Grade		

Sl.No	Description	Units	Data
c)	Nominal cross sectional area	Sq.mm	
10.	Conductor screening		
a)	Material and type		
b)	Approx. thickness of extruded layer	mm	
11.	Insulation		
a)	Nominal thickness of insulation	mm	
b)	Type of curing		
c)	Identification of cores		
12.	Type of extrusion		
13.	Insulation screening		
a)	Material and type		
b)	Approx. thickness of extruded layer	mm	
14.	Metallic Screen		
a)	Material		
b)	Cross section area of screen		
15.	Inner sheath		
a)	Material		
b)	Thickness of sheath (min)	mm	
c)	Extruded or not		
16.	Armour		
a)	Type of material of armour wire		
b)	Dimension of wire	mm x mm	
c)	No. of armour wires		
17.	Outer sheath		
a)	Material and type		
b)	Thickness of sheath	mm	
c)	Minimum Oxygen index		
d)	Minimum Temperature index		
e)	Maximum Smoke Density		
f)	Light Transmission		
g)	Maximum Acid gas emission		
18.	Overall diameters of cable	mm	
19.	Cable Drums		
a)	Type		
b)	Material		

LOW VOLTAGE POWER CABLE
(Data shall be furnished for each type and size of cable)

Sl.No	Description	Units	Data
1.	Make		
2.	Applicable standard		
3.	Cable size	Sq.mm	
4.	Rated voltage	V	
5.	Continuous current rating at 50°C air ambient temperature (For single core cables rating shall be for trefoil form)	A	
6.	Continuous current rating at 40°C ground ambient temperature	A	
7.	Conductor		
a)	Material		
b)	Grade		
c)	Nominal cross sectional area	Sq.mm	
8.	Insulation		
a)	Nominal thickness of insulation	mm	
b)	Type of curing		
9.	Inner sheath		
a)	Material		
b)	Thickness of sheath (min)	mm	
c)	Extruded or not		
10.	Armour		
a)	Type of material of armour wire		
b)	Dimension of wire	mm x mm	
c)	No. of armour wires		
11.	Outer sheath		
a)	Material and type		
b)	Thickness of sheath	mm	
c)	Colour of sheath		
d)	Minimum Oxygen index		
e)	Minimum Temperature index		
f)	Maximum Smoke Density		
g)	Light Transmission		
h)	Maximum Acid gas emission		

Sl.No	Description	Units	Data
12.	Overall diameters of cable	mm	
13.	Cable Drums		
a)	Type		
b)	Material		
14.	Additional data for Fire survival cables		
a)	Conductor material		
b)	Insulation material		
c)	Inner sheath material		
d)	Armour material		
e)	Outer sheath material		
f)	Fire withstand rating as per IEC:60331		

CONTROL CABLE
(Data shall be furnished for each type and size of cable)

Sl.No.	Description	Units	Data
1.	Make		
2.	Applicable standard		
3.	Cable size	Sq.mm	
4.	Rated voltage	V	
5.	Continuous current rating at 50°C air ambient temperature	A	
6.	Continuous current rating at 40°C ground ambient temperature	A	
7.	Conductor		
a)	Material		
b)	Grade		
c)	Nominal cross sectional area	Sq.mm	
d)	Conductor strands	Nos./mm	
8.	Insulation		
a)	Nominal thickness of insulation	mm	
b)	Identification of cores		
9.	Inner sheath		
a)	Material		
b)	Thickness of sheath (min)	mm	
c)	Extruded or not		

Sl.No.	Description	Units	Data
10.	Armour		
a)	Type of material of armour wire		
b)	Dimension of wire	mm x mm	
c)	No. of armour wires		
11.	Outer sheath		
a)	Material and type		
b)	Thickness of sheath	mm	
c)	Colour of sheath		
d)	Minimum Oxygen index		
e)	Minimum Temperature index		
f)	Maximum Smoke Density		
g)	Light Transmission		
h)	Maximum Acid gas emission		
12.	Overall diameters of cable	mm	
13.	Cable Drums		
a)	Type		
b)	Material		
14.	**Additional data for overall screened cables**		
a)	Thickness and coverage of polyester tape	mm and %	
b)	Thickness and coverage of Al-mylar tape	mm and %	
c)	Size of ATC drain wire	mm x mm	
d)	Core to core capacitance	µF	
e)	Core to screen capacitance	µF	
f)	L/R ratio		
g)	Drain wire resistance	Ω/kM	
15.	**Additional data for individually screened and overall screened cables**		
a)	Thickness and coverage of polyester tape for individual screen	mm	
b)	Thickness and coverage of Al-mylar tape for individual screen	mm	
c)	Size of ATC drain wire for individual screen	mm x mm	
d)	Core to core capacitance	µF	
e)	Core to screen capacitance	µF	

Sl.No.	Description	Units	Data
f)	L/R ratio		
g)	Drain wire resistance for individual screen	Ω/kM	
h)	Thickness and coverage of polyester tape for overall screen	mm	
i)	Thickness and coverage of Al-mylar tape for overall screen	mm	
j)	Size of ATC drain wire for overall screen	mm x mm	
k)	Drain wire resistance for overall screen	Ω/kM	

ILLUMINATION SYSTEM

Sl.No.	Description	Unit	Data
1	**LED Medium Bay Luminaire**		
a)	Make		
b)	Catalogue no.		
2	**LED Integral type Well glass Luminaire.**		
a)	Make		
b)	Catalogue no.		
3	**LED Integral type Well glass Luminaire**		
a)	Make		
b)	Catalogue no.		
4	**LED Integral type Well glass Luminaire**		
a)	Make		
b)	Catalogue no.		
5	**LED Low bay type Luminaire**		
a)	Make		
b)	Catalogue no.		
6	**Flame proof Luminaire**		
a)	Make		
b)	Catalogue no.		
c)	Degree of protection		
7	**general purpose rail type LED luminaire**		

Sl.No.	Description	Unit	Data
a)	Make		
b)	Catalogue no.		
8	**Industrial trough type LED luminaire**		
a)	Make		
b)	Catalogue no.		
9	**Corrosion proof type LED luminaire**		
a)	Make		
b)	Catalogue no.		
10	**Dust proof & jet proof LED luminaire**		
a)	Make		
b)	Catalogue no.		
11	**Commercial Mirror optics type surface mounting LED luminaire**		
a)	Make		
b)	Catalogue no.		
12	**Commercial Mirror optics type recess mounting LED luminaire for luxalon ceiling.**		
a)	Make		
b)	Catalogue no.		
13	**Commercial low glare Mirror optics type recess mounting LED luminaire for luxalon ceiling.**		
a)	Make		
b)	Catalogue no.		
14	**LED Street lighting Luminaire.**		
a)	Make		
b)	Catalogue no.		
15	**LED flood lighting Luminaire complete with control gear box.**		
a)	Make		
b)	Catalogue no.		
16	**LED Lamps(to be furnished for each rating)**		
a)	Make		
b)	Type		

Sl.No.	Description	Unit	Data
c)	Lumen output (for each rating)	Lumens	
17	**Lighting Panel (to be furnished for each type)**		
a)	Make & Place of manufacture		
b)	Degree of protection		
c)	Rating & type of incomer	A	
d)	Rating & type of outgoing feeders	A	
e)	Short circuit rating of MCB		
18	**Street Lighting Panel**		
a)	Make & Place of manufacture		
b)	Degree of protection		
c)	Rating & type of incomer	A	
d)	Rating & type of outgoing feeders	A	
e)	Rating of contactor	A	
f)	Short circuit rating of MCB		
19	**Switch box**		
a)	Make & Place of manufacture		
b)	Material of enclosure		
c)	Type, model no. & rating of Switches	A	
d)	Type, model no. & rating of socket	A	
20	**Receptacle Panel (to be furnished for each type)**		
a)	Make & Place of manufacture		
b)	Material of enclosure		
c)	Degree of protection		
d)	Rating & type of incomer	A	
e)	Rating & type of outgoing feeders	A	
f)	Short circuit rating of MCB		
21	**6/16A commercial Receptacles**		
a)	Make & Place of manufacture		
b)	Type & model no.		
c)	Type & rating of switch	A	
d)	Type & rating of receptacle	A	
22	**20A industrial Receptacles of each type**		
a)	Make & Place of manufacture		

Sl.No.	Description	Unit	Data
b)	Type of enclosure		
c)	Degree of protection		
d)	Type & rating of MCB	A	
e)	Type & rating of receptacle	A	
23	**63A industrial Receptacles of each type**		
a)	Make & Place of manufacture		
b)	Type of enclosure		
c)	Degree of protection		
d)	Type & rating of switch & fuse	A	
e)	Type & rating of receptacle	A	
24	**Lighting poles**		
a)	Make & Place of manufacture		
b)	Type & material		
c)	Height		
d)	Weight	kg	
e)	Diameter	mm	
f)	Bracket length	mm	
g)	Thickness of galvanizing		
25	**Lighting Mast**		
a)	Make & Place of manufacture		
b)	Type		
c)	Height	M	
d)	Weight	kg	
e)	Thickness of galvanizing		
f)	Type & rating winch motor		
26	**Wires**		
a)	Make & Place of manufacture		
b)	Conductor material & size	Sq.mm	
c)	Applicable standard		
27	**Wire way duct**		
a)	Make & Place of manufacture		
b)	Type		
c)	Size	mm	
d)	Applicable standard		
e)	Material		

Sl.No.	Description	Unit	Data
f)	Standard length		
g)	Thickness		
28	**Rigid steel Conduit**		
a)	Make & Place of manufacture		
b)	Size	mm	
c)	Applicable standard		
d)	Material		
e)	Duty		
f)	Thickness of galvanizing		
29	**Conduit Fittings**		
a)	Make & Place of manufacture		
b)	Applicable standard		
c)	Material		
d)	Thickness of galvanizing		
30	**Flexible steel Conduit**		
a)	Make & Place of manufacture		
b)	Size	mm	
c)	Applicable standard		
d)	Material		
31	**Junction Boxes (To be furnished for each type)**		
1.0	Make & Place of manufacture		
1.0	Type of enclosure		
1.0	Degree of protection		
1.0	Type & rating terminal blocks		
32	**Portable emergency Lantern**		
a)	Make & Place of manufacture		
b)	Rating of lamp		
c)	Type & rating of battery		
d)	Back up lighting time		
e)	Type of enclosure		
33	**Ceiling Fans**		
a)	Make & Place of manufacture		
b)	Type & Size		
c)	Power rating		
d)	Make & type of electronic regulator		

Sl.No.	Description	Unit	Data
34	**Pedestal Fans**		
a)	Make & Place of manufacture		
b)	Type & Size		
c)	Power rating		
d)	Make & type of electronic regulator		
35	**AC MLDB/ DCELDB**		
a)	Make		
b)	Reference standard(s)		
c)	Rated voltage & frequency	V & Hz	
d)	Short circuit withstand rating for 1 second	kA(rms)	
e)	Dynamic short circuit withstand rating	kA(peak)	
f)	Degree of Protection		
g)	Type of steel		
h)	Busbar Material & grade		
i)	Maximum temperature rise over 50°C	°C	
j)	Short circuit withstand rating for 1 second	kA(rms)	
k)	Dynamic short circuit withstand rating	kA(peak)	
36	**Lighting transformer**		
a)	Make		
b)	Type		
c)	kVA rating		
d)	Rated voltage ratio	V	
a)	Winding Insulation		
a)	Temperature rise		
a)	Winding material		
b)	Total loss		

Cable Trays

Sl.No.	Description	Offered Data			
		600 mm	450 mm	300 mm	150 mm
1	**General**				
a)	Name of the Supplier				
b)	Place of manufacture				
c)	Material				
d)	Thickness of Galvanising				
2	**Ladder type Tray**				
a)	Standard length				
b)	Sheet steel thickness				
c)	Tray Height				
d)	Weight per meter				
e)	Rung spacing				
3	**Perforated type Tray**				
a)	Standard length				
b)	Sheet steel thickness				
c)	Tray Height				
d)	Weight per meter				
4	**Tray Cover**				
a)	Standard length				
b)	Sheet steel thickness				
c)	Weight per meter				
5	**Coupler plate**				
a)	Size				
b)	Sheet steel thickness				
6	**Bends**				
a)	Sheet steel thickness				
b)	Height				
c)	Bending radius				
d)	Weight				
7	**Tees**				
a)	Sheet steel thickness				
b)	Height				
c)	Bending radius				
d)	Weight				

Sl.No.	Description	Offered Data			
		600 mm	450 mm	300 mm	150 mm
8	**Cross**				
a)	Sheet steel thickness				
b)	Height				
c)	Bending radius				
d)	Weight				
9	**Reducers**				
a)	Sheet steel thickness				
b)	Height				
c)	Bending radius				
d)	Weight				
10	**Elbows**				
a)	Sheet steel thickness				
b)	Height				
c)	Bending radius				
d)	Weight				
11	**Hardwares**				
a)	Material				
b)	Thickness of Galvanising				
12	**Cable tray support system**				
a)	Name of the Supplier				
b)	Type				
c)	Material				
d)	Thickness of Galvanising				

Cabling Accessories

Sl.No.	Description	Offered Data
1	**TERMINATION KITS**	
a)	Make:	
b)	Type:	
c)	Voltage Grade & Size:	
d)	Kit no. as per catalogue	
2	**STRAIGHT THROUGH JOINTS**	
a)	Make:	
e)	Type:	
f)	Voltage Grade & Size:	

Sl.No.	Description	Offered Data
g)	Kit no. as per catalogue	
3	**CABLE GLANDS**	
a)	Make of gland:	
b)	Standards Applicable	
c)	Type of compression	
d)	Material:	
e)	Type of surface finish	
4	**CABLE LUGS**	
a)	Make of lugs:	
b)	Standards Applicable	
c)	Type	
d)	Material:	
e)	Whether tinning provided for copper lugs	
5	**EARTHING MATERIAL**	
a)	Make	
b)	Standards Applicable	
c)	Weight of zinc coating	
	• For flats 5mm thick and over	
	• For flats under 5mm thickness	
	• For wires	
6	**LIGHTNING PROTECTION SYSTEM**	
a)	Make	
b)	Standards Applicable	
c)	Weight of zinc coating	
	• For flats 5mm thick and over	
	• For flats under 5mm thickness	
	• For rods	
7	**TREFOIL CLAMPS**	
a)	Material	
b)	Type	
c)	Size	
d)	Short circuit withstand rating	

Sl.No.	Description	Offered Data
8	**OMEGA CLAMPS**	
a)	Make	
b)	Material and type	
c)	Surface Treatment of steel clamps	
d)	Minimum thickness of Galvanization	
9	Nylon self locking tie strips	
a)	Width (mm)	
b)	Tensile Strength (kg)	
10	**STRIP CLAMPS**	
a)	Make	
b)	Material and type	
c)	Surface Treatment of steel clamps	
d)	Minimum thickness of Galvanization	
11	**FIRE STOP SEAL SYSTEM**	
a)	Make & Place of manufacture	
b)	Type	
c)	Fire rating	
d)	Applicable standards for testing	
e)	Type of system	
f)	Fire rating	
g)	Major Components of sealing system	

Communication System

Sl. No	Description	Unit	Data
1.	**EPABX System**		
2.	Manufacturer		
3.	Type		
4.	Name of the Collaborator		
5.	Place of manufacture		
6.	**Telephone Exchange**		
a)	Type		
b)	Model No.		
c)	Capacity • Extensions • External lines		

Sl. No	Description	Unit	Data
a)	Power Consumption		
b)	Voltage rating of auxiliary supply to EPABX system	V	
c)	Overall Dimensions		
d)	Type of enclosure		
e)	Degree of protection		
f)	Thickness of enclosure		
g)	List of features provided		
h)	Paint finish		
7.	**Operator Console**		
a)	Type		
b)	Make		
c)	Model No.		
d)	Overall Dimensions		
e)	Type of enclosure		
i)	List of features provided		
8.	**Maintenance PC**		
a)	Type		
b)	Make		
c)	Model No.		
d)	Rating, Capacity		
e)	List of features provided		
9.	**Standard Analog telephone (Desk mounted)**		
a)	Type		
b)	Model No.		
c)	Overall Dimensions		
d)	Material of enclosure		
e)	List of features provided		
f)	List of operating keys		
g)	Colour		
10.	**Standard Analog telephone (Wall mounted)**		
a)	Type		
b)	Model No.		
c)	Overall Dimensions		
d)	Material of enclosure		

Sl. No	Description	Unit	Data
e)	List of features provided		
f)	List of operating keys		
g)	Colour		
11.	**Flame proof Analog telephone (Wall mounted)**		
a)	Type		
b)	Model No.		
c)	Overall Dimensions		
d)	Material of enclosure		
e)	List of features provided		
f)	List of operating keys		
g)	Colour		
12.	**Digital telephone (Desk mounted)**		
a)	Type		
b)	Model No.		
c)	Overall Dimensions		
d)	Material of enclosure		
e)	List of features provided		
f)	List of operating keys		
g)	Colour		
13.	**Chief / Secretary telephone**		
a)	Type		
b)	Model No.		
c)	Overall Dimensions		
d)	Material of enclosure		
e)	List of features provided		
f)	List of operating keys		
g)	Colour		
h)	Speaker rating		
14.	**Battery & Charger**		
a)	Type of battery		
b)	AH rating	AH	
c)	Backup time	Hours	
d)	Cell voltage	V	
e)	No. of cells		
f)	Make		

Sl. No	Description	Unit	Data
g)	Cell dimensions		
h)	Type of battery rack		
i)	Charger rating	A	
j)	Make & type of charger		
k)	Charger voltage rating	V	
15.	**Main Distribution Frame**		
a)	Make		
b)	Overall Dimensions		
c)	Type of enclosure		
d)	Degree of protection		
e)	Thickness of enclosure		
f)	Paint finish		
g)	Terminal block type & Make		
16.	**Junction Box**		
a)	Make		
b)	Overall Dimensions		
c)	Type of enclosure		
d)	Degree of protection		
e)	Terminal block type & Make		
f)	No. of terminals & size		
17.	**Telephone Tag Box**		
a)	Make		
b)	Overall Dimensions		
c)	Type of enclosure		
d)	Degree of protection		
e)	Terminal block type & Make		
f)	No. of terminals & size		
18.	**Power Cables**		
a)	Make		
b)	Type		
c)	Reference standard		
d)	Conductor material & size		
e)	Insulation material & thickness		
f)	Shielding		
g)	Inner sheath material		
h)	Armouring material		

Sl. No	Description	Unit	Data
i)	Outer sheath material		
j)	Cable parameters		
	• Resistance	ohm / km	
	• Reactance	ohm / km	
19.	**Telecom Cables (outdoor application)**		
a)	Make		
b)	Type		
c)	Reference standard		
d)	Conductor material & size		
e)	Insulation material & thickness		
f)	Jelly filled	Yes/No	
g)	Shielding		
h)	Inner sheath material		
i)	Armouring material		
j)	Outer sheath material		
k)	Cable parameters		
	• Resistance	ohm / km	
	• Reactance	ohm / km	
	• Capacitance	uF / km	
20.	**Telecom Cables (indoor application)**		
a)	Make		
b)	Type		
c)	Reference standard		
d)	Conductor material & size		
e)	Insulation material & thickness		
f)	Jelly filled	Yes/No	
g)	Shielding		
h)	Inner sheath material		
i)	Armouring material		
j)	Outer sheath material		
k)	Cable parameters		
	• Resistance	ohm / km	
	• Reactance	ohm / km	
	• Capacitance	uF / km	

Sl. No	Description	Unit	Data
21.	**Conduits**		
a)	Make		
b)	Type		
c)	Standard		
d)	Size	mm	

Elevator

S.No	Description	Unit	Data Elevator for FGD
1	**GENERAL**		
a)	Manufacturer		
b)	Place of manufacture		
c)	Applicable standard		
d)	Type of elevator		
e)	Capacity	Kg	
f)	Quantity	Nos.	
g)	Speed of elevator	M/Min	
h)	Number of floors served		
i)	Travel	Metres	
j)	Lift well size		
k)	Pit depth		
l)	Minimum over head		
m)	Machine room size(DXW)		
n)	Height of machine room		
2.0	**ELEVATOR CAR**		
a)	Dimensions (internal)	MXMXM	
b)	Dimensions (external)	MXMXM	
c)	Finish(inside)	-	
d)	Platform size	MXM	
e)	Door opening size	MXM	
3.0	**Hoist Motor**		
a)	Make		

S.No	Description	Unit	Data Elevator for FGD
b)	Rating	kW	
4.0	**VVVF drive for Hoist motor**		
a)	Make		
b)	Rating		
c)	Model no.		
5.0	**VVVF drive for door motor**		
a)	Make		
b)	Rating		
c)	Model no.		
6.0	**Controller panel**		
a)	Make		
b)	Type		
c)	Enclosure protection		
d)	Thickness of sheet steel	mm	
e)	Overall dimensions	MXMXM	
f)	List of devices provided		

HT Motors

(To be furnished for each rating of Motor)

Sl.No.	Description	Unit	11kV motor
1.	Make and place of manufacture		
2.	Application		
3.	Type of motor		
4.	Frame size		
5.	Required BKW rating of the driven equipment	kW	
6.	Design margin considered	%	
7.	Rated continuous output of motor at 50°C ambient	kW	
8.	Starting current at rated voltage	% of FLC	
9.	No. of hot / cold starts		
10.	Degree of protection of enclosure		

Sl.No.	Description	Unit	11kV motor
11.	Method of cooling		
12.	Insulation class		
13.	Temperature rise over 50°C ambient. (by resistance)	°C	
14.	Motor terminal box		
	• Type		
	• Fault withstand current and time		

LT Motors

(To be furnished for each rating of Motor)

Sl.No.	Description	Specified Data	Details by Bidder
1.	Make and place of manufacture		
2.	Application		
3.	Quantity		
4.	Type of motor	Squirrel cage	
5.	Duty	S1	
6.	Applicable standard	IS:325	
7.	Frame size		
8.	Required BKW rating of the driven equipment	….kW	
9.	Design margin considered	Minimum 10%	
10.	Rated continuous output of motor at 50°C ambient	…..kW	
11.	Rated voltage and frequency	415V, 50Hz	
12.	Full load current	….. Amps	
13.	Efficiency at 100% load	%	
14.	Energy efficient rating		
15.	Type of starting	DOL	
16.	No. of hot / cold starts	3/2	
17.	Degree of protection of enclosure	IP55	

Sl.No.	Description	Specified Data	Details by Bidder
18.	Method of cooling	TEFC	
19.	Insulation class	F	
20.	Temperature rise over 50°C ambient. (by resistance)	70°C	
21.	Electric Actuator		
	• Make		
	• Type (with integral starter)		
	• Model no.		
	• Rating		

Public Address System (PAS)

Sl No.	Description	Unit	Data
1.	**MASTER STATION**		
a)	Make and country of origin		
b)	Type / Model no.		
c)	Material of construction for enclosure		
d)	Degree of protection		
e)	Rated voltage / frequency		
2.	**CENTRAL EXCHANGE**		
a)	Make and country of origin		
b)	Type / Model no.		
c)	Material of construction for enclosure		
d)	Degree of protection		
e)	Rated voltage / frequency		
3.	**Power distribution panel**		
a)	Make		
b)	Size		
c)	Material of construction for enclosure		
d)	Degree of protection		
e)	List of devices provided	Hz	

Sl No.	Description	Unit	Data
4.	**Main DB for signal**		
a)	Make		
b)	Size		
c)	Material of construction for enclosure		
d)	Degree of protection		
e)	List of devices provided	Hz	
5.	**Sub DB for signal**		
a)	Make		
b)	Size		
c)	Material of construction for enclosure		
d)	Degree of protection		
e)	List of devices provided	Hz	
6.	**INDOOR HAND SET STATION**		
a)	Make		
b)	Type / Model no.		
c)	Material of construction for enclosure		
d)	Power consumption /Power output	W	
e)	Degree of protection		
7.	**OUTDOOR HAND SET STATION**		
a)	Make		
b)	Type / Model no.		
c)	Material of construction for enclosure		
d)	Power consumption /Power output		
e)	Degree of protection	W	
8.	**FLAME PROOF HAND SET STATION**		
a)	Make		
b)	Type / Model no.		
c)	Material of construction for enclosure		

Sl No.	Description	Unit	Data
d)	Power consumption /Power output		
e)	Degree of protection	W	
9.	**MICROPHONE PREAMPLIFIER**		
a)	Make		
b)	Amplifier class		
c)	Rated output – Nom/ max.	Volt	
10.	**SPEAKER POWER AMPLIFIER**		
a)	Make		
b)	Catalogue No.		
c)	Amplifier class		
d)	Rated output RMS/peak	Watt	
11.	**RE-ENTRANT HORN SPEAKER**		
a)	Make	:	
b)	Catalogue No.	:	
c)	Power Handling capacity		
	• RMS	Watt	
	• Peak	Watt	
12.	**CONE TYPE SPEAKER**		
a)	Make		
b)	Catalogue No.		
c)	Power Handling capacity		
	• RMS	Watt	
	• Peak	Watt	
d)	Speaker size	mm	
13.	**TONE GENERATOR**		
a)	Make		
b)	Model no.		
14.	**Power Cables**		
a)	Make		
b)	Size		
c)	Estimated quantity		
d)	Reference standard		
e)	Conductor material and size		
f)	Insulation material and insulation thickness		
g)	Inner sheath material		

Sl No.	Description	Unit	Data
h)	Armoring material		
i)	Outer sheath material		
15.	**Control Cables**		
a)	Make		
b)	Size		
c)	Estimated quantity		
d)	Reference standard		
e)	Conductor material and size		
f)	Insulation material and insulation thickness		
g)	Shield material and insulation thickness		
h)	Inner sheath material		
i)	Armoring material		
j)	Outer sheath material		
16.	**Signal Cables**		
a)	Make		
b)	Size		
c)	Estimated quantity		
d)	Reference standard		
e)	Conductor material and size		
f)	Insulation material and insulation thickness		
g)	Shield material and insulation thickness		
h)	Inner sheath material		
i)	Armoring material		
j)	Outer sheath material		
17.	**Speaker Cables**		
a)	Make		
b)	Size		
c)	Estimated quantity		
d)	Reference standard		
e)	Conductor material and size		
f)	Insulation material and insulation thickness		
g)	Shield material and insulation thickness		

Sl No.	Description	Unit	Data
h)	Inner sheath material		
i)	Armoring material		
j)	Outer sheath material		
18.	**VHF Set**		
a)	Make		
b)	Type		
c)	Model no.		
d)	Operating Frequency	Hz	
e)	Maximum distance between sets	Mtr	

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 4

DEVIATION SCHEDULE TO COMMERCIAL SPECIFICATION

All deviations from the Commercial Specifications shall be filled in by the Bidder clause by clause in this schedule.

SL NO	VOLUME / SECTION	CLAUSE NO.	DESCRIPTION	DEVIATION	REASON FOR DEVIATION

The Bidder hereby certifies that the above mentioned are the only deviations from the Owner*s Commercial Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder*s proposal and accompanying documents including drawings, catalogues, etc., are at variance with the specific requirements laid out in the Owner*s Commercial Specifications, then the latter shall govern and shall be binding on the Bidder for the quoted price.

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 5

DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION

All deviations from the Technical Specifications shall be filled in by the Bidder clause by clause in this schedule.

SL NO	VOLUME / SECTION	CLAUSE NO.	DESCRIPTION	DEVIATION	REASON FOR DEVIATION

The Bidder hereby certifies that the above mentioned are the only deviations from the Owner*s Technical Specifications for this enquiry. The Bidder further confirms that in the event any other data and information presented in the Bidder*s proposal and accompanying documents including drawings, catalogues, etc., are at variance with the specific requirements laid out in the Owner*s Technical Specifications, then the latter shall govern and shall be binding on the Bidder for the quoted price.

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 6

SCHEDULE OF SUB-VENDORS / SUB-CONTRACTORS LIST

Sl. No.	Equipment/Item	Sub Vendor/Sub Contractor	Place	Experience Details

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 7

QUALITY ASSURANCE PLAN

SL. NO.	COMPONENT	CHARACTERISTIC CHECKED	CLASSIFI-CTION	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENTS	ACCEPTANCE NORM	FORMAT OF RECORD	INSPECTION BY			REMARKS
									P	W	V	
1	2	3	4	5	6	7	8	9	10			11

LEGENDS : P- PERFORMANCE, W-WITNESS, V-VERIFY, 1-CONSULTANT, 2-VENDOR, 3-OWNER

SCHEDULE – 8

DETAILS OF SIMILAR WORKS DONE DURING PAST FIVE YEARS

Sl. No.	Full postal address of client & name of officer-in-charge with Telex/Tel. No.	Description of the work (shall indicate parameters)	Value of contract	Completion time as stated	Date of commencement of work	Actual completion time (Month)	Month & year of completion
1	2	3	4	5	6	7	8

Certified that documentary proof for above information shall be enclosed

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 9

CONCURRENT COMMITMENTS OF THE BIDDER

Sl. No.	Full postal address of client & name of officer-in-charge	Description of the work	Value of contract	Date of commencement of work	Schedule completion period	% of completion as on date	Expected date of completion
1	2	3	4	5	6	7	8

Certified that documentary proof for above information is enclosed

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 10

UTILITY CONSUMPTION LIST

Sl. No.	System / Equipment	Quantity	Quantity per Operation Mode		Electricity (KW)		Cooling Water (M3/HR) kg/cm^2 (g)		Filtered Water (M3/HR) kg/cm^2 (g)		Limestone (Kg/hr) kg/cm^2 (g)		Gypsum kg/cm^2 (g)	
			C	I	C	I	C	I	C	I	C	I	C	I

C – Continuous
I – Intermittent
T – Operating Hours per 24 Hours

SIGNATURE OF BIDDER _____
NAME _____

SEAL OF THE COMPANY

DESIGNATION _____

COMPANY _____

DATE _____

SCHEDULE – 11

LUBRICANTS LIST

ITEM NO.						EQUIPMENT				
Sl. No.	GRADE	MAKER'S BRAND				INTIAL CHARGE (L/SET)	REPLACEMENT CHARGE		MAKE-UP		LOCATION TO BE USED
		CALTEX	MOBILE	ESSO	SHELL		QUANTITY (L/SET)	INTERVAL	QUANTITY	INTERVAL	

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY

DESIGNATION _____

COMPANY _____

DATE _____

SCHEDULE – 12

OVERALL TIME SCHEDULE

(Bidder to fill-in and submit with his Bid)

Sl.no	Work Description		
		Start	Finish
1.0	**Design and Engineering**		
a)	Civil		
b)	Structural		
c)	Mechanical		
d)	Electrical		
e)	Refractory		
f)	C & I		
2.0	**Manufacture**		
a)	Technological Structure		
b)	Mechanical		
c)	Electrical		
d)	Refractory		
e)	C & I		
3.1	**Delivery at Site (FOB portion)**		
a)	Foundation bolts and inserts		
b)	Mechanical equipment		
c)	Electrical equipment		
d)	Control and Instrumentation equipment		
e)	Technological Structure		
f)	Refractories		
3.2	**Delivery at Site (Ex-works portion)**		
a)	Foundation bolts and inserts		
b)	Mechanical equipment		
c)	Electrical equipment		

Sl.no	Work Description		
		Start	Finish
d)	Control and Instrumentation equipment		
e)	Technological Structure		
f)	Refractory		
4.0	Dismantling work		
5.0	Civil work at site		
6.0	Refractory work		
7.0	Structural fabrication		
8.0	Structural erection		
9.0	Equipment erection		
10.0	Start-up, trial run and commissioning		
10.1	Mechanical Completion		
10.2	Preliminary operation		
10.3	Initial operation		
10.4	Trial operation		
11.0	**Performance guarantee tests**		

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 13

REQUIREMENTS OF THE CONTRACTOR AT SITE

(Bidder to fill and return with his Bid)

The Bidder shall state his requirements against each of the following including the basis of requirements :

A.	**Requirements**					
1.0	**Land for Site fabrication work, Stores, Site office, etc.**					
	Area Requirement					
1.1	For site fabrication	Sq. m				
1.2	For stores	Sq. m				
1.3	For site office	Sq. m				
1.4	For others	Sq. m				
2.0	**Construction Power (in kVA)**	**Months**				
		0-6	06-12	12-18	18-24	24-30
	Power Requirement					
3.0	**Construction Water (in cu. m/day)**	**Months**				
		0-6	6-12	12-18	18-24	24-30
	Water Requirement					
B.	**Basis of Requirements**					
1.	Land					
2.	Construction Power					
3.	Construction Water					

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 14

CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE

A) Construction Equipment

The bidder shall indicate the schedule of construction equipment he proposes to deploy at the site for executing the works as per the proforma below.

1.0	**Erection Equipments**	**Months**										
		1	2	3	4	5						24
1.1	Mobile Crane											
1.2	Welding Machine											
1.3	Pulling and Lifting Machine											
1.4	Hand Operated Winches											
1.5	Road Rollers											
1.6	Hydraulic Excavator											
1.7	Tippers/ Dumpers											
1.8	Diesel Generator Welding Machine											
1.9	Water Tankers											
1.10	Pipe Bending Machine											
1.11	Gas Welding Set											
1.12	DG Set											
1.13	Concrete Mixer Unit											
1.14	Portable Jib Crane											
1.15	Others as applicable for the work (bidder shall indicate).											

B) RESOURCE DEPLOYMENT SCHEDULE

The bidder shall indicate the schedule of manpower resources he proposes to deploy at the site for executing the works as per the proforma below.

Sl. no	Type of Resources	Months								
		1	2	3	4					24
2.0	**Human Resources**									
2.1	**Engineering Category**									
2.1.1	Project Engg.									
2.1.2	Mech. Engg.									
2.1.3	Elect Engg.									
2.1.4	Civil Engg.	**	**	**	**					
2.1.5	Inst. Engg.									
2.1.6	Comm. Engg.						**			
2.1.7	Structural Engg.									
2.1.8	Others as applicable for the work (bidder shall indicate).									
2.2	**Supervisory Category**									
2.2.1	Constn. Manager	**	**	**	**	**	**	**	**	**
2.2.2	Elect. Supervisor									
2.2.3	Mech. Supervisor									
2.2.4	Inst. Supervisor									
2.2.5	Civil Supervisor									
2.2.6	Purchase Officer									
2.2.7	Finance/ Site Office									
2.2.8	Inspection/QC									
2.2.9	Others as applicable for the work (Bidder shall indicate).									
2.3	**Labour Category**									
2.3.1	Welder									
2.3.2	Fitter									

Sl. no	Type of Resources	Months								
		1	2	3	4					24
2.3.3	Rigger									
2.3.4	Un-Skilled labour									
2.3.5	Others as applicable for the work (bidder shall indicate).									
2.4	**Foreign supervisory personnel for**									
2.4.1	Supervision of Erection									
2.4.2	Commissioning									
2.4.3	Performance Testing									
2.4.4	From Provisional Takeover upto completion of Warranty period Refer Note –5 below.									

NOTE:

1. The above charts are only indicative (sample) and bidder shall indicate their list of human resources and the list of erection equipments as applicable to the project and their mobilisation period shall also be indicated in the charts.

2. (**) – Sample for resource deployment duration is indicated in this table.

3. Organization and Manpower Deployment

   The Bidder shall also submit:

   a) Number of engineers with details, he proposes to deploy at his head office for design and engineering and for equipment procurement and follow –up including bio data of his personnel.

   b) Site organization chart with details and Bio-data of the site in charge and other key personnel.

   c) Details of safety organization he proposes to deploy at site.

4. Bidder shall indicate the details of initial mobilization at site, which will be mutually discussed and finalized with the successful bidder before award of the Contract. It is the responsibility of the successful bidder to mobilize all additional resources, if the progress is slow or to make up the delay already occurred in order to match the completion schedule.

5. BIDDER shall add suitable number of rows in this schedule to indicate number of personnel to indicate the details

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 15

SCHEDULE OF WEIGHTS AND DIMENSIONS

The BIDDER shall state hereunder the weights and dimensions of various packages for shipment comprising the complete scope.

Description	Dimensions (In Metres) L x B x H	Weight (In Tonnes)
1	2	3

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 16

SCHEDULE OF PLACES OF TEST AND INSPECTION

The Bidder shall indicate the item of Equipment to be supplied, name of the Manufacturer or Sub-Contractor and place of test and inspection as shown below:

Item of Equipment	Manufacturer/Sub-Contractor	Place of test and Inspection
1	2	3

SIGNATURE _____

OF BIDDER
NAME _____

SEAL OF THE COMPANY

DESIGNATION _____

COMPANY _____

DATE _____

SCHEDULE – 17

SCHEDULE OF RECOMMENDED SPARES

The Bidder shall indicate hereunder the quantity of Recommended Spares for equipment included in his offer.

Sl. No.	Manufacturer & Part No.	Description	Qty.	If set, Nos. Per set	Remarks
1	2	3	4	5	7

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 18

SCHEDULE OF MAINTENANCE TOOLS AND TACKLES

The bidder shall give below the list of special maintenance and erection tools & tackles offered by him.

Sl. No.	Particulars	Unit / Qty

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

SCHEDULE – 19

CHECK LIST

Sl.No.	Item / Description	Reference	Declaration, strike out whichever is not applicable.	If no, reasons for not enclosing
1	FUNCTIONAL GUARANTEES	SCHEDULE – 1		
2	GUARANTEED AUXILIARY POWER CONSUMPTION	SCHEDULE – 2		
3	TECHNICAL DATA SHEET	SCHEDULE – 3	Yes/No	
4	DEVIATION SCHEDULE TO COMMERCIAL SPECIFICATION	SCHEDULE – 4	Yes/No	
5	DEVIATION SCHEDULE TO TECHNICAL SPECIFICATION	SCHEDULE – 5	Yes/No	
6	SCHEDULE OF SUB-VENDORS / SUB-CONTRACTORS LIST	SCHEDULE – 6	Yes/No	
7	QUALITY ASSURANCE PLAN	SCHEDULE – 7	Yes/No	
8	DETAILS OF SIMILAR WORKS DONE DURING PAST FIVE YEARS	SCHEDULE – 8	Yes/No	
9	CONCURRENT COMMITMENTS OF THE BIDDER	SCHEDULE – 9	Yes/No	
10	UTILITY CONSUMPTION LIST	SCHEDULE – 10	Yes/No	
11	LUBRICANTS LIST	SCHEDULE – 11	Yes/No	
12	OVERALL TIME SCHEDULE	SCHEDULE – 12	Yes/No	
13	REQUIREMENTS OF THE CONTRACTOR AT SITE	SCHEDULE – 13	Yes/No	
14	CONTRACTOR'S RESOURCE DEPLOYMENT SCHEDULE	SCHEDULE – 14	Yes/No	
15	SCHEDULE OF WEIGHTS AND DIMENSIONS	SCHEDULE – 15	Yes/No	
16	SCHEDULE OF PLACES OF TEST AND INSPECTION	SCHEDULE – 16	Yes/No	
17	SCHEDULE OF RECOMMENDED SPARES	SCHEDULE – 17	Yes/No	
18	SCHEDULE OF MAINTENANCE TOOLS AND TACKLES	SCHEDULE – 18	Yes/No	

SIGNATURE OF BIDDER _____

NAME _____

SEAL OF THE COMPANY **DESIGNATION** _____

COMPANY _____

DATE _____

Tamil Nadu Generation and Distribution Corporation Ltd.

Flue Gas Desulphurisation System & Auxiliaries for North Chennai TPP-Stage-III - 1x800 MW Supercritical Thermal Power Station Project

TENDER ENQUIRY DOCUMENT
FOR
EPC CONTRACT

[TENDER SPECIFICATION No. SE/E/PROJ-II/OT.NO.2/2018-2019]

VOLUME II

SECTION - 8

REFERENCE DOCUMENTS / DRAWINGS

FICHTNER Consulting Engineers (India) Private Limited
Chennai, India

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VOLUME	SECTION	TITLE
I		COMMERCIAL & GENERAL CONDITIONS OF CONTRACT
	1.0	INVITATION TO BID
	2.0	INSTRUCTIONS TO THE BIDDERS
	3.0	GENERAL TERMS AND CONDITIONS OF THE CONTRACT (GCC)
	4.0	ERECTION & COMMISSIONING CONDITIONS OF THE CONTRACT (ECC)
	5.0	SPECIAL CONDITIONS OF THE CONTRACT (SCC)
	6.0	FORMATS AND SCHEDULES
II	**TECHNICAL**	
	1.0	GENERAL TECHNICAL SPECIFICATION
	2.0	DETAILED TECHNICAL SPECIFICATION – MECHANICAL
	3.0	DETAILED TECHNICAL SPECIFICATION – ELECTRICAL
	4.0	DETAILED TECHNICAL SPECIFICATION – CONTROL & INSTRUMENTATION
	5.0	DETAILED TECHNICAL SPECIFICATION – CIVIL AND STRUCTURAL WORKS
	6.0	TENDER DRAWINGS
	7.0	SCHEDULES
	8.0	**REFERENCE DOCUMENTS / DRAWINGS**
III		PRICE SCHEDULE

VOLUME – II

SECTION – 8

REFERENCE DOCUMENTS / DRAWINGS

The following lists of attachments are enclosed with the specification.

Sl. No.	Drawing / Document Title	Drawing / Document Number
1	Preliminary Geotechnical Investigation	-
2	Flue Gas Duct Layout Between ID Fan & Chimney	LAYOUT OF ID SYSTEM – PLAN (DWG no 0-00-020-7715) LAYOUT OF ID SYSTEM ELEVATION(0-00-020-7714)
3	275 M High RC Chimney – General Arrangement	-
4	GA drawing for ID Fan with foundation and loading data	1-00-099-29103, Rev 3
5	Performance curve of ID Fan	3-00-103-39775, Rev 0
6	Detailed Piping Layout on Pipe rack between TG Building to TP @432.0119 W (PR-03-03)	GID-244-ME-UMY-XM-11928
7	Yard Piping and Trestle Layout – 2	PE-DG-423-100-M052
8	GA of Fire & Filter water pumphouse	GID-244-ME-USG-XD-13022
9	Piping Layout for CW and ACW System	GID-244-ME-PAB-XM-11832, GID-244-ME-PAB-XM-11833 and GID-244-ME-PAB-XM-11834
10	Piping Layout for Overall Pipe Rack-Plan and Section	GID-244-ME-UMY-XM-11800, GID-244-ME-UMY-XM-11801, GID-244-ME-UMY-XM-11802 and GID-244-ME-UMY-XM-11803
11	CW-ACW System P&ID	PD-DG-423-165-N001
12	Detailed Piping layout on pipe rack between forwarding pump house and Compressor house (PR-01-05 Sht 2 of 4)	GID-244-ME-UMY-XM-11910

TAMILNADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

1X800 MW NORTH CHENNAI TPP STAGE-III

Customer's Consultant: Fichtner Consulting Engineers (India) Private Limited, Chennai

GEOTECHNICAL INVESTIGATION REPORT

BOP AREA

DOCUMENT NO: PE-DC-423-602-C001 , R01

BHARAT HEAVY ELECTRICALS LIMITED
PROJECT ENGINEERING MANAGEMENT
NOIDA-201301

GEO TECHNICAL INVESTIGATION FOR 1X800 MW NORTH CHENNAI TPP STAGE III.

CLIENT

BHARAT HEAVY ELECTRICALS LIMITED

TITLE

REPORT – BOP AREA

REPORT NO: SI/CHN/16/1317/BOP/01

AUGUST 2016

GEO FOUNDATIONS & STRUCTURES PVT LTD
3/2, RAMS, No.89, I Main Road, Gandhi Nagar, Adyar,
Chennai – 600 020. Ph: 044 – 24431462, 24430399
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GEO TECHNICAL INVESTIGATION FOR 1X800 MW NORTH CHENNAI TPP STAGE III.

CLIENT

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REPORT – BOP AREA

REPORT NO: SI/CHN/16/1317/BOP/01

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GEO FOUNDATIONS & STRUCTURES PVT LTD
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Chennai – 600 020. Ph: 044 – 24431462, 24430399
Website: www.geofoundations.net
Email: geogfs@gmail.com

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★ ★ ★ ★ ★ ★ ★

GEOGRAPHICAL DESCRIPTION – NORTH CHENNAI THERMAL POWER STATION

The North Chennai Thermal Power Station is a power station situated about 25 kilometres from Chennai city. It is one of the major power plants of Tamil Nadu.

The North Chennai Thermal Power Station was commissioned in 1994 in the Thiruvallur district. It was built there due to its proximity to the Ennore Port, which also supplies Ennore Thermal Power Station.

LOCATION, GEOGRAPHY AND CLIMATE:

Ennore is a suburb in Chennai, India. It is situated on a peninsula and is bounded by the Korttalaiyar River, Ennore creek and the Bay of Bengal. The creek separates Ennore from the Ennore Port and Athipattu Pudunagar.

GEOLOGY

The project site is located along the Bay coast. The sea coast is flat and sandy for about 1 km from the shore. The study area has two distinct geological environments. The eastern and southern part of the stretches consists of shallow bedrock (crystalline) while western and northern areas have Gondwana deposits below the alluvium. Almost the entire area is covered by Pleistocene / Recent alluvium, deposited by Adyar, Cooum and Kottalaiyar rivers. The thickness of these deposits ranges from a few meters in southern part to as much as 50 m in the central and northern parts, the average being 20-25 m thick. The alluvium is made up of mainly clays, sand, sandy clay and occasional boulders / gravel zones. Sandy areas are found along the river bank and coast. Igneous / metamorphic rocks are found in the southern area. The marine sediments containing clayey silt – sands and charnokite rocks are found in the eastern and northern parts. The western part is composed of alluvium and

sedimentary rocks. A thin layer of Laterites is also noticed at some places. Well rounded pebbles and small boulders have been encountered at several locations at different depths. It is seen that in general, the eastern coastal area is predominantly sandy, while the northwestern region is mostly clayey in nature. From different fields of studies it has been established that, along the coast crystalline rocks of Archean era overlain by Phenerozoic rocks. Lower Permian to Carboniferous Lower Gondwana rocks are exposed in the northeast part of the Polar basin. Mesozoic rocks are represented by Upper Gondwana Formation. Mesozoic rocks are covered with late Pleistocene to Recent sediments along the coast. The sands are composed of quartz, fragments of feldspar, magnetite and rare garnet. The alluvial soils vary in color and texture from light brown to dirty white and are composed of sand grains, clay and silt. They are more sandy along river and stream courses but silty and clayey in the flood plains. Along the coast, an arenaceous formation called Coromondal Formation of probable Holocene age has been recorded below the beach sand. This formation is essentially quartz arenite which, at places, grades in depth to clayey sand and sandy clay.

FINAL GEO TECHNICAL INVESTIGATION REPORT – BOP AREA

1.0 INTRODUCTION

- The work of Detailed Geo Technical Investigation for 1x800 MW North Chennai TPP Stage III, Chennai, Tamil Nadu, being developed by Bharat Heavy Electricals Limited, was entrusted to M/s. Geo Foundations and Structures (P) Ltd., Adyar, Chennai – 600 020, wide Detailed Letter of Intent No: BHEL PSSR SCT 1608 dated 07.05.2016.
- The soil Investigation and laboratory studies of BOP Area were carried out during **March to August 2016**. This report summarizes the results of the soil investigation carried out at BOP area, and interpretation of the results, where applicable and presents recommendation for suitable type of foundation.

2.0 OBJECTIVE OF INVESTIGATION

- The objective of the soil investigation is to determine the nature and characteristics of sub-soil below the ground level for the proposed structures. The study includes identification of suitable type of foundation for the proposed structures and assessment of safe bearing capacity at BOP area.

3.0 SCOPE OF WORK

The scope of work is as follows:

- Mobilization of four boring rigs with all necessary equipments and personnel.
- Boring of ninety five bore-holes in the project site with calyx power drilling equipments through sand, silt, clay etc. to a maximum depth up to **40.0 m**.
- The Boring was carried out at locations indicated in drawing PE-DG-423-602-C001.
- Conducting Standard Penetration Tests in the bore-holes and collecting representative soil samples including packing and transportation to laboratory.
- To conduct the following laboratory tests on soil samples as applicable to the type of soil

(a) Particle size analysis:

(i) Sieve analysis

(ii) Hydrometer analysis

(b) Index properties:

(i) Liquid limit

(ii) Plastic limit

(iii) Free swell index

(c) Dry & wet density

(d) Relative density

(e) Water content

(f) Specific gravity

(g) Shrinkage limit

(h) Swell pressure

(i) Direct shear test

(j) Tri-axial shear test

(k) One dimensional consolidation test

(l) Unconfined Compressive strength test

(i) Un consolidated undrained test

(ii) Consolidated undrained test

(iii) Consolidated drained test

(m) Chemical analysis on soil & water samples

(n) CBR Tests.

(o) Standard and Modified Proctor compaction tests

- Conducting four static plate load tests at specified locations.
- Conducting thirty eight Electrical Resistivity tests.
- Conducting three pump out field permeability tests.
- Conducting thirteen dynamic cone penetration tests.
- Conducting three pressure meter tests.
- Conducting fourteen static cone penetration tests.
- Conducting eight field CBR tests
- Conducting two cross hole shear tests

- Recording ground water table level and collection of water samples.
- Preparation and submitting detailed report with field and laboratory results and recommendations for foundations.

4.0 FIELD INVESTIGATIONS

- Nine boring rigs with all requisite equipments and accessories were mobilized at the work site in **March 2016**. A team of technical personnel with skilled labours were deployed.
- **Ninety Five bore holes** pertaining to BOP area were bored to a maximum depth up to **40 m** below the existing ground level as per **IS: 1892- 1979**. Details of the co-ordinates, Reduced Levels of the existing ground level and termination depths are given in **Table A**.
- Representative soil samples were collected at every change of strata or about 1.0 m depth intervals up to 5.0 m and thereafter at 1.5 meters depth intervals up to termination depth. The samples so collected were sealed and numbered with full particulars for identification and sent to the laboratory for conducting the required tests.
- Standard Penetration Tests were conducted in the bore- holes at intervals of 1.0 m up to 5.0 m and thereafter at 1.50 m intervals up to termination depth, as per IS: 2131-1981. In this test, the standard split spoon sampler is driven into the ground at the required depth by means of standard hammer of 63.5 kgs weight; freely falling from a height of 75 cm. Number of blows for the first 15 cm is not

taken into consideration because of possible disturbances or presence of settled suspended matters at the bottom of the bore- holes. The total number of blows for the next 30 cm depth of penetration is considered as SPT 'N' values which are shown in **Appendix I** (Page Nos. 34- 128).

- Thirty Eight Electrical Resistivity tests were conducted as per **IS 3043-1987**. Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table B**.
- Four static plate load tests were conducted as per **IS 1888**. Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table C**.
- Thirteen Dynamic cone penetration tests were conducted as per **IS 4968 Part I.** Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table D**.
- Three Pressure meter tests were conducted as per **IS 1892**. Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table E**.
- Three Pump out field permeability tests were conducted as per **IS 5529 Part I**. Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table F**.
- Nine Field CBR tests were conducted as per **IS 2720 Part XXXI.** Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table G**.
- Three Cross hole Shear tests were conducted as per **IS 13372**. Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table H**.

- Fourteen Static Cone Penetration tests were conducted as per **IS 4968 Part III.** Details of the co-ordinates and Reduced Levels of the existing ground level are given in **Table I.**

5.0 LABORATORY INVESTIGATION

The following laboratory tests (as applicable to the type of soil) were conducted on the selected soil samples collected from the bore holes:

(a) Particle size analysis:

(i) Sieve analysis
(ii) Hydrometer analysis

(b) Index properties:

(i) Liquid limit
(ii) Plastic limit
(iii) Free swell index

(c) Dry & wet density
(d) Relative density
(e) Water content
(f) Specific gravity
(g) Shrinkage limit
(h) Swell pressure
(i) Direct shear test
(j) Consolidation test
(k) Chemical analysis on selected soil & water samples

All the above laboratory tests were carried out as per relevant Indian Standards.

All the samples were identified and classified as per relevant Indian Standard, IS: 1498. The results are shown in **Appendix II** (Page Nos. 129- 223).

TABLE A- Bore Hole Location Details.

S. No	Borehole No.	Co-ordinates		Existing Ground Level (m)	Termination Depth (m)
1	1	1399 S	408 W	RL (+) 8.09	26
2	6	1483 S	313 W	RL (+) 7.94	24.5
3	7	1483 S	294 W	RL (+) 7.85	24.5
4	7A	1473 S	310 W	RL (+) 7.88	40
5	33	1371 S	177 W	RL (+) 8.59	26
6	36	1249 S	174 W	RL (+) 8.87	26
7	39	1135 S	115 W	RL (+) 8.76	29
8	40	1190 S	111 W	RL (+) 8.82	29
9	41	1249 S	94 W	RL (+) 9.04	29
10	42	1184 S	81 W	RL (+) 8.89	29
11	44	1311 S	400 W	RL (+) 8.04	27.5
12	45	1121 S	399 W	RL (+) 7.97	26
13	46	1442 S	464 W	RL (+) 8.02	30.5

Table A (Contd)

S. No	Borehole No.	Co-ordinates		Existing Ground Level (m)	Termination Depth (m)
14	47	1298 S	461 W	RL (+) 7.97	29
15	48	1254 S	477 W	RL (+) 8.05	29
16	49	1205 S	446 W	RL (+) 8.14	33.5
17	50	1224 S	512 W	RL (+)8.22	33.5
18	51	1160 S	485 W	RL (+)8.14	31.5
19	52	1130 S	449 W	RL (+)8.24	29
20	53	1051 S	457 W	RL (+)8.18	26
21	54	1082 S	588 W	RL (+)8.89	26
22	55	1629 S	408 W	RL (+)7.47	27.5
23	56	1690 S	358 W	RL (+)7.97	24.5
24	57	1627 S	346 W	RL (+)7.74	29
25	58	1535 S	305 W	RL (+)8.17	27.5
26	59	1771 S	269 W	RL (+)7.67	40
27	60	1845 S	200 W	RL (+)9.49	26
28	61	1771 S	200 W	RL (+)9.34	40
29	62	1700 S	200 W	RL (+)9.43	27.5
30	63	1629 S	200 W	RL (+)9.31	29
31	64	1506 S	161 W	RL (+)10.52	29

Table A (Contd)

S. No	Borehole No.	Co-ordinates		Existing Ground Level (m)	Termination Depth (m)
32	65	1771 S	134 W	RL (+)8.82	27.5
33	66	1668 S	134 W	RL (+)8.79	27.5
34	67	1913 S	74 W	RL (+)8.41	27.5
35	68	1549 S	45 W	RL (+)9.79	27.5
36	69	1760 S	14 W	RL (+) 7.78	27.5
37	70	1629 S	14 W	RL (+)9.34	30.5
38	71	1506 S	14 W	RL (+)9.71	29
39	72	1809 S	22 E	RL (+)8.06	30.5
40	73	1700 S	100 E	RL (+)10.29	29
41	74	1600 S	100 E	RL (+)9.52	29
42	75	1505 S	100 E	RL (+)9.32	30.5
43	76	1465 S	129 E	RL (+)9.35	30.5
44	77	1800 S	228 E	RL (+)7.65	29
45	78	1635 S	212 E	RL (+)9.56	29
46	79	1568 S	272 E	RL (+)7.78	29
47	80	1690 S	300 E	RL (+)9.97	30.5
48	81	1475 S	300 E	RL (+)9.08	29
49	82	1629 S	352 E	RL (+)11.67	29
50	83	1160 S	394 E	RL (+)9.11	40

Table A (Contd)

S. No	Borehole No.	Co-ordinates		Existing Ground Level (m)	Termination Depth (m)
51	84	1462 S	432 E	RL (+)9.14	30.5
52	85	1760 S	472 E	RL (+)9.29	30.5
53	86	1629 S	472 E	RL (+)10.15	30.5
54	87	1506 S	472 E	RL (+)9.64	40
55	88	1506 S	550 E	RL (+)9.62	30.5
56	89	575 S	455 W	RL (+)9.41	30.5
57	90	484 S	457 W	RL (+)8.82	14
58	91	910 S	380 W	RL (+)8.15	27.5
59	92	768 S	380 W	RL (+)8.51	29
60	93	651 S	362 W	RL (+)8.54	30.5
61	94	978 S	305 W	RL (+)7.69	27.5
62	95	842 S	305 W	RL (+)8.29	26
63	96	698 S	305 W	RL (+)8.44	30.5
64	97	651 S	305 W	RL (+)8.43	30.5
65	98	910 S	237 W	RL (+)8.21	29
66	99	768 S	237 W	RL (+)8.41	26
67	100	400 S	121 W	RL (+)9.64	29
68	101	809 S	55 W	RL (+)9.21	29
69	102	842 S	123 W	RL (+)9.34	29

Table A (Contd)

S. No	Borehole No.	Co-ordinates		Existing Ground Level (m)	Termination Depth (m)
70	103	1306 S	550 E	RL (+)9.35	30.5
71	104	906 S	550 E	RL (+)9.41	29
72	105	706 S	550 E	RL (+)9.34	30.5
73	106	922 N	405 E	RL (+)10.67	40
74	107	862 N	450 E	RL (+)10.52	30.5
75	108	1265 N	450 E	RL (+)11.74	29
76	109	700 N	559 E	RL (+)9.81	30.5
77	110	1415 S	55 W	RL (+)8.87	29
78	112	1242 S	408 W	RL (+)8.01	29
79	113	306 S	550 E	RL (+)9.50	27.5
80	114	106 S	550 E	RL (+)9.78	30.5
81	115	94 N	550 E	RL (+)9.29	30.5
82	116	294 N	550 E	RL (+)9.34	30.5
83	117	745 S	601 W	RL (+)7.88	27.5
84	118	1537 S	357 W	RL (+)7.98	24.5
85	119	1537 S	246 W	RL (+)8.22	24.5
86	120	1661 S	330 W	RL (+)7.96	24.5
87	121	411 S	400 W	RL (+)8.59	30.5
88	122	400 N	379 W	RL (+)9.89	29

Table A (Contd)

S. No	Borehole No.	Co-ordinates		Existing Ground Level (m)	Termination Depth (m)
89	123	350 S	107 E	RL (+)9.51	30.5
90	124	350 S	336 E	RL (+)9.75	32
91	125	200 S	418 E	RL (+)9.14	27.5
92	126	29 N	418 E	RL (+)9.01	29
93	127	258 N	418 E	RL (+)9.45	29
94	128	487 N	418 E	RL (+)9.55	27.5
95	129	716 N	418 E	RL (+)9.81	30.5

TABLE B- ERT Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	ERT - 1	712 S	384 W	RL (+) 8.34
2	ERT - 2	769 S	354 W	RL (+) 8.16
3	ERT - 3	852 S	340 W	RL (+) 8.13
4	ERT - 4	873 S	329 W	RL (+) 8.02
5	ERT - 5	928 S	293 W	RL (+) 7.73
6	ERT - 6	993 S	264 W	RL (+) 8.04
7	ERT -20	1473 S	305 W	RL (+) 7.87
8	ERT - 21	1125 S	428 W	RL (+) 8.07
9	ERT - 22	1159 S	493 W	RL (+) 8.02
10	ERT - 23	1200 S	525 W	RL (+) 8.18
11	ERT - 24	1309 S	475 W	RL (+) 7.88
12	ERT - 25	1298 S	407 W	RL (+) 8.05
13	ERT - 26	1385 S	409 W	RL (+) 7.93
14	ERT - 28	1535 S	455 W	RL (+) 8.12
15	ERT - 29	1552 S	326 W	RL (+)8.34

Table B (Contd)

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
16	ERT - 30	1631 S	335 W	RL (+) 7.70
17	ERT - 31	1759 S	230 W	RL (+)8.00
18	ERT - 32	1929 S	256 W	RL (+)7.93
19	ERT - 33	1651 S	200 W	RL (+) 9.39
20	ERT - 34	1637 S	170 W	RL (+) 8.69
21	ERT - 35	1904 S	66 W	RL (+) 8.34
22	ERT -36	2047 S	56 E	RL (+) 8.00
23	ERT - 37	1681 S	108 W	RL (+) 10.15
24	ERT – 38	2348 S	161 W	RL (+) 8.09
25	ERT - 39	1575 S	40 W	RL (+) 9.79
26	ERT - 40	1881 S	489 E	RL (+) 9.24
27	ERT - 41	1685 S	232 E	RL (+) 8.40
28	ERT - 42	1477 S	123 E	RL (+) 9.29
29	ERT - 43	1456 S	288 E	RL (+) 8.99
30	ERT - 44	1447 S	443 E	RL (+)9.04
31	ERT - 45	141 S	562 E	RL (+)9.23
32	ERT - 46	25 S	530 E	RL (+)9.40

Table B (Contd)

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
33	ERT - 47	892 N	465 E	RL (+) 10.09
34	ERT - 48	926 N	381 E	RL (+) 10.60
35	ERT - 49	1393 S	184 W	RL (+) 8.57
36	ERT - 50	621 S	186 W	RL (+) 8.83
37	ERT - 51	649 S	320 W	RL (+) 8.54
38	ERT - 52	361 S	349 W	RL (+) 9.03

TABLE C- PLT Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	PLT - 1	900 S	305 W	RL (+) 7.78
2	PLT - 3	1271 S	118 W	RL (+) 9.41
3	PLT - 4	1651 S	257 E	RL (+) 7.99
4	PLT - 5	788 N	494 E	RL (+) 9.02

TABLE D- DCPT Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	DCPT - 1	760 S	305 W	RL (+) 8.78
2	DCPT - 2	842 S	380 W	RL (+)8.27
3	DCPT - 4	1245 S	537 W	RL (+)8.30
4	DCPT - 5	1254 S	72 W	RL (+)8.73
5	DCPT - 6	1269 S	220 W	RL (+)7.59
6	DCPT - 7	1664 S	200 W	RL (+)9.25
7	DCPT - 8	1800 S	328 E	RL (+)7.53
8	DCPT - 9	1722 S	246 E	RL (+)8.69
9	DCPT - 10	1460 S	272 E	RL (+)9.03
10	DCPT - 11	1698 S	471 E	RL (+)8.47

Table D (Contd)

11	DCPT - 14	925 N	371 E	RL (+)8.21
12	DCPT - 15	1451 N	285 E	RL (+)7.98
13	DCPT - 16	1483 N	324 W	RL (+)10.61

TABLE E- PMT Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	PMT - 3	1500 S	307 W	RL (+) 7.84
2	PMT - 4	1730 S	164 W	RL (+) 8.39
3	PMT - 5	1496 S	482 E	RL (+) 9.19

TABLE F- POTFPT Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	POTFPT - 2	1629 S	228 W	RL (+) 8.36
2	POTFPT - 3	1570 S	471 E	RL (+) 9.22
3	POTFPT - 4	531 S	100 W	RL (+) 8.69

TABLE G- CBR Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	CBR - 1	817 S	140 W	RL (+) 9.60
2	CBR - 3	1397 S	487 W	RL (+)7.89
3	CBR - 4	1722 S	80 W	RL (+)10.36
4	CBR - 5	1434 S	113 E	RL (+)9.10
5	CBR - 6	500 S	389 W	RL (+)8.56
6	CBR - 7	900 S	595 W	RL (+)10.2
7	CBR - 8	1100 S	530 W	RL (+)8.45
8	CBR - 9	1573 S	260 W	RL (+)7.88

TABLE H- CST Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	CST - 4	1444 S	305 W	RL (+) 7.39
2	CST - 5	1524 S	471 E	RL (+) 8.06

TABLE I- SCPT Location Details.

S. No	Test No.	Co-ordinates		Existing Ground Level (m)
1	SCPT- 1	700 S	380 W	RL (+) 8.36
2	SCPT- 2	978 S	240 W	RL (+)8.17
3	SCPT- 3	910 S	115 W	RL (+)9.14
4	SCPT- 4	1212 S	163 W	RL (+)8.86
5	SCPT- 5	1084 S	492 W	RL (+)8.31
6	SCPT- 6	1293 S	487 W	RL (+)7.89
7	SCPT- 7	1800 S	128 E	RL (+)7.85
8	SCPT- 8	1700 S	169 E	RL (+)8.05
9	SCPT- 9	1106 S	550 E	RL (+)9.15
10	SCPT- 10	506 S	550 E	RL (+)9.28
11	SCPT- 11	24 S	536 E	RL (+)9.42
12	SCPT- 12	507 N	556 E	RL (+)9.47
13	SCPT- 13	1062 N	450 E	RL (+)10.63
14	SCPT- 14	1000 S	55 W	RL (+)9.39

Details along with calculations of thirty eight electrical resistivity tests, four static plate load tests, fourteen static cone penetration tests, thirteen dynamic cone penetration tests, two cross hole shear tests, three pressure meter tests, three pump out field permeability tests, eight field CBR test, Chemical analysis of water and soil samples, eleven laboratory CBR test results are given in **Appendix III** (Page No. 224-341), **Appendix IV** (Page No. 342- 349), **Appendix V**(Page No. 350- 398), **Appendix VI** (Page No. 399- 454), **Appendix VII** (Page No. 455- 465), **Appendix VIII** (Page No. 466-537), **Appendix IX** (Page No. 538- 541), **Appendix X** (Page No. 542- 545), **Appendix XI** (Page No. 546- 548), & **Appendix XII** (Page No. 549- 550) respectively.

6.0 GROUND WATER

Ground water level was met at a depth of **1.50 m to 4.5 m** in the bore holes during the boring from **22.03.2016** to **21.06.2016**.

6.1 Chemical composition of the ground water are presented in Appendix XI

6.2 Considering the ground water characteristics and close proximity of site to sea, it is recommended to use ordinary Portland cement with C3A from 5% to 8%.

7.0 DESIGN PROFILES

DESIGN PROFILE FOR BOP area near/ at BH 06, BH 07, BH 07A, BH 36, BH 39, BH 40, BH 41, BH 42, BH 44, BH 46, BH 47, BH 48, BH 52, BH 53, BH 54, BH 55, BH 56, BH 57, BH 59, BH 60, BH 61, BH 62, BH 63, BH 64, BH 65, BH 66, BH 67, BH 68, BH 69, BH 70, BH 71, BH 72, BH 73, BH 75, BH 77, BH 78, BH 79, BH 80, BH 81, BH 82, BH 84, BH 85, BH 87, BH 88, BH 89, BH 90, BH 91, BH 92, BH 93, BH 94, BH 95, BH 96, BH 97, BH 98, BH 99, BH 101, BH 102, BH 103, BH 104, BH 105, BH 106, BH 107, BH 108, BH 109, BH 110, BH 112, BH 113, BH 114, BH 115, BH 116, BH 117, BH 118, BH 119, BH 120, BH 121, BH 122, BH 123, BH 124, BH 125, BH 126, BH 127, BH 128, BH 129.

Depth from EGL	Type of sub Soil stratum	Average Corrected 'N' Value	Shear Parameters	
(m)			C (kg/cm^2)	Φ
0-5	Medium dense Silty Sand	14	-	30
5-14	Stiff Silty Clay/Sandy Clay	10	0.625	-
14-18.5	Medium dense Clayey Sand/ Silty Sand	24	-	34
18.5 -22	Hard Silty Clay	50	2.5	-
22 - 40	Hard Silty Clay/very dense Silty Sand*	>100	4	0

*Considering the complete BOP area and variation in soil type in different bore holes, the sub-soil is considered as fine grained soil.

DESIGN PROFILE FOR BOP area near/ at BH 01, BH 33, BH 45, BH 49, BH 50, BH 51, BH 58, BH 74, BH 76, BH 83, BH 86 & BH 100

Depth from EGL	Type of sub Soil stratum	Average Corrected 'N' Value	Shear Parameters	
(m)			C (kg/cm^2)	Φ
0-3	Medium dense Silty Sand	14	-	30
3- 6.5	Loose to medium dense Silty Sand	5	0	28.5
6.5-12.5	Soft Silty Clay	3	2	
12.5-18.5	Loose to medium dense Clayey Sand/ Silty Sand	5	-	28.5
18.5 -23	Medium dense Silty Sand	14	-	30
23 - 40	Hard Silty Clay	>100	4	0

8.0 RECOMMENDATIONS:

- The excavated earth can be used for back filling the foundations and grading purpose.
- For average resistivity values at the corresponding locations, Appendix -III can be referred.
- For Plate load test result, Appendix -IV can be referred
- The Modulus of Subgrade reaction (K) can be obtained as Ratio of allowable Bearing Pressure divided by Estimated Settlement
- For Static Cone penetration test results, Appendix -V can be referred
- For Dynamic Cone penetration test results, Appendix -VI can be referred
- For Cross hole shear tests results, Appendix -VII can be referred

- For Pressure meter tests results, Appendix -VIII can be referred
- For Field permeability tests results, Appendix -IX can be referred
- For Field CBR tests results, Appendix -X can be referred
- Considering the ground water characteristics (refer Appendix -XI) and close proximity of site to sea, it is recommended to use ordinary Portland cement with C3A from 5% to 8%.
- For Laboratory CBR results, Appendix -XII can be referred
- Wherever roads are to be constructed in fill, the CBR value in soaked condition shall be determined from the fill material in laboratory during execution. It has to be checked by Field CBR testing, during execution.
- Considering Seismic zone – 3 and sub soil characteristic, the project site is not prone to liquefaction. Sample calculation on liquefaction analysis is furnished in Appendix XIII.
- The recommended safe load carrying capacity of Bored cast-in-situ RCC piles for BOP area near/ at BH 06, BH 07, BH 07A, BH 36, BH 39, BH 40, BH 41, BH 42, BH 44, BH 46, BH 47, BH 48, BH 52, BH 53, BH 54, BH 55, BH 56, BH 57, BH 59, BH 60, BH 61, BH 62, BH 63, BH 64, BH 65, BH 66, BH 67, BH 68, BH 69, BH 70, BH 71, BH 72, BH 73, BH 75, BH 77, BH 78, BH 79, BH 80, BH 81, BH 82, BH 84, BH 85, BH 87, BH 88, BH 89, BH 90, BH 91, BH 92, BH 93, BH 94, BH 95, BH 96, BH 97, BH 98, BH 99, BH 101, BH 102, BH 103, BH 104, BH 105, BH 106, BH 107, BH 108, BH 109, BH 110, BH 112, BH 113, BH 114, BH 115, BH 116, BH 117, BH 118, BH 119, BH 120, BH 121, BH 122, BH 123, BH 124, BH 125, BH 126, BH 127, BH 128, BH 129.

Diameter of pile (mm)	Length of pile below cut off level (m)	Safe Load carrying capacity of piles (MT)		
		Vertical Compression	Uplift	Lateral*
600	17	75	15	7
	26	150	30	7
760	28	240	50	10.5

* For fixed head condition. In case of free head pile, the lateral capacity shall be reduced suitably.

Cut off level considered in case of 600 mm = 1 m below EGL

Cut off level considered in case of 760 mm = 2 m below EGL

Existing Ground Level (EGL) = RL (+) 8.000 m

- In case of Open Foundation, the allowable bearing pressure for BOP area near/ at BH 06, BH 07, BH 07A, BH 36, BH 39, BH 40, BH 41, BH 42, BH 44, BH 46, BH 47, BH 48, BH 52, BH 53, BH 54, BH 55, BH 56, BH 57, BH 59, BH 60, BH 61, BH 62, BH 63, BH 64, BH 65, BH 66, BH 67, BH 68, BH 69, BH 70, BH 71, BH 72, BH 73, BH 75, BH 77, BH 78, BH 79, BH 80, BH 81, BH 82, BH 84, BH 85, BH 87, BH 88, BH 89, BH 90, BH 91, BH 92, BH 93, BH 94, BH 95, BH 96, BH 97, BH 98, BH 99, BH 101, BH 102, BH 103, BH 104, BH 105, BH 106, BH 107, BH 108, BH 109, BH 110, BH 112, BH 113, BH 114, BH 115, BH 116, BH 117, BH 118, BH 119, BH 120, BH 121, BH 122, BH 123, BH 124, BH 125, BH 126, BH 127, BH 128, BH 129 shall be as follows.

Width of the Footing* (m)	Depth of Foundation from Ground level (m)	Allowable Bearing Pressure (T/m²)	
		Total permissible settlement of 25 mm**	Total permissible settlement of 40 mm**
Up to 2	1.0	10	11***
Up to 2	1.5	11	14
Up to 2	2.0	6.5	10

* Considering minimum width of foundation as 1 m & maximum width of foundation as 2 m. Open foundation are not recommended for foundation size/ width greater than 2 m.

** Also considering Shear failure consideration, with factor of safety.

*** Even though the bearing pressure for 40 mm settlement is 13 T/m², but on the shear failure criterion it is only 11 T/m² and this governs the allowable bearing pressure. In all the other cases, the settlement criterion governs the allowable bearing pressure.

- Open foundation are not recommended in BOP area near/ at BH 01, BH 33, BH 45, BH 49, BH 50, BH 51, BH 58, BH 74, BH 76, BH 83, BH 86 & BH 100.
- The recommended safe load carrying capacity of Bored cast-in-situ RCC piles for area near/ at BH 01, BH 33, BH 45, BH 49, BH 50 BH 51, BH 58, BH 74, BH 76, BH 83, BH 86 & BH 100 shall be as follows.

Diameter of pile (mm)	Length of pile below cut off level (m)	Safe Load carrying capacity of piles (MT)		
		Vertical Compression	Uplift	Lateral*
600	20	55	11	4.5
	30	145	30	4.5
760	32	230	50	6.5

* For fixed head condition. In case of free head pile, the lateral capacity shall be reduced suitably.

Cut off level considered in case of 600mm = 1 m below EGL

Cut off level considered in case of 760mm = 2 m below EGL

Existing Ground Level (EGL) = RL (+) 8.000 m

9.0 The results and recommendations given in this report are based on the results of the soil investigation carried out. If, in actual execution, any variation is found, the consultants may also be referred to.

For GEO FOUNDATIONS & STRUCTURES PVT. LTD.

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APPENDIX I

BORE LOGS

CLIENT	**: BHARAT HEAVY ELECTRICALS LIMITED**		
PROJECT	**: 1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT**	CASING	: NOT USED
BORE HOLE NO.	**: 58**	SHEET NO.	: 25 OF 95
LOCATION	: AHP CONTROL ROOM	DATE	: 09.04.2016 to 10.04.2016
CO-ORDINATES	: 1535 S 305 W	METHOD	: CALYX / ROTARY DRILLING
EXISTING GROUND LEVEL	: RL(+) 8.17	GROUND WATER TABLE	: 2.75 M FROM THE G.L
DIA OF BORING	: 150 MM	TERMINATION DEPTH	: 27.50 M

DEPTH (M)	LOG	STRATA DISCRIPTION	DEPTH (M)	TYPE OF SAMLE	SAMPLER TYPE	BLOWS/15 cm			SPT N	CR %	RQD %	REMARK
						15	15	15				
1.00		**SAND**	1.00-1.45	SPT - 1	SS	7	10	15	25			
2.00		**SAND**	2.00-2.45	UDS-1	OT	-	-	-	-			
3.00		**SAND**	3.00-3.45	SPT - 2	SS	10	13	18	31			
4.00		**SAND**	4.00-4.45	UDS-2	OT	-	-	-	-			
5.00		**SAND**	5.00-5.45	SPT - 3	SS	9	15	19	34			
6.50		**SAND**	6.50-6.95	UDS-3	OT	-	-	-	-			
8.00		**SAND**	8.00-8.45	SPT - 4	SS	2	3	3	6			
9.50		**SAND**	9.50-9.95	UDS-4	OT	-	-	-	-			
11.00		**SAND**	11.00-11.45	SPT - 5	SS	3	3	4	7			
12.50		**SAND**	12.50-12.95	UDS-5	OT	-	-	-	-			
14.00		**SAND**	14.00-14.45	SPT - 6	SS	2	3	4	7			
15.50		**SAND**	15.50-15.95	UDS-6	OT	-	-	-	-			
17.00		**SAND**	17.00-17.45	SPT - 7	SS	3	5	7	12			
18.50		Silty **SAND**	18.50-18.95	SPT - 8	SS	7	8	13	21			
20.00		Silty **SAND**	20.00-20.45	SPT - 9	SS	9	13	18	31			
21.50		Silty **SAND**	21.50-21.95	SPT - 10	SS	14	19	28	47			
23.00		Silty **CLAY**	23.00-23.24	SPT - 11	SS	28	>50	-	>100			50/09 CM PENETRATION
24.50		Silty **CLAY**	24.50-24.72	SPT - 12	SS	35	>50	-	>100			50/07 CM PENETRATION
26.00		Silty **CLAY**	26.00-26.08	SPT - 13	SS	>50	-	-	>100			50/08 CM PENETRATION
27.50		Silty **CLAY**	27.50-27.54	SPT - 14	SS	>50	-	-	>100			50/04 CM PENETRATION

SPT - Standard Penetration Test
SS - Split Spoon Sampler
OT - Open Tube
EGL - Existing Ground Level
RL - Reduced Level .

CLIENT	**: BHARAT HEAVY ELECTRICALS LIMITED**		
PROJECT	**: 1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT**	CASING	: NOT USED
BORE HOLE NO.	**: 70**	SHEET NO.	: 37 OF 95
LOCATION	:	DATE	: 02.07.2016 TO 03.07.2016
CO-ORDINATES	: 1629 S 14 W	METHOD	: CALYX / ROTARY DRILLING
EXISTING GROUND LEVEL	: RL(+) 9.34	GROUND WATER TABLE	: 2.00 M BELOW THE E.G.L
DIA OF BORING	: 150 MM	TERMINATION DEPTH	: 30.50 M

DEPTH (M)	LOG	STRATA DISCRIPTION	DEPTH (M)	TYPE OF SAMPLE	SAMPLER TYPE	BLOWS/15 cm			SPT N	CR %	RQD %	REMARK
						15	15	15				
1.00		Silty **CLAY**	1.00-1.45	SPT - 1	SS	3	4	5	9			
2.00		Silty **CLAY**	2.00-2.45	SPT - 2	SS	4	4	6	10			
3.00		**SAND**	3.00-3.45	SPT - 3	SS	6	8	4	12			
4.00		**SAND**	4.00-4.45	SPT - 4	SS	7	9	13	22			
5.00		**SAND**	5.00-5.45	SPT - 5	SS	7	12	14	26			
6.50		**SAND**	6.50-6.95	SPT - 6	SS	10	13	15	28			
8.00		Clayey **SAND**	8.00-8.45	SPT - 7	SS	3	3	4	7			
9.50		Clayey **SAND**	9.50-9.95	UDS-1	OT	-	-	-	-			
11.00		Clayey **SAND**	11.00-11.45	SPT - 8	SS	3	4	5	9			
12.50		Clayey **SAND**	12.50-12.95	UDS-2	OT	-	-	-	-			
14.00		Clayey **SAND**	14.00-14.45	SPT - 9	SS	4	6	3	9			
15.50		Clayey **SAND**	15.50-15.95	SPT - 10	SS	5	8	11	19			
17.00		Clayey **SAND**	17.00-17.45	SPT - 11	SS	5	9	13	22			
18.50		Sandy **CLAY**	18.50-18.95	SPT - 12	SS	6	8	11	19			
20.00		Sandy **CLAY**	20.00-20.45	SPT - 13	SS	8	12	16	28			
21.50		Silty **SAND**	21.50-21.95	SPT - 14	SS	10	14	19	33			
23.00		Sandy **SILT**	23.00-23.45	SPT - 15	SS	15	31	44	71			
24.50		Sandy **SILT**	24.50-24.95	SPT - 16	SS	18	32	48	80			
26.00		Sandy **SILT**	26.00-26.36	SPT - 17	SS	21	38	>50	>100			50/02 CM PENETRATION
27.50		Sandy **SILT**	27.50-27.83	SPT - 18	SS	23	39	>50	>100			50/05 CM PENETRATION
29.00		Sandy **SILT**	29.00-29.22	SPT - 19	SS	31	>50	-	>100			50/01 CM PENETRATION
30.50		Sandy **SILT**	30.50-30.68	SPT - 20	SS	32	>50	-	>100			50/04 CM PENETRATION

SPT - Standard Penetration Test
SS - Split Spoon Sampler
OT - Open Tube
EGL - Existing Ground Level
RL - Reduced Level .

CLIENT	**: BHARAT HEAVY ELECTRICALS LIMITED**		
PROJECT	**: 1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT**	CASING	: NOT USED
BORE HOLE NO.	**: 118**	SHEET NO.	: 84 OF 95
LOCATION	: SPACE FOR FGD	DATE	: 12.04.2016 to 13.04.2016
CO-ORDINATES	: 1537 S 357 W	METHOD	: CALYX / ROTARY DRILLING
EXISTING GROUND LEVEL	:RL(+) 7.98	GROUND WATER TABLE	: 3.0 M BELOW THE E.G.L
DIA OF BORING	: 150 MM	TERMINATION DEPTH	: 24.50 M

DEPTH (M)	LOG	STRATA DISCRIPTION	DEPTH (M)	TYPE OF SAMPLE	SAMPLER TYPE	BLOWS/15 cm			SPT N	CR %	RQD %	REMARK
						15	15	15				
1.00		**SAND**	1.00-1.45	SPT - 1	SS	2	3	5	8			
2.00		**SAND**	2.00-2.45	UDS-1	OT	-	-	-	-			
3.00		**SAND**	3.00-3.45	SPT - 2	SS	3	4	5	9			
4.00		**SAND**	4.00-4.45	UDS-2	OT	-	-	-	-			
5.00		**SAND**	5.00-5.45	SPT - 3	SS	1	2	3	5			
6.50		**SAND**	6.50-6.95	UDS-3	OT	-	-	-	-			
8.00		Silty **SAND**	8.00-8.45	SPT - 4	SS	2	4	4	8			
9.50		Silty **SAND**	9.50-9.95	UDS-4	OT	-	-	-	-			
11.00		Sandy **CLAY**	11.00-11.45	SPT - 5	SS	3	5	8	13			
12.50		Sandy **CLAY**	12.50-12.95	UDS-5	SS	-	-	-	-			
14.00		Silty **SAND**	14.00-14.45	SPT - 6	SS	10	12	13	25			
15.50		Silty **SAND**	15.50-15.95	UDS-6	OT	-	-	-	-			
17.00		Silty **SAND**	17.00-17.45	SPT - 7	SS	10	14	16	30			
18.50		Silty **SAND**	18.50-18.95	SPT - 8	SS	7	15	19	34			
20.00		Silty **SAND**	20.00-20.40	SPT - 9	SS	8	19	>50	>100			50/10 CM PENETRATION
21.50		Silty **SAND**	21.50-21.93	SPT - 10	SS	40	48	>50	>100			50/13 CM PENETRATION
23.00		Silty **SAND**	23.00-23.20	SPT - 11	SS	42	>50	-	>100			50/05 CM PENETRATION
24.50		Silty **SAND**	24.50-24.57	SPT - 12	SS	>50	-	-	>100			50/07 CM PENETRATION

SPT - Standard Penetration Test
SS - Split Spoon Sampler
OT - Open Tube
EGL - Existing Ground Level
RL - Reduced Level .

CLIENT	**: BHARAT HEAVY ELECTRICALS LIMITED**		
PROJECT	**: 1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT**	CASING	: NOT USED
BORE HOLE NO.	**: 119**	SHEET NO.	: 85 OF 95
LOCATION	: SPACE FOR FGD	DATE	: 11.04.2016 to 12.04.2016
CO-ORDINATES	: 1537 S 246 W	METHOD	: CALYX / ROTARY DRILLING
EXISTING GROUND LEVEL	:RL(+) 8.22	GROUND WATER TABLE	: 2.45 M BELOW THE E.G.L
DIA OF BORING	: 150 MM	TERMINATION DEPTH	: 24.50 M

DEPTH (M)	LOG	STRATA DISCRIPTION	DEPTH (M)	TYPE OF SAMPLE	SAMPLER TYPE	BLOWS/15 cm			SPT N	CR %	RQD %	REMARK
						15	15	15				
1.00		**SAND**	1.00-1.45	SPT - 1	SS	6	10	14	24			
2.00		**SAND**	2.00-2.45	UDS-1	OT	-	-	-	-			
3.00		**SAND**	3.00-3.45	SPT - 2	SS	9	13	17	30			
4.00		**SAND**	4.00-4.45	UDS-2	OT	-	-	-	-			
5.00		Silty **SAND**	5.00-5.45	SPT - 3	SS	12	16	21	37			
6.50		Silty **SAND**	6.50-6.95	UDS-3	OT	-	-	-	-			
8.00		Silty **CLAY**	8.00-8.45	SPT - 4	SS	2	3	4	7			
9.50		Silty **CLAY**	9.50-9.95	UDS-4	OT	-	-	-	-			
11.00		Sandy **CLAY**	11.00-11.45	SPT - 5	SS	2	4	4	8			
12.50		Sandy **CLAY**	12.50-12.95	UDS-5	OT	-	-	-	-			
14.00		Clayey **SAND**	14.00-14.45	SPT - 6	SS	7	10	16	26			
15.50		Clayey **SAND**	15.50-15.95	UDS-6	OT	-	-	-	-			
17.00		Silty **SAND**	17.00-17.45	SPT - 7	SS	9	14	19	33			
18.50		Silty **SAND**	18.50-18.95	SPT - 8	SS	10	16	23	39			
20.00		Clayey **SILT**	20.00-20.21	SPT - 9	SS	44	>50	-	>100			50/06 CM PENETRATION
21.50		Clayey **SILT**	21.50-21.56	SPT - 10	SS	>50	-	-	>100			50/06 CM PENETRATIOM
23.00		Silty **CLAY**	23.00-23.04	SPT - 11	SS	>50	-	-	>100			50/04 CM PENETRATION
24.50		Silty **CLAY**	24.50-24.953	SPT - 12	SS	>50	-	-	>100			50/03 CM PENETRATIOM

SPT - Standard Penetration Test
SS - Split Spoon Sampler
OT - Open Tube
EGL - Existing Ground Level
RL - Reduced Level .

APPENDIX II

LABORATORY TEST RESULTS

1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT

BORE HOLE NO	DEPTH (m)	TYPE OF SAMPLE	DENSITY (KN/m³)		WATER CONTENT (%)	PARTICLE SIZE (%)				ATTERBERG'S LIMITS				SOIL			STRENGTH TEST			CONSOLIDATION TEST						SWELL TEST		COMPACTION TEST			RELATIVE DENSITY	PERMEABILITY (m/hr)	REMARKS
			BULK	DRY		GRAVEL	SAND	SILT	CLAY	LL	PL	PI	SL	IS CLASSIFICATION	DESCRIPTION	SPECIFIC GRAVITY	TYPE	C in kN/ m²	Ø °	e	Pc	Cc	ρ	mv	Cv	S.Pr	FSI	MDD	OMC	CBR			
58	1.00	SPT			13	0	94	6						SP	**SAND**																	
	2.00	UDS												SP	**SAND**																	
	3.00	SPT												SP	**SAND**																	
	4.00	UDS												SP	**SAND**																	
	5.00	SPT			16	0	95	5						SP	**SAND**																	
	6.50	UDS												SP	**SAND**																	
	8.00	SPT												SP	**SAND**																	
	9.50	UDS												SP	**SAND**																	
	11.00	SPT												SP	**SAND**																	
	12.50	UDS												SP	**SAND**																	
	14.00	SPT												SP	**SAND**																	
	15.50	UDS												SP	**SAND**																	
	17.00	SPT												SP	**SAND**																	
	18.50	SPT			15	0	78	22						SM	Silty **SAND**																	
	20.00	SPT			16	0	75	25						SM	Silty **SAND**																	
	21.50	SPT												SM	Silty **SAND**																	
	23.00	SPT			23					42	16	26		CI	Silty **CLAY**												55					
	24.50	SPT												CI	Silty **CLAY**																	
	26.00	SPT												CI	Silty **CLAY**																	
	27.50	SPT												CI	Silty **CLAY**																	

1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT

BORE HOLE NO	DEPTH (m)	TYPE OF SAMPLE	DENSITY (KN/m³)		WATER CONTENT (%)	PARTICLE SIZE (%)				ATTERBERG'S LIMITS				SOIL		SPECIFIC GRAVITY	STRENGTH TEST			CONSOLIDATION TEST						SWELL TEST		COMPACTION TEST			RELATIVE DENSITY	PERMEABILITY (m/hr)	REMARKS
			BULK	DRY		GRAVEL	SAND	SILT	CLAY	LL	PL	PI	SL	IS CLASSIFICATION	DESCRIPTION		TYPE	C	Ø	e_o	Pc	Cc	p	mv	Cv	S.Pr	FSI	MDD	OMC	CBR			
70	1.00	SPT											19.36		Silty **CLAY**																		
	2.00	SPT													Silty **CLAY**																		
	3.00	SPT				0	92	8						SP	**SAND**																		
	4.00	SPT												SP	**SAND**																		
	5.00	SPT												SP	**SAND**																		
	6.50	SPT												SP	**SAND**																		
	8.00	SPT													Clayey **SAND**																		
	9.50	UDS													Clayey **SAND**																		
	11.00	SPT													Clayey **SAND**																		
	12.50	UDS													Clayey **SAND**																		
	14.00	SPT													Clayey **SAND**																		
	15.50	SPT													Clayey **SAND**																		
	17.00	SPT													Clayey **SAND**																		
	18.50	SPT													Sandy **CLAY**																		
	20.00	SPT													Sandy **CLAY**																		
	21.50	SPT				0	89	11						SM	Silty **SAND**																		
	23.00	SPT								Non-Plastic					Sandy **SILT**																		
	24.50	SPT													Sandy **SILT**																		
	26.00	SPT													Sandy **SILT**																		
	27.50	SPT													Sandy **SILT**																		
	29.00	SPT													Sandy **SILT**																		
	30.50	SPT													Sandy **SILT**																		

1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT

BORE HOLE NO	DEPTH (m)	TYPE OF SAMPLE	DENSITY (KN/m³)		WATER CONTENT (%)	PARTICLE SIZE (%)				ATTERBERG'S LIMITS				SOIL			STRENGTH TEST			CONSOLIDATION TEST						SWELL TEST		COMPACTION TEST			RELATIVE DENSITY	PERMEABILITY (m/hr)	REMARKS
			BULK	DRY		GRAVEL	SAND	SILT	CLAY	LL	PL	PI	SL	IS CLASSIFICATION	DESCRIPTION	SPECIFIC GRAVITY	TYPE	C	Ø	e	Pc	Cc	ρ	mv	Cv	S.Pr	FSI	MDD	OMC	CBR			
118	1.00	SPT				0	95	5						SP	**SAND**																		
	2.00	UDS												SP	**SAND**																		
	3.00	SPT				0	95	5						SP	**SAND**																		
	4.00	UDS												SP	**SAND**																		
	5.00	SPT				0	93	7						SP	**SAND**																		
	6.50	UDS												SP	**SAND**																		
	8.00	SPT				0	89	11						SM	Silty **SAND**																		
	9.50	UDS												SM	Silty **SAND**																		
	11.00	SPT				0	24	76		42	18	24		CI	Sandy **CLAY**																		
	12.50	UDS												CI	Sandy **CLAY**																		
	14.00	SPT				0	86	14						CI	Silty **SAND**																		
	15.50	UDS												CI	Silty **SAND**																		
	17.00	SPT				0	79	21						CI	Silty **SAND**																		
	18.50	SPT												CI	Silty **SAND**																		
	20.00	SPT												CI	Silty **SAND**																		
	21.50	SPT												CI	Silty **SAND**																		
	23.00	SPT												CI	Silty **SAND**																		
	24.50	SPT												CI	Silty **SAND**																		

1X800 MW NORTH CHENNAI STAGE 3 SUPER CRITICAL THERMAL POWER PROJECT

BORE HOLE NO	DEPTH (m)	TYPE OF SAMPLE	DENSITY (KN/m^3)		WATER CONTENT (%)	PARTICLE SIZE (%)				ATTERBERG'S LIMITS				SOIL			STRENGTH TEST			CONSOLIDATION TEST						SWELL TEST		COMPACTION TEST			RELATIVE DENSITY	PERMEABILITY (m/hr)	REMARKS
			BULK	DRY		GRAVEL	SAND	SILT	CLAY	LL	PL	PI	SL	IS CLASSIFICATION	DESCRIPTION	SPECIFIC GRAVITY	TYPE	C	Ø°	e	Pc	Cc	ρ	mv	Cv	S.Pr	FSI	MDD	OMC	CBR			
119	1.00	SPT				0	96	4						SP	**SAND**																	
	2.00	UDS												SP	**SAND**																	
	3.00	SPT				0	95	5						SP	**SAND**																	
	4.00	UDS												SP	**SAND**																	
	5.00	SPT				0	90	10						SM	Silty **SAND**																	
	6.50	UDS												SM	Silty **SAND**																	
	8.00	SPT				0	8	92		52	19	33		CH	Silty **CLAY**																	
	9.50	UDS												CH	Silty **CLAY**																	
	11.00	SPT				0	23	77		54	20	34		CH	Sandy **CLAY**																	
	12.50	UDS												CH	Sandy **CLAY**																	
	14.00	SPT				0	70	30		40	17	23		SC	Clayey **SAND**																	
	15.50	UDS												SC	Clayey **SAND**																	
	17.00	SPT				0	76	24						SM	Silty **SAND**																	
	18.50	SPT												SM	Silty **SAND**																	
	20.00	SPT												CL	Clayey **SILT**																	
	21.50	SPT												CL	Clayey **SILT**																	
	23.00	SPT								38	21	17		CI	Silty **CLAY**																	
	24.50	SPT												CI	Silty **CLAY**																	

APPENDIX III

ELECTRICAL RESISTIVITY TESTS

2.0 ELECTRICAL RESISTIVITY TEST – BOP Area

1.0 INTRODUCTION

1.1 The field studies were carried out in **April** to **July 2016**. This report summarizes Earth Resistivity values for 38 different locations pertaining to BOP Area.

2.0 OBJECT OF INVESTIGATION

2.1 The object of investigation is to ascertain the variation in apparent resistivity of sub-soil below the ground level and to obtain an idea about the variation in soil profile at BOP area for the proposed site. Electrical Resistivity values are required for designing safety grounding system in the area.

3.0 FIELD INVESTIGATIONS

3.1 The method depends on the difference in the electrical resistance of different soil strata. These are several methods by which the field resistivity measurements are made. The most popular method is by Wenner's four-electrode configuration. The test is carried out as per IS 3043-1987.

3.2 Four electrodes were driven into the ground at equal spacing and designed depth .The four electrodes are connected to the terminals of the earth resistivity meter. The resistivity meter is pressed "ON" to allow the current to flow through the electrodes .On pressing the "TEST" switch available in the meter for 10 ohms and 1000 ohms, the resistance value is displayed in the meter, which is noted down.

3.3 Readings of resistance for different electrode spacing in different directions are noted as per the said procedure.

4.0 METHOD OF COMPUTING OF RESISTIVITY VALUE

Earth resistivity is calculated by according to the formula.

$= 2 \pi d R$

Where

R = resistance in Ohms (megger reading for 10 ohm)

d = is the distance between spikes if spikes are placed at equal distances (m).

5.0 RESULTS

The values of resistivity, calculated as per formula given in section 4.0 above are as enclosed. After finding out the resistivity, average resistivity value at very test locations were also calculated and given in Table No: 2.1. The polar resistivity curves were drawn as per IS: 3043-1987 under Clause: 36.6. and corresponding other graphs are also drawn show in figure nos. 2.1.1 to 2.38.3.

Table No.2.1

MARKINGS	Co - ordinates	Average Resistivity in each direction (Ω m)			
		1 m	2 m	5 m	10 m
ERT 1	712 S 384 W	12.08	2.04	2.91	4.40
ERT 2	769 S 354 W	0.36	1.85	3.85	6.60
ERT 3	852 S 340 W	0.58	1.23	2.20	6.91
ERT 4	873 S 329 W	0.44	3.02	4.16	4.71
ERT 5	928 S 293 W	13.35	2.54	1.41	2.04
ERT 6	993 S 264 W	26.73	11.50	3.77	4.71
ERT 20	1473 S 305 W	2.62	0.63	1.18	3.46
ERT 21	1125 S 428 W	13.89	6.19	10.13	9.74
ERT 22	1159 S 493 W	8.32	9.93	18.14	2.20
ERT 23	1200 S 525 W	0.20	0.97	1.96	3.30
ERT 24	1309 S 475 W	10.13	14.61	12.02	3.93
ERT 25	1298 S 407 W	11.91	13.41	17.04	4.71
ERT 26	1385 S 409 W	7.63	2.80	14.14	19.79
ERT 28	1535 S 455 W	11.04	18.66	17.51	3.61
ERT 29	1552 S 326 W	9.20	11.00	22.46	3.77
ERT 30	1631 S 345 W	13.60	5.72	9.03	5.81
ERT 31	1759 S 230 W	8.42	11.09	19.48	2.67
ERT 32	1929 S 256 W	10.43	16.21	15.94	3.93
ERT 33	1651 S 200 W	4.84	3.20	4.16	5.03
ERT 34	1637 S 170 W	5.59	9.39	17.51	2.04
ERT 35	1904 S 66 W	11.91	13.95	17.28	6.44
ERT 36	2047 S 56 E	10.04	5.31	4.16	5.03

MARKINGS	Co - ordinates	Average Resistivity in each direction (Ω m)			
		1 m	2 m	5 m	10 m
ERT 37	1681 S 108 W	5.48	6.38	9.42	2.04
ERT 38	2348 S 161 W	13.21	12.19	15.79	10.84
ERT 39	1575 S 40 W	21.94	26.14	15.31	4.24
ERT 40	1881 S 489 E	3.74	2.42	3.53	2.83
ERT 41	1685 S 232 E	7.32	10.87	9.90	6.91
ERT 42	1477 S 123 E	34.59	23.03	14.06	5.03
ERT 43	1456 S 288 E	17.25	12.72	15.08	4.56
ERT 44	1447 S 443 E	6.86	6.60	6.44	4.87
ERT 45	141 S 562 E	10.38	8.86	5.73	4.08
ERT 46	25 S 530 E	7.07	10.65	12.25	8.64
ERT 47	892 N 465 E	11.14	9.64	5.10	3.93
ERT 48	926 N 381 E	13.34	9.02	3.30	3.46
ERT 49	1393 S 184 W	20.84	16.43	15.47	5.34
ERT 50	621 S 186 W	24.77	14.86	10.29	7.07
ERT 51	649 S 320 W	7.95	7.73	6.20	4.56
ERT 52	361 S 349 W	10.24	7.48	5.89	4.24

GRAPHICAL REPRESENTATION 1- POLAR GRAPH AS PER IS 3043 - 1987

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Direction	Average Resistivity in each direction				
	1 m	2 m	5 m	10 m	Avg.
N	8.80	11.44	22.62	3.14	11.50
E	10.74	12.31	26.07	5.65	13.70
S	9.24	10.30	21.68	1.88	10.78
W	8.04	9.93	19.48	4.40	10.46

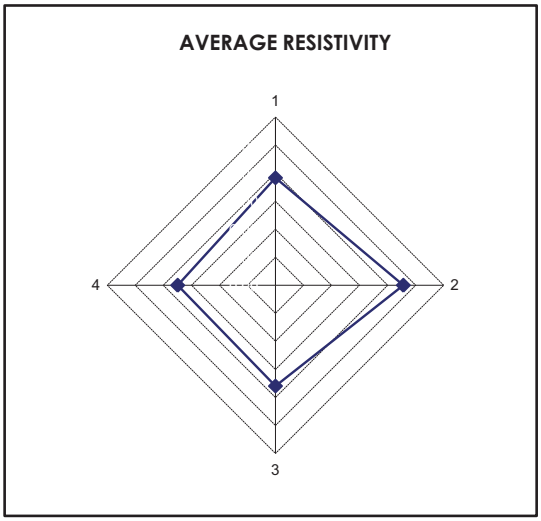


FIG NO 2.15.1

Average Resistivity at 10 m (ohm-meter) : 11.61

The term 1,2,3,4 in Polar graph indicates direction N, E, S, W respectively.

Each axis unit indicates 3 Ohm - m

ERT 29

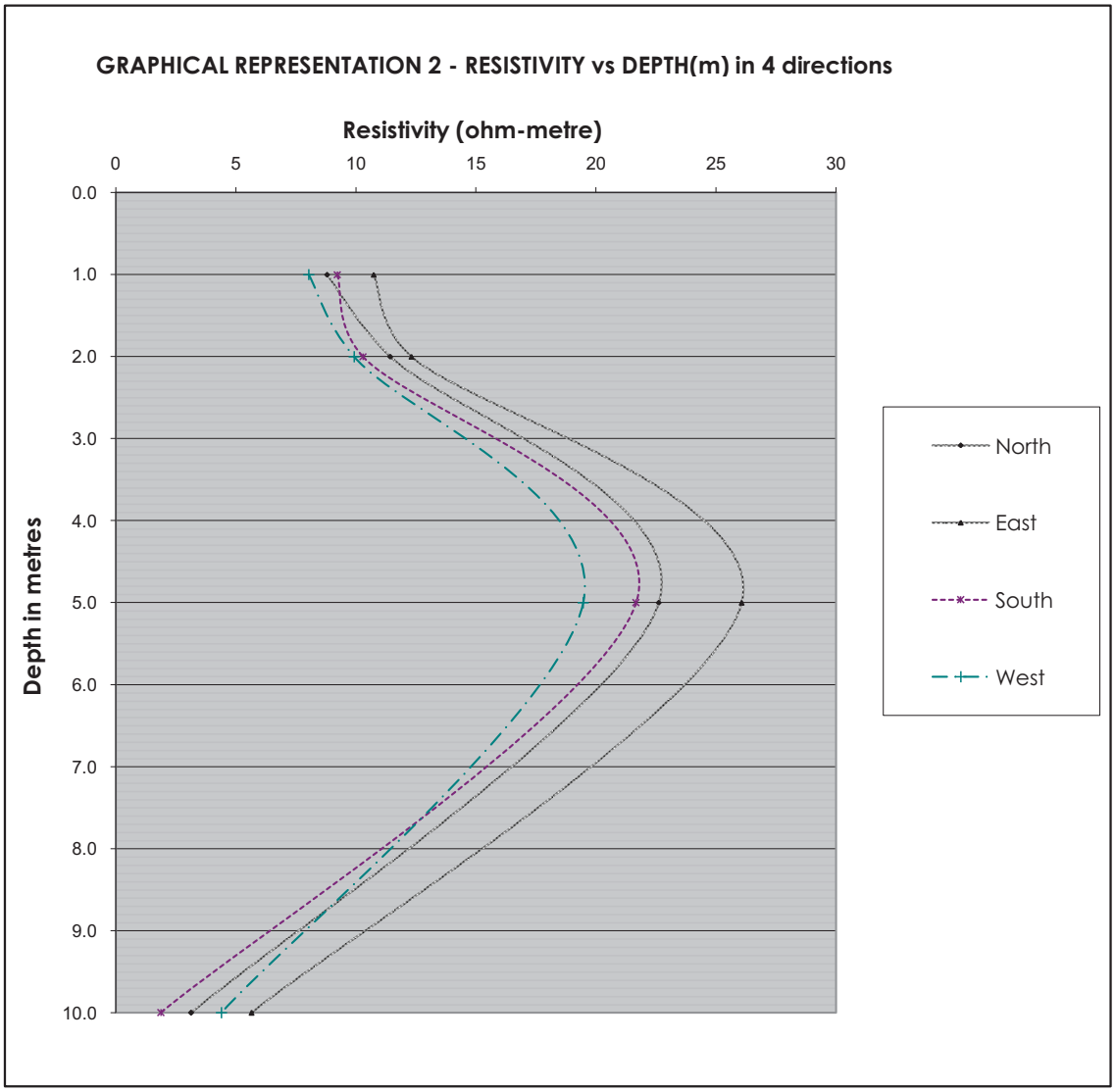


Fig No : 2.15.2

ERT 29

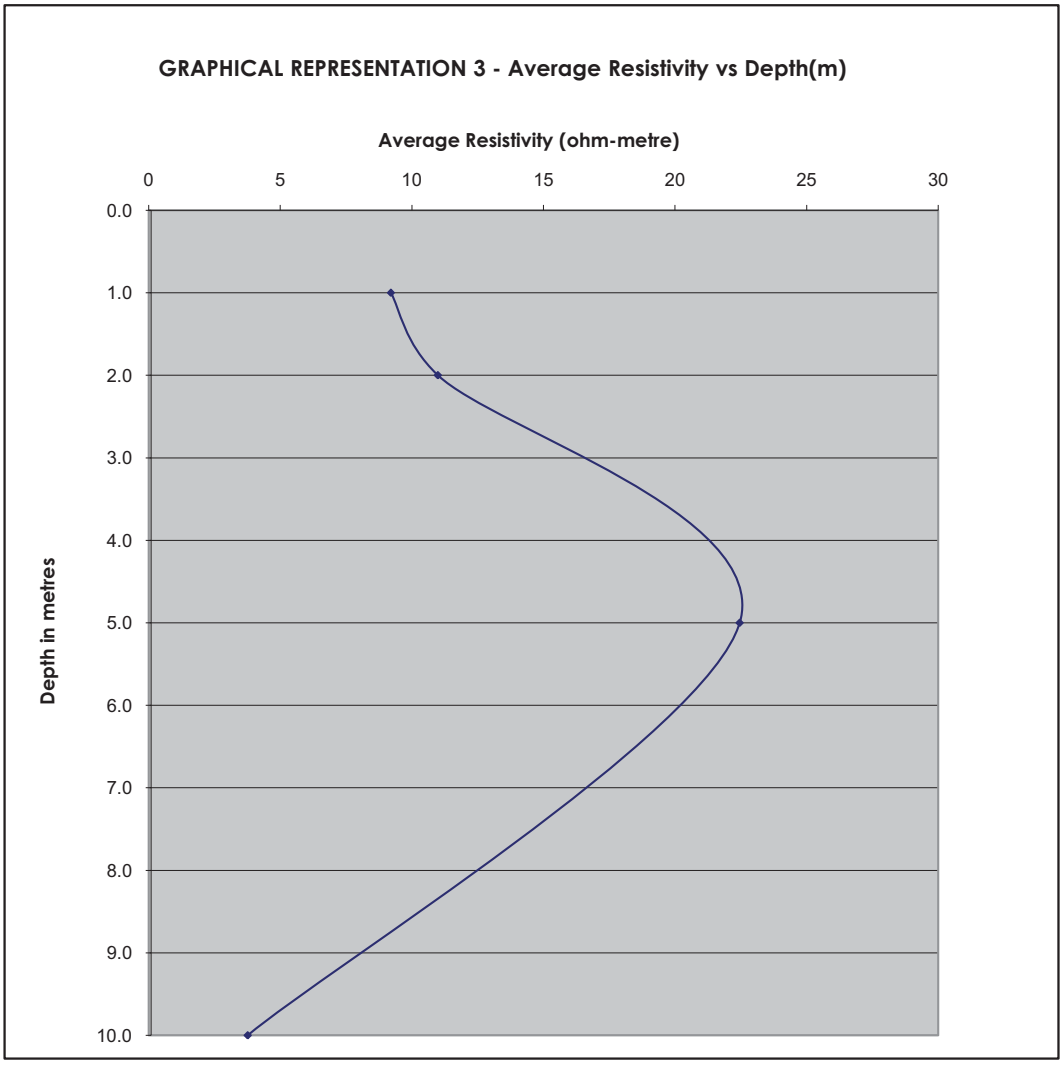


Fig No : 2.15.3

ERT 29

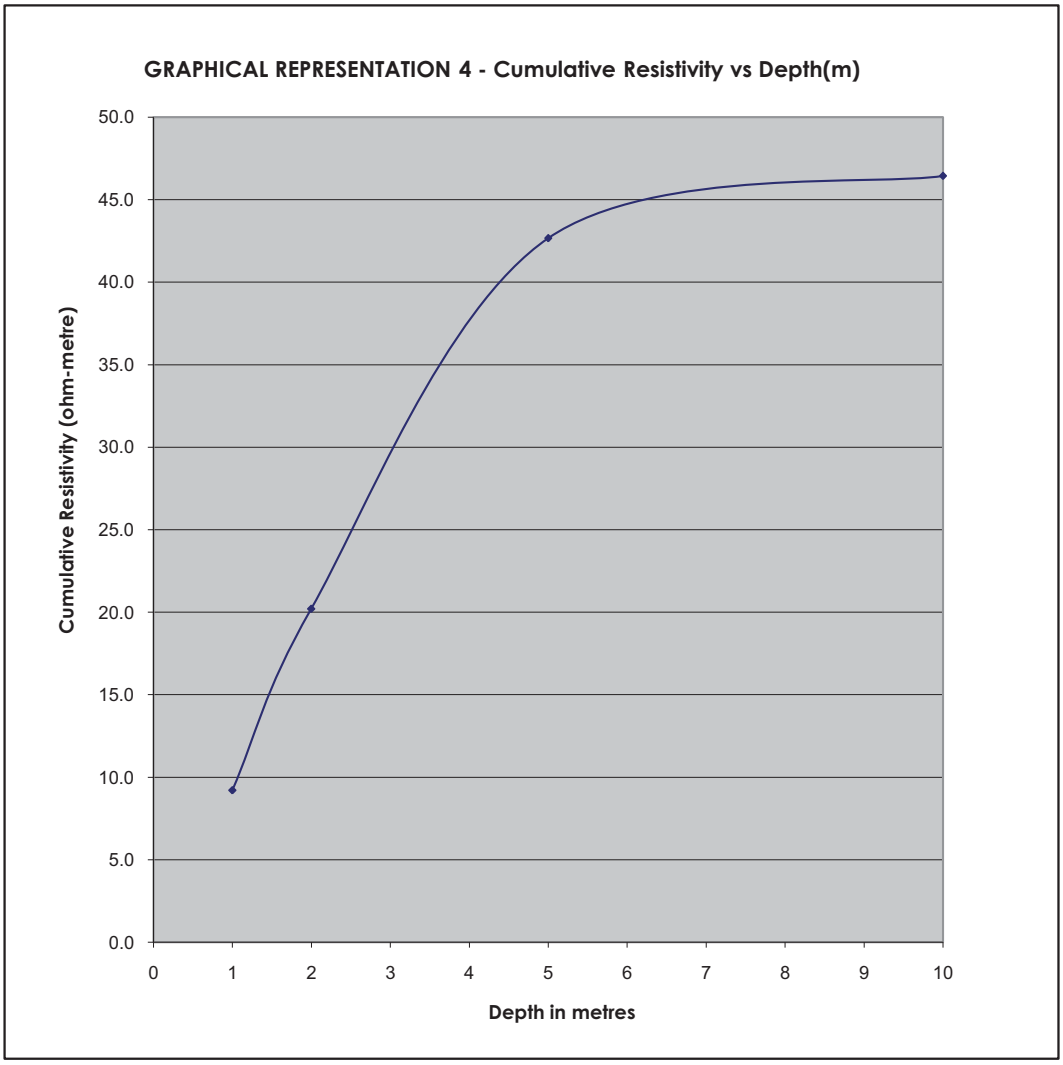


Fig No : 2.15.4

APPENDIX X

FIELD CBR TESTS

9.0 FIELD CBR TEST- BOP AREA

1.0 OBJECT OF INVESTIGATION

The objective of the investigation is to ascertain the California Bearing Ratio by conducting eight load penetration tests for the BOP area at the proposed site. The california bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements.

2.0 FIELD INVESTIGATION

The California Bearing Ratio Tests were carried out as per relevant Indian Standards as per as per **IS: 2720 Part (XXXI).**

First the test locations were cleared and the equipment used to provide load reaction was located such that the centre of the beam against which the loading jack will work over the centre to the test location.

The screw jack with swivel was installed to the underside of the equipment providing reaction, at the correct position of the test. The proving ring was connected to the bottom end of the jack and the piston connected to the bottom of the proving ring.

The surcharge annular weight of 5 kg was kept in position in the surface where the test was conducted so that when the piston lowered it will pass through the hole in the annular weight.

The penetration piston was seated with the smallest possible load but in no case in excess of a total load of 4 kg or 0.002 kgf/sq.mm so that full contact was established between the piston and the surface where the test was conducted.

A layer of clean sand (3mm to 6mm) was spread over the surface in order to distribute the surcharge normally.

The penetration indicating the dial was fixed suitably for recording the penetration and initially the dial was set to zero. The load readings were recorded at penetrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0 and 10.0 mm. Note

the maximum load and corresponding penetration till it occurs for a penetration less than 12.5 mm/min.

3.0 METHOD OF COMPUTING CALIFORNIA BEARING RATIO

The load vs penetration curves were plotted. The corrected load values shall be taken from the load penetration curve and the bearing ratio was calculated as follows.

C.B.R. = P_T/P_S x 100

Where,

P_t = Corrected unit(or total) test load corresponding to the chosen penetration value read from the load penetration curve.

Ps = Unit Standard load for the same depth of penetration as given in Table 10.2.1.

The following table No: 9.1 gives the standard loads adopted for different penetrations for the standard material with a C.B.R. value of 100%.

Table No : 9.1

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5.0	2055
7.5	2630
10.0	3180
12.5	3600

A sample calculation of California bearing ratio is given below.

Test Location No : 1

Depth of test : 0.50 m

Proving Ring Constant : 6.52 kg

Proving Ring dial Reading at 2.5 mm Penetration = 12 divisions

Therefore, Applied load = 12 x 6.52 = 78.19 kg

Unit standard load for 2.5 mm penetration = 1370 kg.

Therefore, Bearing Ratio at 2.5 mm penetration = (78.19/1370)* 100 = 5.71%

Proving Ring dial Reading at 5 mm Penetration = 16 divisions

Therefore, Applied load = 16 x 6.52 = 104.25 kg

Unit standard load for 5 mm penetration = 2055 kg.

Therefore, Bearing Ratio at 5 mm penetration = (104.25/2055)

= 5.07%

Recommended CBR value = 5.71%
Detailed calculation with Field data are presented in Table 9.2

Table No: 9.2

Test location no : 1 **Test Date** : 15.06.2016
Co-ordinates : 817 S 140 W **Test Depth** : 0.50 m

Penetration in mm	Proving Ring Dial Gauge Readings	Load in Kg
0.5	2.000	13.03
1.0	6.000	39.09
1.5	8.000	52.13
2.0	10.000	65.16
2.5	12.000	78.19
3.0	12.000	78.19
4.0	14.000	91.22
5.0	16.000	104.25
6.0	18.000	117.28
8.0	24.000	156.38

Bearing Ratio at 2.5mm penetration (%) : 5.71

Bearing Ratio at 5.0mm penetration (%) : 5.07

Recommended CBR Value (%) : 5.71

4.0 INTERPRETATION OF RESULTS

The C.B.R. values are usually calculated for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater that at 5 mm and in such a case/the former shall be taken as C.B.R. for design purpose. Detailed Results of CBR are presented in 9.3.

Table – 9.3

S.NO	TEST NO	CO - ORDINATES		FIELD CBR %
1	FCBR-1	817 S	140 W	5.71
2	FCBR-3	1397 S	481 W	4.44
3	FCBR-4	1722 S	80 W	3.80
4	FCBR-5	1434 S	113 E	6.34
5	FCBR-6	500 S	389 W	9.04
6	FCBR-7	900 S	595 W	8.56
7	FCBR-8	1100 S	530 W	6.34
8	FCBR-9	1573 S	260 W	6.34

APPENDIX XI

CHEMICAL ANALYSIS OF WATER AND SOIL

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Client : **Bharat Heavy Electricals Limited**

Table No :

Project : **Detailed Geo Technical Investigation for 1x800 MW North Chennai TPP Stage III, Chennai**

Report No. : **SI/CHN/16/**

548

Chemical Analysis of Water Sample

TESTS	BH 7	BH 49	BH 65	BH 74	BH 79	BH 80	BH 82
Colour	Pale yellow	Pale yellow	Pale Yellow	Pale Yellow	Pale yellow	Pale yellow	Pale Yellow
Odour	Muddy	Muddy	Odourless	Muddy	Muddy	Muddy	Muddy
pH at 25^{o} C	7.12	8.38	7.49	7.39	7.75	7.86	7.25
Carbonate Hardness as CaCO3 (mg/l)	254	350	556	206	250	145	155
Sulphate as SO3 (mg/l)	732	910	2676	433	122	135	120
Sulphate as SO4 (mg/l)	530	1092	3210	519	216	175	195
Chloride as CL (mg/l)	845	482	4113	695	150	250	354
Nitrogen as N (mg/l)	3	2	3	4	2	4	6
Organic Matter (mg/l)	320	44	47	39	65	120	51

GEO FOUNDATIONS & STRUCTURES PVT. LTD

Client : **Bharat Heavy Electricals Limited**

Table No :

Project : **Detailed Geo Technical Investigation for 1x800 MW North Chennai TPP Stage III, Chennai**

Report No. : **SI/CHN/16/**

Chemical Analysis of Water Sample

TESTS	BH 91	BH 96	BH 103	BH 107	BH 108
Colour	Pale yellow	Pale yellow	Pale yellow	Pale Yellow	Pale yellow
Odour	Soil	Muddy	Muddy	Solvent Smell	Muddy
pH at 25^{o} C	7.49	7.39	7.29	7.63	7.62
Carbonate Hardness as CaCO3 (mg/l)	232	158	140	154	145
Sulphate as SO3 (mg/l)	13	155	145	152	125
Sulphate as SO4 (mg/l)	16	128	118	182	128
Chloride as CL (mg/l)	71	295	525	1007	1010
Nitrogen as N (mg/l)	6	5	4	1	3
Organic Matter (mg/l)	110	100	59	41	45

Client : Bharat Heavy Electricals Limited

Table No :

Project : Detailed Geo Technical Investigation for 1x800 MW North Chennai TPP Stage III, Chennai

Report No. : SI/CHN/16/

550

Chemical Analysis of Soil Sample

TESTS	BH33	BH 64	BH 77	BH 83	BH 85	BH 86	BH 89	BH 95	BH 103	BH 110
	15.5 m	15.5 m	9.5 m	11 m	12.50 m	8 m	9.5	11 m	17 m	2 m
P^H	6.13	4.65	5.68	5.88	5.2	6.44	6.25	8.48	8.35	5.8
Carbonate CO3	0.01%	0.002%	0.003%	0.008%	0.009%	0.01%	0.04%	0.03%	0.050%	0.002%
Sulphate as SO3	0.040%	0.12%	0.08%	0.05%	0.08%	0.19%	0.26%	0.17%	0.29%	0.12%
Sulphate as SO4	0.050%	0.09%	0.05%	0.06%	0.11%	0.23%	0.25%	0.20%	0.34%	0.14%
Chloride asCl	430 ppm	150 ppm	120 ppm	200 ppm	150ppm	2800 ppm	1500 ppm	0.11%	0.13%	250 ppm
Nitrate as NO3	0.09%	0.20%	0.11%	0.09%	0.14%	0.12%	0.16%	0.04%	0.08%	0.08%
Organic Matter	2.62%	0.75%	0.80%	0.78%	0.91%	3.79%	4.10%	6.67%	6.55%	6.49%

APPENDIX XII

LABORATORY CBR TEST RESULT

11.0 LAB CALIFORNIA BEARING RATIO TEST RESULTS- BOP AREA

1.0 OBJECTIVE OF THE TEST

- The objective of the test is to evaluate the California Bearing Ratio values of soil sample collected from eleven locations in BOP area at a depth of 0.5 m from the existing ground level.

2.0 SCOPE OF WORK

The scope of work at this site comprises the following:

- Mobilization of all necessary equipments and personnel.
- Collecting soil samples from the specified locations, packing and transporting to laboratory.
- Conducting Standard and Modified Proctor tests to determine Maximum dry density and Optimum Moisture content.
- Conducting California Bearing Ratio Tests.
- Preparation and submission of the laboratory results.

3.0 FIELD INVESTIGATION

- The soil samples were collected from eleven locations at a depth of 0.5 m from the existing ground level.

4.0 LABORATORY INVESTIGATION

- California Bearing Ratio tests were conducted on the soil samples at maximum dry density, as per the relevant Indian Standard, IS 2720: Part 16 : Latest version. The results of CBR tests are presented in Table No 11.1

5.0 CONCLUSIONS

The field and laboratory tests were carried out as per the relevant Indian Standard and the results shows soaked and unsoaked CBR values as per Table 11.1 at the maximum dry density and optimum moisture content.

Table 11.1

SAMPLE	STANDARD COMPACTION		MODIFIED COMPACTION		CBR (%)	CBR (%)
	OMC (%)	MDD (g/cc)	OMC (%)	MDD (g/cc)	SOAKED	UNSOAKED
CBR 1	9.43	1.76	-	-	5.5	
CBR 3	11.2	1.83	-	-	9.3	
CBR 4	10.65	1.78	9.5	1.96	5.2	10.3
CBR 5	11.07	1.66	11.73	1.75	7.5	
CBR 6	10.94	1.79	9.82	1.84	11	
CBR 7	10.94	1.71	10.22	1.85	9.3	13.5
CBR 8	11.48	1.75	9.9	1.79	8.2	
CBR 9	11.53	1.77	8.03	1.9	10.7	17
CBR NEAR 7	-	-	10.6	1.96	8.5	
CBR NEAR 8	11.21	1.73	11.15	1.86	6.3	
CBR NEAR 9	10.87	1.79	11.1	1.82	12	

APPENDIX XIII

LIQUEFACTION ANALYSIS

1 x 800 MW NORTH CHENNAI STPP STAGE # 3

Liquefaction analysis of sub- soil

1) C_N= Correction for Overburden pressure limited to 1.70

$$C_N = \sqrt{\frac{P_a}{\sigma}}$$

P_a = 1 Atmospheric pressure = 10t/sqm

σ = Vertical effective stress at the depth of SPT

2) C_E = Correction for Level of energy delivered by SPT hammer = 1.00.

3) C_B = Correction for Borehole Diameter = 1.05 for 150mm borehole dia.

4) C_S = Correction for SPT sampler use = 1.10 for sampler without liner.

5) C_R = Correction for short length of drill rod.

Rod length(r	C_R	Rod length	C_R
<3	0.75	6-<10	0.95
3-<4	0.80	10-30	1.00
4-<6	0.85		

$(N1) = C_N C_E C_B C_S C_R$

Fine content means particles smaller than 75 micron

For Fine Content<=5,α = 0 and β = 1

For(Fine Content>5 AND <35),α = EXP((1.76-(190/FC^2)) and β = (0.99+($FC^{1.5}$/1000))

For Fine Content>35,α = 5 and β = 1.20

Corr. (N1) = α+β*(N1)

$r_d=(1-0.4113*d^{0.5}+0.04052*d+0.001753*d^{1.5})/(1-0.4177*d^{0.5}+0.05729*d-0.006205*d^{1.5}+0.00121*d^2)$

CSR = 0.65*(a_{max}/g)*(Total Overburden pressure)*r_d/(Effective Overburden pressure)

CRR=1/(34-Final$(N1)_{60}$)+Final$(N1)_{60}$/135+50/(10*Final$(N1)_{60}$+45)^2-1/200

FOS against Liquifaction = CRR/CSR

For FOS > 1.0, liquefaction is not expected

For calculation of CSR & CRR, water level is considered at ground level.

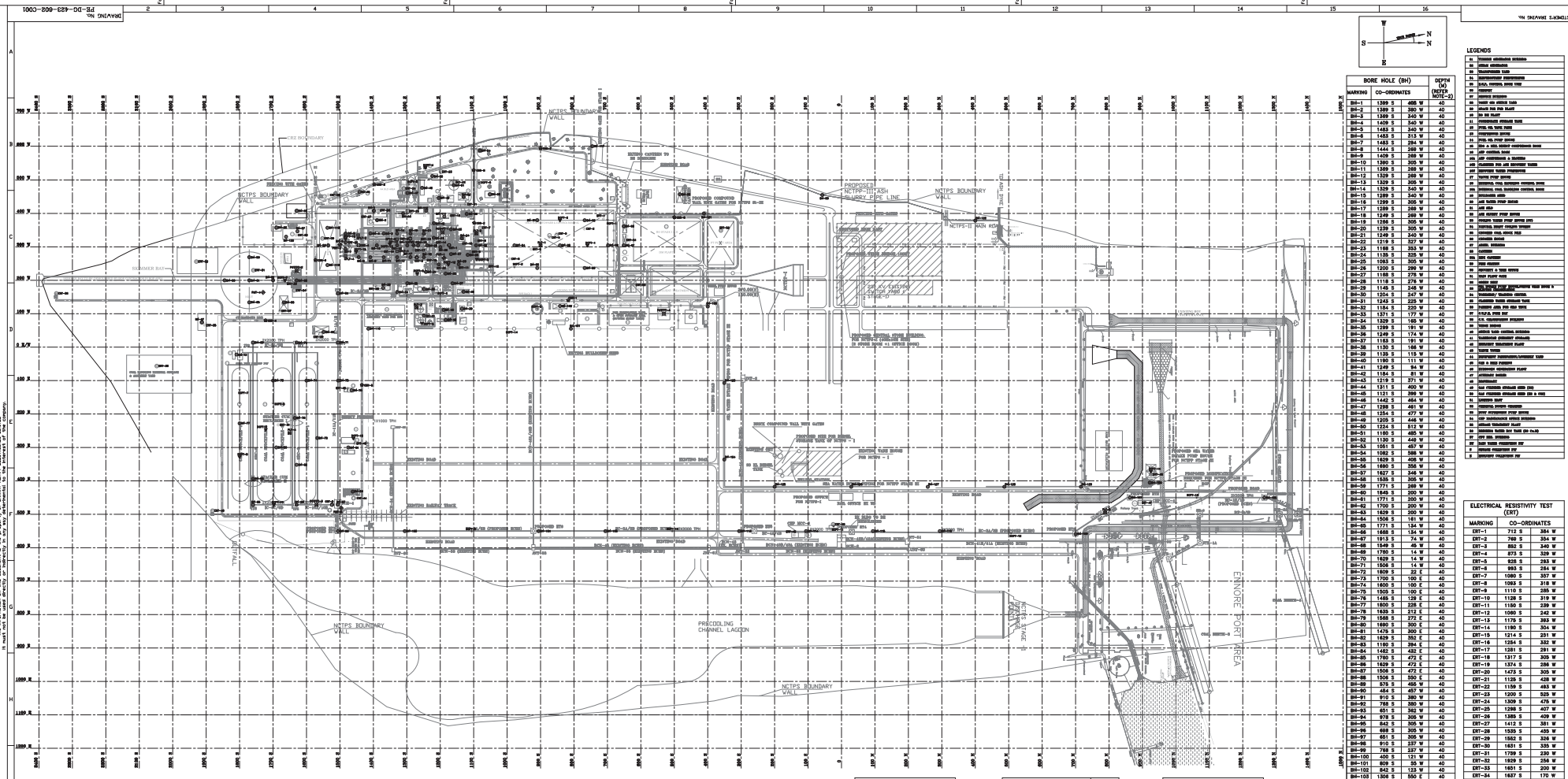
Location	Depth below EGL	Field N	Total OVP (t/sqm)	Effective OVP (t/sqm)	CN	CE	CB	CS	CR	(N1)	FC	α	β	Corr. (N1)	r_d	CSR	CRR	FOS	Remarks
BH-45	1.00	8	1.85	1.85	1.70	1.00	1.05	1.10	0.75	11.8	9	0.56	1.02	12.5	0.99	0.10	0.14	1.88	**No liquefaction**
	3.00	9	5.55	5.04	1.41	1.00	1.05	1.10	0.80	11.7	10	0.87	1.02	12.8	0.98	0.11	0.14	1.77	**No liquefaction**
	5.00	12	9.25	7.04	1.19	1.00	1.05	1.10	0.85	14.0	9	0.56	1.02	14.8	0.97	0.13	0.16	1.72	**No liquefaction**
	8.00	8	14.80	10.04	1.00	1.00	1.05	1.10	0.95	8.8	3	0.00	1.00	8.8	0.94	0.14	0.10	1.02	**No liquefaction**
	11.00	16	20.35	13.04	0.88	1.00	1.05	1.10	1.00	16.2	6	0.03	1.00	16.3	0.88	0.14	0.17	1.73	**No liquefaction**
	14.00	18	25.90	16.04	0.79	1.00	1.05	1.10	1.00	16.4	6	0.03	1.00	16.5	0.79	0.13	0.18	1.88	**No liquefaction**

APPENDIX XIV

SITE LOCATION DRAWING

DRAWING No. PE-DG-423-602-C001

FIRST ANGLE PROJECTION | ALL DIMENSIONS ARE IN MM



LEGENDS

BL	BITUMEN EMULSION DISTRIBUTOR
CA	CRUSH ASSEMBLER
CB	CRUSHER BUNKER
CH	CONVEYOR WITH HOOD
CT	CONVEYOR WITH TUNNEL
DB	DRAG BOARD FOR SLAKE
DC	DE-ICE PLANT
DG	DIESEL GENERATOR HOUSE
DP	DRAG PAN TYPE FEEDER
DT	DISTRIBUTION BUNKER
EL	PIPE OR TUBE FEEDER
EP	EMULSION PUMP
FB	FEED & SOIL BINDER CONVEYANCE HOOD
GP	GRIP CONTROL HOUSE
HB	HOPPER WITH GATE & DELIVERY
HP	HOPPER FOR AIR ENTRAINED WATER
HT	HOPPER TYPE FEEDER
IT	INCLINED TUBE CONVEYOR
LC	LOADING CHUTE
LH	LOADING HOOD
LT	LOADING TUBE
MC	MOTOR CONTROL CENTRE
MH	MOTOR HOUSE
MT	MIXING TUBE
OT	OVERHEAD TUBE
PC	PUMP CONTROL CENTRE
PH	PUMP HOUSE
PT	PUMP TUBE
RC	REMOTE CONTROL CENTRE
RH	RELAY HOUSE
RT	RETURN TUBE
SC	SCRAPER CONVEYOR
SH	SCRAPER CONVEYOR WITH HOOD
SP	SPRAY PUMP
ST	SPRAY TUBE
TC	TRANSFORMER CENTRE
TH	TRANSFORMER HOUSE
TT	TRANSFORMER TUBE
VC	VALVE CHAMBER
VH	VALVE HOUSE
VT	VENT TUBE
WC	WATER & TUBE CENTRE
WH	WATER PUMP HOUSE
WT	WATER TUBE
AB	AIR BLOWER
AH	AIR BLOWER PUMP HOUSE
AT	AIR BLOWER PUMP HOUSE WITH
BC	BOILER FEED PUMP CONTROL CENTRE
BH	BOILER FEED PUMP HOUSE
CC	CONDENSER CONTROL CENTRE
CH	CONDENSER PUMP HOUSE
CT	CONDENSER TUBE
DH	DEMINERALISATION PLANT HOUSE
DT	DEMINERALISATION PLANT TUBE
EH	ELECTRICAL EQUIPMENT HOUSE
ET	ELECTRICAL EQUIPMENT TUBE
FH	FIRE PUMP HOUSE
FT	FIRE PUMP TUBE
GH	GENERATOR TRANSFORMER HOUSE
GT	GENERATOR TRANSFORMER TUBE
HC	HYDROGEN GENERATION PLANT
HT	HYDROGEN GENERATION PLANT TUBE
LH	LUBRICATING OIL PUMP HOUSE
LT	LUBRICATING OIL PUMP TUBE
MH	MAIN CONTROL ROOM
MT	MAIN CONTROL ROOM TUBE
OH	OIL PUMP HOUSE
OT	OIL PUMP TUBE
PH	PUMP HOUSE
PT	PUMP TUBE
SH	SERVICE WATER PUMP HOUSE
ST	SERVICE WATER PUMP TUBE
TH	TURBINE HOUSE
TT	TURBINE TUBE
UH	UNIT AUXILIARY TRANSFORMER HOUSE
UT	UNIT AUXILIARY TRANSFORMER TUBE
WH	WATER TREATMENT PLANT HOUSE
WT	WATER TREATMENT PLANT TUBE
AT	ACETYLENE GENERATOR
BH	BOOSTER PUMP HOUSE
BT	BOOSTER PUMP TUBE
CH	CHEMICAL STORAGE HOUSE (DM)
CT	CHEMICAL STORAGE TUBE (DM & PRE)
DH	DIESEL HOUSE
DT	DIESEL TUBE
EH	ELECTRICAL EQUIPMENT HOUSE
ET	ELECTRICAL EQUIPMENT TUBE
FH	FIRE PUMP HOUSE
FT	FIRE PUMP TUBE
GH	GENERATOR TRANSFORMER HOUSE
GT	GENERATOR TRANSFORMER TUBE
HC	HYDROGEN GENERATION PLANT
HT	HYDROGEN GENERATION PLANT TUBE
LH	LUBRICATING OIL PUMP HOUSE
LT	LUBRICATING OIL PUMP TUBE
MH	MAIN CONTROL ROOM
MT	MAIN CONTROL ROOM TUBE
OH	OIL PUMP HOUSE
OT	OIL PUMP TUBE
PH	PUMP HOUSE
PT	PUMP TUBE
SH	SERVICE WATER PUMP HOUSE
ST	SERVICE WATER PUMP TUBE
TH	TURBINE HOUSE
TT	TURBINE TUBE
UH	UNIT AUXILIARY TRANSFORMER HOUSE
UT	UNIT AUXILIARY TRANSFORMER TUBE
WH	WATER TREATMENT PLANT HOUSE
WT	WATER TREATMENT PLANT TUBE
AT	ACETYLENE GENERATOR
BH	BOOSTER PUMP HOUSE
BT	BOOSTER PUMP TUBE
CH	CHEMICAL STORAGE HOUSE (DM)
CT	CHEMICAL STORAGE TUBE (DM & PRE)
DH	DIESEL HOUSE
DT	DIESEL TUBE
EH	ELECTRICAL EQUIPMENT HOUSE
ET	ELECTRICAL EQUIPMENT TUBE
FH	FIRE PUMP HOUSE
FT	FIRE PUMP TUBE
GH	GENERATOR TRANSFORMER HOUSE
GT	GENERATOR TRANSFORMER TUBE
HC	HYDROGEN GENERATION PLANT
HT	HYDROGEN GENERATION PLANT TUBE
LH	LUBRICATING OIL PUMP HOUSE
LT	LUBRICATING OIL PUMP TUBE
MH	MAIN CONTROL ROOM
MT	MAIN CONTROL ROOM TUBE
OH	OIL PUMP HOUSE
OT	OIL PUMP TUBE
PH	PUMP HOUSE
PT	PUMP TUBE
SH	SERVICE WATER PUMP HOUSE
ST	SERVICE WATER PUMP TUBE
TH	TURBINE HOUSE
TT	TURBINE TUBE
UH	UNIT AUXILIARY TRANSFORMER HOUSE
UT	UNIT AUXILIARY TRANSFORMER TUBE
WH	WATER TREATMENT PLANT HOUSE
WT	WATER TREATMENT PLANT TUBE

BORE HOLE (BH)

MARKING	CO-ORDINATES		DEPTH (M) (NOTE-2)
BH-1	1399 S	488 W	40
BH-2	1389 S	380 W	40
BH-3	1399 S	340 W	40
BH-4	1409 S	340 W	40
BH-5	1483 S	340 W	40
BH-6	1453 S	313 W	40
BH-7	1483 S	284 W	40
BH-8	1444 S	260 W	40
BH-9	1409 S	260 W	40
BH-10	1380 S	305 W	40
BH-11	1369 S	260 W	40
BH-12	1329 S	260 W	40
BH-13	1329 S	305 W	40
BH-14	1329 S	340 W	40
BH-15	1289 S	340 W	40
BH-16	1259 S	305 W	40
BH-17	1289 S	260 W	40
BH-18	1249 S	260 W	40
BH-19	1266 S	305 W	40
BH-20	1239 S	305 W	40
BH-21	1249 S	340 W	40
BH-22	1219 S	327 W	40
BH-23	1188 S	353 W	40
BH-24	1135 S	325 W	40
BH-25	1083 S	305 W	40
BH-26	1209 S	299 W	40
BH-27	1188 S	275 W	40
BH-28	1119 S	276 W	40
BH-29	1145 S	248 W	40
BH-30	1204 S	247 W	40
BH-31	1249 S	225 W	40
BH-32	1184 S	220 W	40
BH-33	1181 S	177 W	40
BH-34	1329 S	165 W	40
BH-35	1299 S	191 W	40
BH-36	1249 S	174 W	40
BH-37	1185 S	191 W	40
BH-38	1130 S	166 W	40
BH-39	1139 S	119 W	40
BH-40	1190 S	111 W	40
BH-41	1249 S	94 W	40
BH-42	1184 S	81 W	40
BH-43	1319 S	371 W	40
BH-44	1311 S	400 W	40
BH-45	1121 S	299 W	40
BH-46	1442 S	464 W	40
BH-47	1298 S	461 W	40
BH-48	1254 S	477 W	40
BH-49	1205 S	448 W	40
BH-50	1224 S	512 W	40
BH-51	1180 S	485 W	40
BH-52	1130 S	440 W	40
BH-53	1081 S	457 W	40
BH-54	1082 S	388 W	40
BH-55	1629 S	408 W	40
BH-56	1680 S	356 W	40
BH-57	1627 S	346 W	40
BH-58	1580 S	305 W	40
BH-59	1771 S	269 W	40
BH-60	1845 S	200 W	40
BH-61	1771 S	200 W	40
BH-62	1700 S	200 W	40
BH-63	1629 S	200 W	40
BH-64	1506 S	161 W	40
BH-65	1771 S	134 W	40
BH-66	1688 S	134 W	40
BH-67	1913 S	74 W	40
BH-68	1845 S	45 W	40
BH-69	1780 S	14 W	40
BH-70	1629 S	14 W	40
BH-71	1506 S	14 W	40
BH-72	1809 S	22 E	40
BH-73	1700 S	100 E	40
BH-74	1600 S	100 E	40
BH-75	1505 S	100 E	40
BH-76	1486 S	128 E	40
BH-77	1600 S	228 E	40
BH-78	1630 S	212 E	40
BH-79	1588 S	272 E	40
BH-80	1690 S	300 E	40
BH-81	1476 S	300 E	40
BH-82	1629 S	352 E	40
BH-83	1180 S	394 E	40
BH-84	1482 S	432 E	40
BH-85	1790 S	472 E	40
BH-86	1629 S	472 E	40
BH-87	1506 S	472 E	40
BH-88	1506 S	550 E	40
BH-89	579 S	485 W	40
BH-90	484 S	457 W	40
BH-91	910 S	380 W	40
BH-92	788 S	380 W	40
BH-93	651 S	342 W	40
BH-94	978 S	305 W	40
BH-95	842 S	305 W	40
BH-96	698 S	305 W	40
BH-97	651 S	305 W	40
BH-98	910 S	237 W	40
BH-99	788 S	237 W	40
BH-100	400 S	121 W	40
BH-101	400 S	55 W	40
BH-102	842 S	123 W	40
BH-103	1506 S	550 E	40
BH-104	906 S	550 E	40
BH-105	708 S	550 E	40
BH-106	952 N	405 E	40
BH-107	862 N	460 E	40
BH-108	1080 N	450 E	40
BH-109	700 N	359 E	40
BH-110	1418 S	85 W	40
BH-111	1188 S	391 E	40
BH-112	1242 S	408 W	40
BH-113	306 S	550 E	40
BH-114	106 S	550 E	40
BH-115	94 N	550 E	40
BH-116	294 N	550 E	40
BH-117	749 S	601 W	40
BH-118	1577 S	357 W	40
BH-119	1577 S	246 W	40
BH-120	1661 S	330 W	40
BH-121	411 S	400 W	40
BH-122	400 N	379 W	40
BH-123	350 S	107 E	40
BH-124	350 S	336 E	40
BH-125	200 S	418 E	40
BH-126	29 N	418 E	40
BH-127	258 N	418 E	40
BH-128	478 N	418 E	40
BH-129	718 N	418 E	40

ELECTRICAL RESISTIVITY TEST (ERT)

MARKING	CO-ORDINATES	
ERT-1	712 S	384 W
ERT-2	768 S	334 W
ERT-3	822 S	340 W
ERT-4	873 S	339 W
ERT-5	925 S	283 W
ERT-6	993 S	284 W
ERT-7	1060 S	287 W
ERT-8	1065 S	318 W
ERT-9	1110 S	285 W
ERT-10	1128 S	319 W
ERT-11	1150 S	239 W
ERT-12	1080 S	242 W
ERT-13	1175 S	263 W
ERT-14	1190 S	304 W
ERT-15	1214 S	231 W
ERT-16	1254 S	232 W
ERT-17	1281 S	281 W
ERT-18	1317 S	305 W
ERT-19	1374 S	256 W
ERT-20	1473 S	305 W
ERT-21	1125 S	428 W
ERT-22	1159 S	483 W
ERT-23	1200 S	525 W
ERT-24	1309 S	475 W
ERT-25	1298 S	407 W
ERT-26	1385 S	409 W
ERT-27	1412 S	381 W
ERT-28	1535 S	455 W
ERT-29	1562 S	326 W
ERT-30	1631 S	335 W
ERT-31	1627 S	230 W
ERT-32	1629 S	256 W
ERT-33	1651 S	200 W
ERT-34	1627 S	170 W
ERT-35	1804 S	66 W
ERT-36	2047 S	56 E
ERT-37	1681 S	106 W
ERT-38	2348 S	181 W
ERT-39	1575 S	40 W
ERT-40	1481 S	499 E
ERT-41	1685 S	232 E
ERT-42	1477 S	123 E
ERT-43	1456 S	288 E
ERT-44	1447 S	443 E
ERT-45	141 S	562 E
ERT-46	25 S	530 E
ERT-47	892 N	485 E
ERT-48	826 N	381 E
ERT-49	1063 S	194 E
ERT-50	621 S	188 W
ERT-51	648 S	320 W
ERT-52	361 S	249 W

DYNAMIC CONE PENETRATION TEST (DCPT)

MARKING	CO-ORDINATES	
DCPT-1	760 S	305 W
DCPT-2	843 S	380 W
DCPT-3	1081 S	253 W
DCPT-4	1243 S	537 W
DCPT-5	1254 S	73 W
DCPT-6	1298 S	220 W
DCPT-7	1864 S	200 W
DCPT-8	1800 S	328 E
DCPT-9	1732 S	246 E
DCPT-10	1460 S	272 E
DCPT-11	1698 S	471 E
DCPT-12	1170 S	247 W
DCPT-13	1350 S	309 W
DCPT-14	928 N	371 E
DCPT-15	1451 N	285 E
DCPT-16	1483 N	324 W

STATIC CONE PENETRATION TEST (SCPT)

MARKING	CO-ORDINATES	
SCPT-1	700 S	380 W
SCPT-2	978 S	240 W
SCPT-3	910 S	115 W
SCPT-4	1212 S	163 W
SCPT-5	1084 S	492 W
SCPT-6	1293 S	487 W
SCPT-7	1800 S	128 E
SCPT-8	1700 S	169 E
SCPT-9	1106 S	550 E
SCPT-10	504 S	550 E
SCPT-11	24 S	536 E
SCPT-12	507 N	556 E
SCPT-13	1062 N	490 E
SCPT-14	1000 S	55 W

PUMP OUT TYPE FIELD PERMEABILITY TEST (POTPFT)

MARKING	CO-ORDINATES		DEPTH (M)
POTPFT-1	1183 S	344 W	10
POTPFT-2	1629 S	228 W	10
POTPFT-3	1570 S	471 E	10
POTPFT-4	531 S	100 W	10

CYCLIC PLATE LOAD TEST (CPLT)

MARKING	CO-ORDINATES		DEPTH (M)
CPLT-1	1329 S	287 W	4
CPLT-2	1329 S	323 W	4
CPLT-3	1448 S	335 W	4
CPLT-4	1483 S	272 W	4

PLATE LOAD TEST (PLT)

MARKING	CO-ORDINATES		DEPTH (M)
PLT-1	900 S	305 W	3
PLT-2	1093 S	340 W	3
PLT-3	1271 S	118 W	3
PLT-4	1851 S	257 E	3
PLT-5	788 N	484 E	3

FIELD CBR TEST

MARKING	CO-ORDINATES		DEPTH (M)
CBR-1	817 S	140 W	0.5
CBR-2	1099 S	371 W	0.5
CBR-3	1397 S	487 W	0.5
CBR-4	1723 S	80 W	0.5
CBR-5	1434 S	113 E	0.5
CBR-6	500 S	389 W	0.5
CBR-7	900 S	695 W	0.5
CBR-8	1100 S	530 W	0.5
CBR-9	1573 S	260 W	0.5

CROSSHOLE SHEAR TEST (CST)

MARKING	CO-ORDINATES	
CST-1	1174 S	308 W
CST-2	1290 S	328 W
CST-3	1270 S	268 W
CST-4	1444 S	308 W
CST-5	1524 S	471 E

PRESSURE METER TEST (PMT)

MARKING	CO-ORDINATES	
PMT-1	1188 S	299 W
PMT-2	1280 S	308 W
PMT-3	1500 S	307 W
PMT-4	1730 S	164 W
PMT-5	1498 S	482 E

N O T E S:-

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. BORE HOLE SHALL BE DRILLED UPTO THE DEPTH INDICATED AGAINST EACH BORE HOLE OR SPT 'N' VALUE GREATER THAN 100 IS OBTAINED FOR FOUR CONSECUTIVE INTERVALS WHICHEVER IS EARLIER.
3. BACKFILLING OF BORE HOLES AND PITS SHALL BE AS PER SPECIFICATION AND AS DIRECTED BY THE ENGINEER-IN-CHARGE.
4. STARTING DEPTH OF STANDARD PENETRATION TEST (SPT) SHALL BE 1M BELOW GROUND LEVEL AND THE TEST SHALL BE CONDUCTED AT EVERY 1M INTERVAL ALTERNATE TO COLLECTION OF UNDISTURBED SAMPLE (UDS) UPTO 5M DEPTH BELOW GROUND LEVEL AND AT EVERY 1.5M INTERVAL ALTERNATE TO COLLECTION OF UDS BEYOND 5M DEPTH, AT CHANGE OF STRATA & AT DEPTHS WHEREVER UDS COULD NOT BE COLLECTED.
5. STARTING DEPTH OF COLLECTION OF UDS SHALL BE 2M BELOW GROUND LEVEL AND UDS SHALL BE COLLECTED AT 1M INTERVAL ALTERNATE TO CONDUCTING SPT UPTO 10M DEPTH BELOW GROUND LEVEL & AT EVERY 1.5M INTERVAL ALTERNATE TO CONDUCTING SPT BEYOND 5M DEPTH.
6. CROSS HOLE SHEAR WAVE TEST SHALL BE CARRIED OUT AT 3M, 5M, 7M, 9M, 11M, 13M, 15M, 17M, 20M, 23M, 26M, 30M, 35M, & 40M DEPTH BELOW GROUND LEVEL.
7. FIELD VANE SHEAR TEST SHALL BE CARRIED OUT IN BH-6, BH-9, BH-14, BH-25, BH-30, BH-61, BH-73, BH-79, BH-85 BH-88, BH-95 & BH-103 AT DEPTH WHERE VERY SOFT CLAY SOFT CLAY LAYER IS ENCOUNTERED IN CONSULTATION WITH ENGINEER IN-CHARGE.
8. PUMP IN TYPE FIELD PERMEABILITY TEST SHALL BE CARRIED OUT IN BH-8, BH-15, BH-25, BH-54, BH-81, BH-83 & BH-99 AT 1.5M & 4.5M DEPTH BELOW GROUND LEVEL.
9. ELECTRICAL RESISTIVITY TEST SHALL BE CARRIED OUT AS PER WENNER'S METHOD.
10. PRESSURE METER TEST SHALL BE CARRIED OUT AT 2M, 4M, 6M, 8M, 10M, 12M, 15M, 18M, 21M, 23M, 25M, 30M, 35M & 40M DEPTH BELOW GROUND LEVEL.
11. GROUND WATER SAMPLE SHALL BE COLLECTED FROM BH-7, BH-13, BH-20, BH-25, BH-25, BH-36, BH-49, BH-65 BH-73, BH-74, BH-80, BH-82, BH-91, BH-96, BH-103, BH-107 & BH-108.
12. PERCOLATION TEST SHALL BE CARRIED OUT AT 3.0M DEPTH BLEOW GROUND LEVEL IN PLT-1, PLT-3, PLT-4 & CPLT-4.
13. GEOTECHNICAL INVESTIGATION SHALL BE CARRIED OUT AS PER SPECIFICATION.
14. DO NOT SCALE THIS DRAWING.

REF DRG :
PE-DG-K75-100-M001, REV-00 "PLOT PLAN".

GEOTECHNICAL INVESTIGATION LEGEND:

1. BOREHOLE (BH) . . . . . ●
2. PLATE LOAD TEST (PLT) . . . . . ⊠
3. DYNAMIC CONE PENETRATION TEST (DCPT) . . . . . ▼
4. STATIC CONE PENETRATION TEST (SCPT) . . . . . ▽
5. PUMP OUT TYPE FIELD PERMEABILITY TEST (POTFPT) . . . . . ⊠
6. PRESSURE METER TEST (PMT). . . . . ⊕
7. CROSSHOLE SHEAR TEST (CST). . . . . ⊙
8. CYCLIC PLATE LOAD TEST (CPLT) . . . . . ⊡
9. FIELD CBR TEST (CBR). . . . . ⛤
10. ELECTRICAL RESISTIVITY TEST (ERT) . . . . . ◎

REV	DATE	ALTD BY	CHD BY	APPD BY
03	19.04.16	JPK	TRM	SKP

REVISION MARKED AS △3 THUS TO INCORPORATE THE CUSTOMER COMMENTS.

REV	DATE	ALTD BY	CHD BY	APPD BY
02	02.04.16	JPK	TRM	SKP

REVISION MARKED AS △2 THUS TO INCORPORATE THE CUSTOMER COMMENTS.

REV	DATE	ALTD BY	CHD BY	APPD BY
01	18.03.16	JPK	TRM	SKP

i. REVISION MARKED AS △1 THUS DUE TO INCORPORATE THE CUSTOMER COMMENTS AND SBT VENT LOCATIONS HAS BEEN INCORPORATED.

CUSTOMER	TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED
CUSTOMER'S CONSULTANT	
JOB No. 423	1 X 800 MW NORTH CHENNAI TPP (STAGE-III, UNIT # 1)
STATUS CONTRACT	
DISTRIBUTION	
TO	
M/S	

BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NEW DELHI

DEPT	NAME	SIGN	DATE
DRN	S.SEN	-sd-	08.03.2016
DES	T.R.	-sd-	08.03.2016
CHD	TMR	-sd-	08.03.2016
APPD	SKP	-sd-	08.03.2016

TITLE: GEOTECHNICAL INVESTIGATION LAYOUT

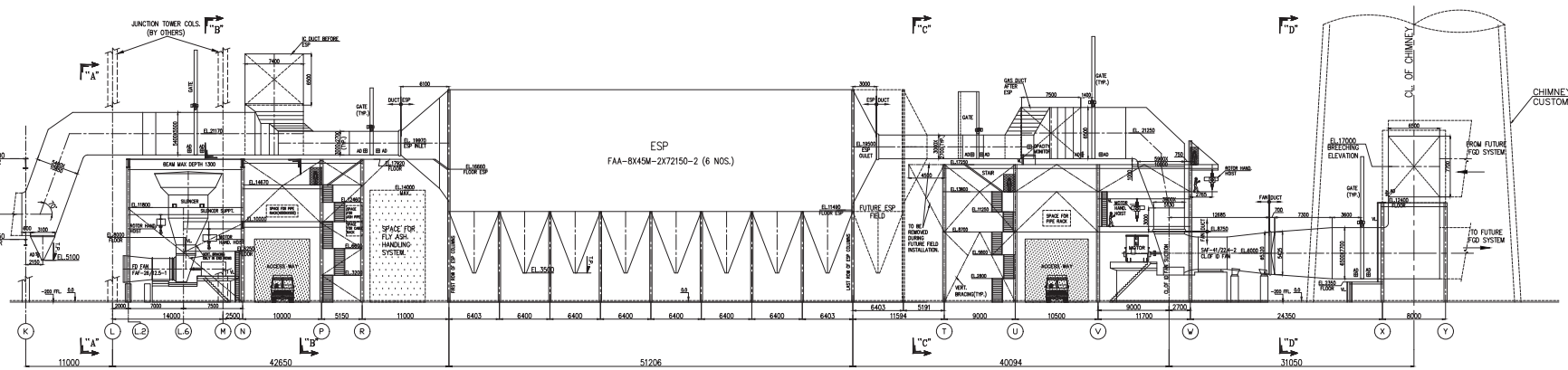
DRAWING No. PE-DG-423-602-C001

NPL	C	MSE	I	MAX	E	DEPT.
						SCALE
						SIGN
						DATE

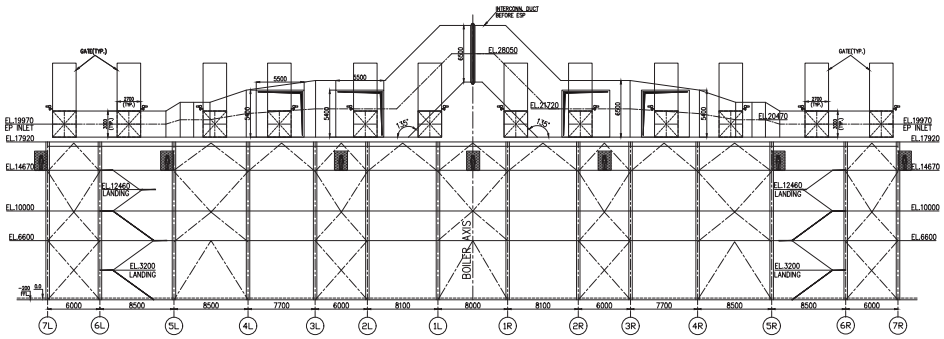
SHEET 1 OF 1 | REV 03 | SIZE-A0

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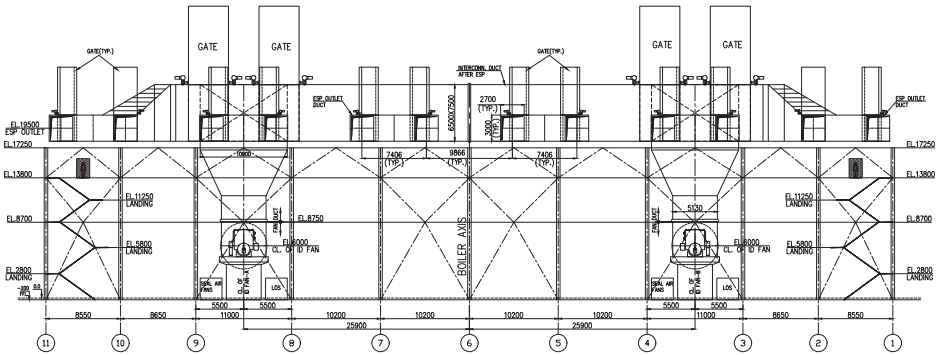
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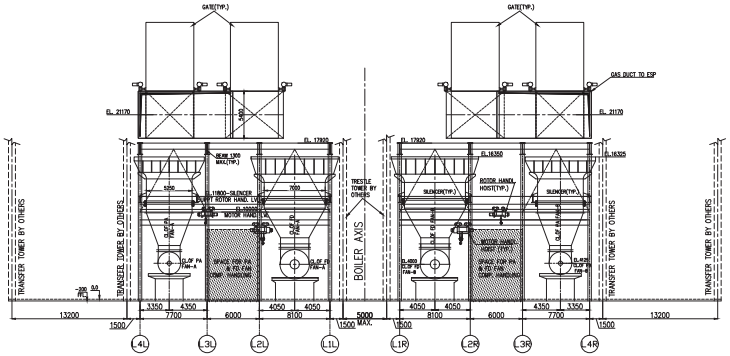
SIDE ELEVATION



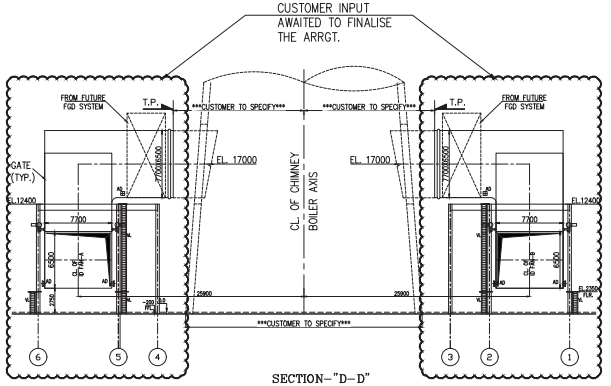
SECTION–"B–B"
ROW P & R



SECTION–"C–C"
ROW T & U



SECTION–"A–A"
ROW L2 & N



SECTION–"D–D"
ROW X & Y

NOTE:–
1. FOR GENERAL NOTES,LEGEND,DESCRIPTION OF UNIT, REFERENCE DRAWINGS REFER
   a. GENERAL ARRGT. OF BOILER SEC.SIDE ELEVATION–SEC–"E–E" – 0–00–022–77167.
   b. KEY PLAN OF BOILER – 0–00–020–77173.
2. THIS DRAWING IS TO BE READ ALONG WITH "LAYOUT OF ID SYSTEM–PLAN"–0–00–020–77175
3. DUCT SIZES CORRESPONDS TO INNER DIMENSIONS ONLY.
4. ALL DUCT RADII ARE 600 mm EXCEPT NOTED.
5. ACCESS DOOR CENTERLINE ARE AT 600 mm FROM DUCT BOTTOM.

LEGEND:
AD. – ACCESS DOOR – 450X450 mm.
TP – TERMINAL POINT UNDER BOILER SCOPE.
VL – VERTICAL LADDER
EL. – ELEVATION.

CUSTOMER NO.: 1818

CUSTOMER:	TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED 5th Floor, Western Wing, NPKRR Maaligai, 144, Anna Salai, Chennai–600002
CONSULTANT: FICHTNER INDIA	Fichtner Consulting Engineers (India) Pvt Ltd. Menon Eternity, 9th Floor, No.165, St. Mary's Road, Alwarpet, Chennai–600018
PROJECT:	1X800 MW TANGEDCO NORTH CHENNAI TPP STAGE III–BTG
M/S BHEL	BHARAT HEAVY ELECTRICALS LTD BOILER PLANT UNIT, TIRUCHIRAPALLI–620014

DEPT CODE	NAME	SIGN	DATE
DRN	KRISHNA.R	Sd.	04.01.17
CHD	KRISHNA.R	Sd.	04.01.17
APPD	A.PALANIYAPPAN	Sd.	05.01.17

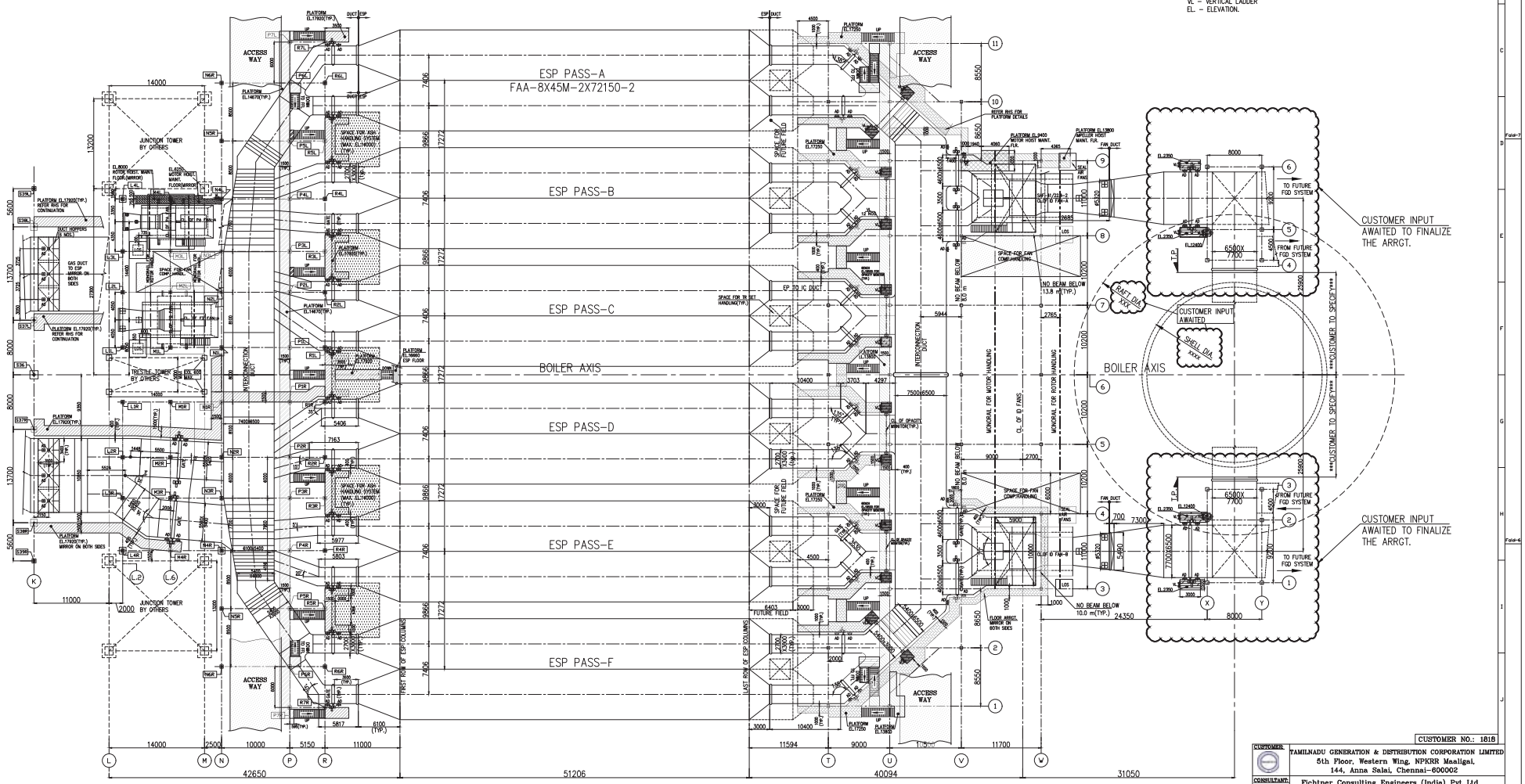
TITLE: LAYOUT OF ID SYSTEM–ELEVATION

TYPE	REASONS FOR REVISION	DRAWN	CHECKED	APPROVED	DATE

DEPT. SCALE :1:800 | DRAWING NO. 0–00–020–77174
SIGN | SHEET : 1 OF 1 | REV. 00
SIZE–A0

DRAWING NO. 0–00–020–77174

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COMPUTER FILE NAME:



PLAN

NOTE:–
1. FOR GENERAL NOTES,LEGEND,DESCRIPTION OF UNIT, REFERENCE DRAWINGS REFER
   a. GENERAL ARRGT. OF BOILER SEC.SIDE ELEVATION–SEC–"E–E" – 0–00–022–77167.
   b. KEY PLAN OF BOILER – 0–00–020–77173.
2. THIS DRAWING IS TO BE READ ALONG WITH "LAYOUT OF ID SYSTEM–ELEVATION"–0–00–020–77174
3. DUCT SIZES CORRESPONDS TO INNER DIMENSIONS ONLY.
4. ALL DUCT RADII ARE 600 mm EXCEPT NOTED.
5. ACCESS DOOR CENTERLINE ARE AT 600 mm FROM DUCT BOTTOM.

LEGEND:
AD. – ACCESS DOOR – 450X450 mm.
TP – TERMINAL POINT UNDER BOILER SCOPE.
VL – VERTICAL LADDER
EL. – ELEVATION.

CUSTOMER NO.: 1818

CUSTOMER:	TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED 5th Floor, Western Wing, NPKRR Maaligai, 144, Anna Salai, Chennai–600002
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	BHARAT HEAVY ELECTRICALS LTD BOILER PLANT UNIT, TIRUCHIRAPALLI–620014

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DEPT CODE	NAME	SIGN	DATE
DSN	KRISHNA.R	Sd.	04.01.17
CHD	KRISHNA.R	Sd.	04.01.17
APPD	A.PALANIAPPAN	Sd.	05.01.17

REV.	STATUS	TYPE	REASONS FOR REVISION	DRAWN	CHECKED	APPROVED	DATE

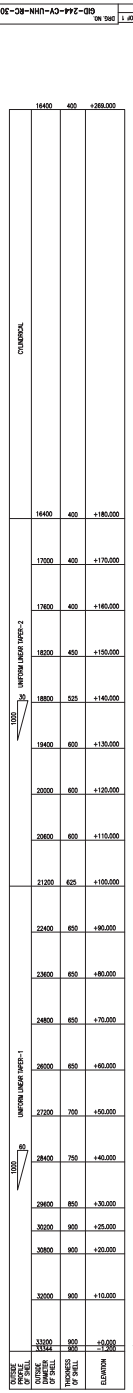
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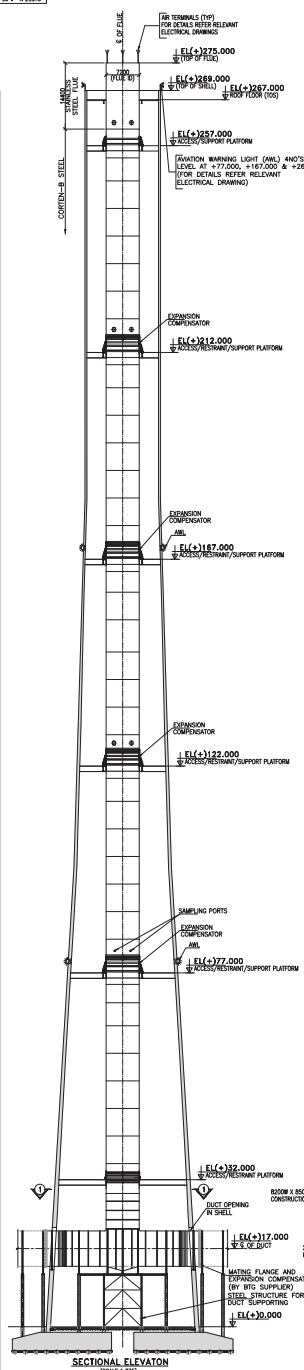
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SHEET : 1 OF 1 REV. 00
SIZE–A0
SCALE :1:200

DRAWING NO. 0–00–020–77175
FIRST ANGLE PROJECTION
ALL DIMENSIONS ARE IN MM
CUSTOMER'S DRAWING NO. --
COMPUTER FILE NAME:

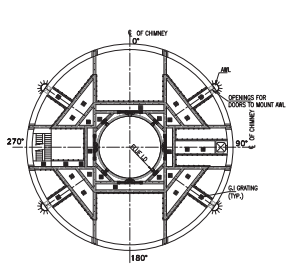
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DWG. NO. GID-244-CV-UHN-RC-30201 | SHEET No. 1 OF 1

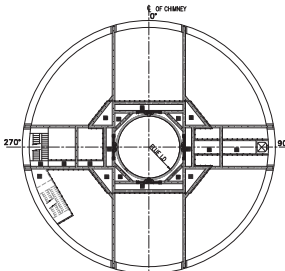




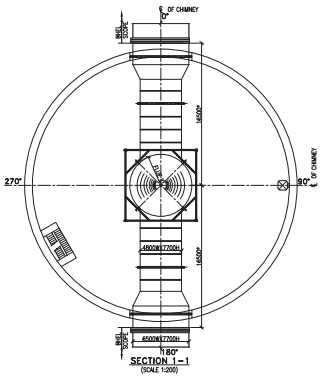
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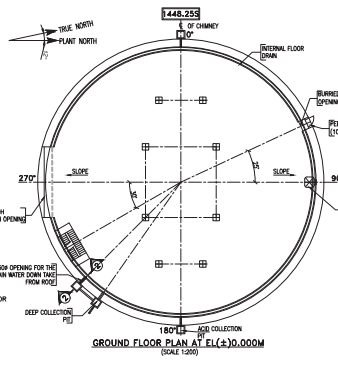
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(SCALE 1:200)



PLATFORM AT +32.000M LVL.
(SCALE 1:200)

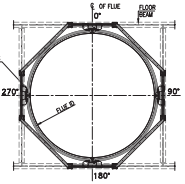


SECTION 1-1
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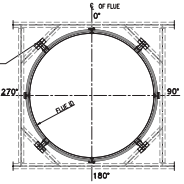


GROUND FLOOR PLAN AT EL(±)0.000M
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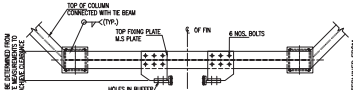
PLATFORM AT +122.000, +212.000 & 257.000M LVL.
(SCALE 1:200)



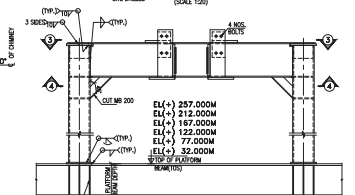
SHOWING ORIENTATION OF RESTRAINT WITH ELEVATED FRAMING
(SCALE 1:100)



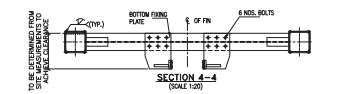
SHOWING ORIENTATION OF SUPPORTS
(SCALE 1:100)



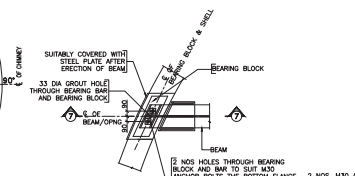
VIEW 3-3
(SCALE 1:20)



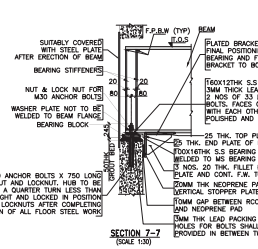
ELEVATION
(RESTRAINT WITH ELEVATED FRAMING)



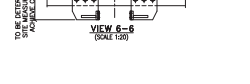
SECTION 4-4
(SCALE 1:20)



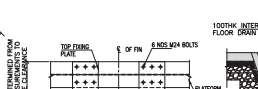
BEARING PLAN AT SHELL RECESS/POCKET
(SCALE 1:20)



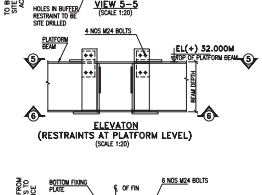
SECTION 7-7
(SCALE 1:30)



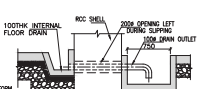
VIEW 6-6
(SCALE 1:20)



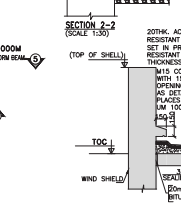
VIEW 5-5
(SCALE 1:20)

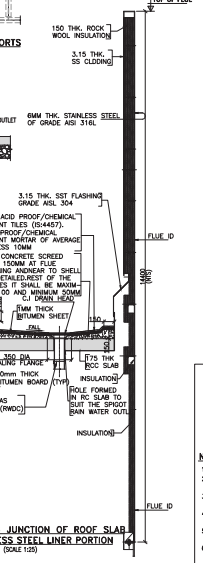


ELEVATON
(RESTRAINTS AT PLATFORM LEVEL)
(SCALE 1:20)

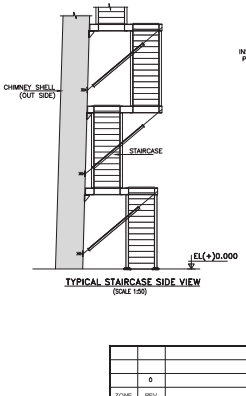


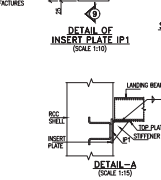
SECTION 2-2
(SCALE 1:30)

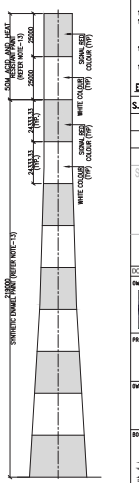




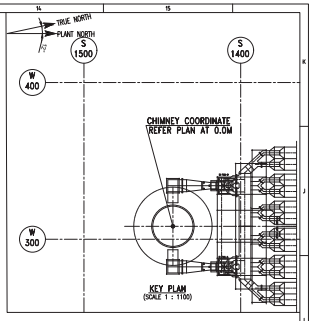
DETAIL SHOWING JUNCTION OF ROOF SLAB AND THE STAINLESS STEEL LINER PORTION
(SCALE 1:25)

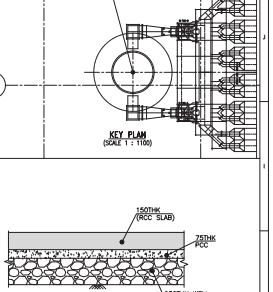






EXTERNAL PAINTING SCHEME
(SCALE 1:1000)





TYPICAL DETAILS OF GRADE SLAB
(SCALE 1:15)

LEGEND:

AWL	: AVIATION WARNING LIGHTS	M.S	: MILD STEEL
C.I	: CAST IRON	SS	: STAINLESS STEEL
℄	: CENTER LINE	TYP	: TYPICAL
FPBW	: FULL PENETRATION BUTT WELD	TOS	: TOP OF STEEL
FFL	: FINISHED FLOOR LEVEL	TOC	: TOP OF CONCRETE
FPL	: FINISHED PAVED LEVEL		: GRATING
ID	: INSIDE DIAMETER		: HAND RAIL

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METERS.
2. EL. (±)0.000 CORRESPONDS TO FINISHED FLOOR LEVEL OF MAIN POWER PLANT BUILDING WHICH CORRESPONDS TO RL. 10.000M.
3. CONCRETE FOR FOUNDATION SHALL BE OF GRADE M-25 AND FOR SHELL IT SHALL BE OF GRADE M-35 CONFORMING TO IS:456
4. ALL REINFORCING STEEL SHALL BE CORROSION RESISTANT TMT BARS OF GRADE Fe500 CONFIRMING TO IS:1786 UNLESS SHOWN OTHERWISE.
5. ALL MATERIAL TESTING, STORAGE, MIXING, FORM WORK, PLACEMENT OF CONCRETE & REINFORCEMENT DETAILING AND WORKMAN SHIP SHALL CONFIRM TO IS: 456
6. INSULATION SHALL BE RESIN BONDED ROCK WOOL WITH WIRE MESH HAVING DENSITY NOT LESS THAN 64 KG/CU.M. AS PER IS: 8183.
7. THE OTHER COMPONENTS OF CHIMNEY INCLUDE A ROLL UP DOOR, ELEVATOR,PERSONAL ACCESS DOORS, LADDERS, HAND RAILING, CLEAN OUT DOORS, LINER TEST PORTS, POWER SUPPLY DISTRIBUTION BOARDS, LIGHTING PANELS, SOCKETS, OUTLETS, AVIATION ELECTRICAL LIGHTS, LIGHTNING PROTECTION, GROUNDING SYSTEM, LIGHTING AND TEMPORARY AVIATION WARNING LIGHTS ETC.
8. THE EXPANSION COMPENSATOR SHALL BE PROCURED FROM A SPECIALIST MANUFACTURER
9. ALL STRUCTURAL MEMBERS OF PLATFORMS & STAIRCASE SHALL BE PAINTED WITH 2 COATS OF ZINC CHROMATE RED OXIDE PRIMER, FOLLOWED BY 3 COATS OF SYNTHETIC ENAMEL PAINT.
10. STAINLESS STEEL LINER FABRICATED USING MATERIAL CONFORMING TO AISI 316L
11. THE ENTIRE OUTSIDE SURFACE SHALL BE PAINTED WITH ALTERNATE BANDS OF SIGNAL RED AND WHITE COLOUR. OUT OF WHICH TOP 50M SHALL BE PAINTED WITH 4 COATS OF ACID AND HEAT RESISTANT PAINT (POLYURETHANE) OVER A COAT OF PRIMER WITH TOTAL DFT OF 150 MICRONS.
12. FLUE AND DUCT PLATES IN CONTACT WITH FLUE GAS SHALL BE FABRICATED FROM CORROSION RESISTANT STEEL TYPE " CORTEN-B " HAVING AN YIELD STRENGTH OF 250MPA.
13. ALL STRUCTURAL MEMBERS OTHER THAN PLATES FOR FLUES AND DUCT SHALL BE FABRICATED FROM MS STEEL CONFIRMING TO IS:2062 HAVING AN YIELD STRENGTH OF 250MPA.

ENGG. REF DRG/DOC.

S.NO.	DESCRIPTION	DRAWING NO.
1	PLOT PLAN	GID-244-ME-U-XF-10001.
2	LAYOUT OF ID SYSTEM ELEVATION	0-00-020-77174.
3	LAYOUT OF ID SYSTEM PLAN	0-00-020-77175.

SPACE FOR STAMP

ISSUED FOR APPROVAL

DO NOT SCALE THE DRAWING

POWER PROJECTS DIVISION-CH/IT/MR/TL

OWNER

TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT

1 X 800MW - NCTPP - STAGE - III

ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT

FICHTNER CONSULTING ENGINEERS(INDIA) PRIVATE LIMITED
CHENNAI - INDIA

BOP CONTRACTOR

BGR ENERGY SYSTEMS LIMITED
CHENNAI, INDIA

	NAME	SIGN	DATE	SHEET SIZE
DRN.	MMH		22/02/2017	A0
REP.	BECK		22/02/2017	
CHD.	SAS		22/02/2017	
APPD.	PS		22/02/2017	
DEPT.	VADA, BMC, CHP	SCALE	AS SHOWN	
CODE.				

TITLE

CHIMNEY
GENERAL ARRANGEMENT

BOP CONTRACTOR'S DRAWING NO. GID-244-CV-UHN-RC-30201 | REV. 0

OWNER'S DRAWING NO. -

SHEET No. 1 OF 1

ZONE	REV	DESCRIPTION	DATE	DRN.	CIVIL	MECH.	ELEC.	C&I	H.O.D.
	0	FOR APPROVAL	22.02.17	MMH					

REVISIONS APPROVED

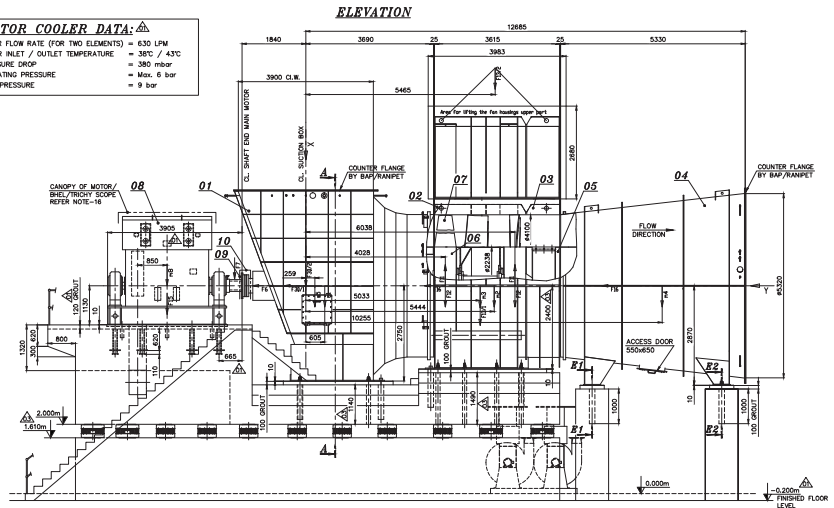
MOTOR COOLER DATA:

WATER FLOW RATE (FOR TWO ELEMENTS)	= 630 LPM
WATER INLET / OUTLET TEMPERATURE	= 38°C / 43°C
PRESSURE DROP	= 380 mbar
OPERATING PRESSURE	= Max. 6 bar
TEST PRESSURE	= 9 bar

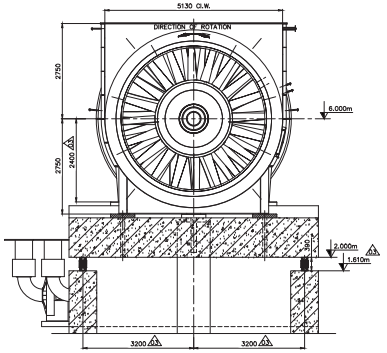
IMPORTANT NOTES:

1. FOUNDATION SLEEVE OF THE MOTOR TO BE USED WHILE CASTING FAN FOUNDATION. CIVIL DESIGNER TO ENSURE AVAILABILITY OF MOTOR SLEEVE AT SITE BEFORE CASTING FOUNDATION.
2. FAN IS SIZED TO TAKE CARE OF FUTURE INSTALLATION OF De-NOx EQUIPMENT (PREDUCTED HEAD). HOWEVER SECOND STAGE BLADES & OGV ARE NOT COVERED IN THE SCOPE OF SUPPLY. ANNULAR ADAPTER DUCT SHALL BE PROVIDED IN PLACE OF SECOND STAGE OGV. REFER LETTER No. CE/F/SE/E/THF/E5/AEE/F.NCTPP. STAGE-III(BTG)/D.173/16 dtd. 18.06.16.

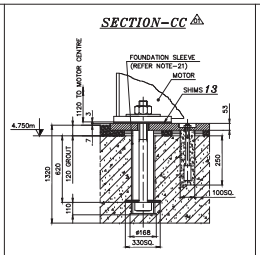
ELEVATION



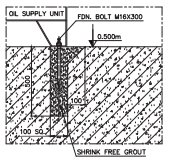
SECTION-AA



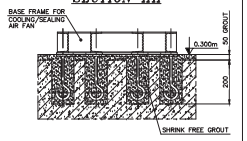
SECTION-CC



SECTION-FF



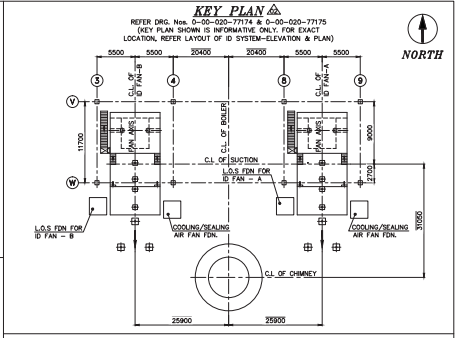
SECTION-HH



KEY PLAN

REFER DRG. Nos. 0-00-020-77174 & 0-00-020-77175
(KEY PLAN SHOWN IS INFORMATIVE ONLY. FOR EXACT LOCATION, REFER LAYOUT OF ID SYSTEM-ELEVATION & PLAN)

NORTH



NOTES:-

01. THE LOADS INDICATED ON FOUNDATION ARE WITHOUT ALLOWANCES FOR VIBRATIONS. CIVIL DESIGNERS ARE RESPONSIBLE FOR PROPER DESIGN OF FOUNDATION TAKING INTO ACCOUNT OF THE ALLOWANCES FOR VIBRATION ALSO.
02. THE DIFFERENT NATURAL FREQUENCY OF THE FOUNDATION HAVE TO BE 20% AWAY FROM THE SPEED FREQUENCY, fnmax = n/60 AND 15% AWAY FROM THE DOUBLE OF THE SPEED FREQUENCY, 2 x fnmax. THIS MEANS : 0.8xfn TO 1.2xfn AND 0.85x(2xfn) TO 1.15x(2xfn).
SPEED FREQUENCY fnmax. = 12.42 HZ
(2 * fnmax.) = 24.84 HZ
03. THE STIFFNESS OF THE FOUNDATION HAS TO BE ATLEAST CF>1.0E+06 N/mm IN LONGITUDINAL, TRANSVERSAL AND VERTICAL DIRECTIONS RELATING TO THE FAN AXIS. IT HAS TO BE TAKEN INTO CONSIDERATION THAT ON SETTLING OF THE FOUNDATION THE TOTAL NATURAL FREQUENCIES OF THE FOUNDATION CAN ARISE DUE TO THE SOIL COMPACTION AND THE RESULTING INCREASES OF THE ELASTIC MODULUS. AN UNEVEN SETTLING OF THE FOUNDATION HAS TO BE EXCLUDED.
04. THE RATIO OF THE FOUNDATION MASS TO THE ROTOR MASS HAS TO BE GREATER THAN 20.
05. ADOPT IS: 2974 / PART-IV FOR THE FOUNDATION DESIGN.
06. THE CONNECTING DUCTS AT INLET AND OUTLET OF FAN MUST BE SELF SUPPORTED AND SHOULD NOT BE WELDED WITH EXPANSION JOINTS.
07. FOUNDATION POCKETS SHOULD BE PERPENDICULAR TO THE FLAT SURFACES OF FOUNDATION.
08. ACCURATE TEMPLATES SHALL BE USED FOR LOCATING CORES FOR POCKET HOLES TO ENSURE THEIR DIMENSIONAL ACCURACY.
09. TOLERANCE BETWEEN ANY TWO POCKET CENTRES IS ±5 mm.
10. TOLERANCE ON CONCRETE LEVELS $^{+25}_{-25}$ mm.
11. IN AREAS WHERE SOLE PLATES AND ANCHOR PLATES ARE TO BE INCORPORATED IN FOUNDATION CONCRETE, THE SIZE OF THE COARSE AGGREGATE USED SHALL NOT EXCEED 20 mm AND DOWN GRADED TO FACILITATE CHIPPING AND THEREBY ENSURING MAXIMUM CONTACT ON THE MATING AREAS.
12. NON-SHRINK GROUT IS TO BE USED. REFER GENERAL SPECIFICATIONS ISSUED BY BHEL/RANIPET FOR NON-SHRINK GROUT. THIS ALSO CONTAINS THE PREPARATIONS OF PRIMARY PACKERS & SHIMS.
13. GROUTING SHOULD BE DONE ONLY AFTER FINAL ALIGNMENT OF FAN.
14. ELEVATION & POCKET DEPTHS SHOWN IN FOUNDATION PLAN ARE INCLUDING GROUTING THICKNESS.
15. GROUTING IS IN THE SCOPE OF ERECTION GROUP OF BHEL/AUTHORISED AGENCY.
16. HANDRAILS, STEEL PLATFORMS & CANOPY FOR MOTOR AND THEIR EMBEDMENTS ARE IN THE SCOPE OF BHEL/TRICHY.
17. FAN FOUNDATION SHOULD NOT BE USED AS SUPPORT FOR OTHER STRUCTURES OR EQUIPMENTS.
18. FOUNDATION CONFIGURATION SHOWN IN THIS DRAWING IS ONLY INFORMATIVE/TYPICAL. TYPE AND DETAILS OF FOUNDATION ARE TO BE FINALISED BY CIVIL DESIGNERS.
19. FOR MOTOR ERECTION, REFER MOTOR SUPPLIER'S ERECTION MANUAL.
20. BASE FRAME, SOLE PLATE, FOUNDATION BOLTS, FDN. SLEEVE & FASTENERS RELATED TO MOTORS ARE IN THE SCOPE OF MOTOR SUPPLIER (BHEL BHOPAL UNIT)
21. FOUNDATION SLEEVE OF THE MOTOR IS TO BE EMBEDDED IN THE CONCRETE AS PER THE DIMENSION SHOWN. AFTER CONCRETE HAS SET, THE EXCESS PROTRUDING HEIGHT TO BE SUITABLY CUT-OFF.
22. ALL ELEVATIONS ARE WITH RESPECT TO EL. (+)0.00m, FINISHED GROUND FLOOR LEVEL OF TG BUILDING, WHICH CORRESPONDS TO RL. (+)10.0M.
FINISHED GROUND FLOOR LEVEL (PAVING LEVEL) OF BOILER AND ESP AREAS ARE AT EL. (-)0.200m, WHICH CORRESPONDS TO RL. (+)9.8M.

FAN DETAILS:-

TYPE	: SAF 41/22.4-2
NO. OF FANS PER BOILER	: TWO (IDENTICAL)
WEIGHT OF ROTATING PARTS	: 18500 Kg
GD^2 OF FAN	: 41100 kg.m^2
SPEED OF FAN	: 745 RPM
MAXIMUM WEIGHT TO BE HANDLED FOR MAINTENANCE	: 19000 Kg

MOTOR DETAILS:-

MAKE	: M/s. BHEL/BHOPAL
TYPE	: 1TF6743-8, IP55
CAPACITY	: 8450 KW/747 RPM/536 AMP/11 KV
WEIGHT OF MOTOR	: 32000 Kg
WEIGHT OF ROTOR	: 10200 Kg
GD^2 OF MOTOR	: 6468 kg.m^2
MOTOR DRG. NO.	: 1 402 00 41422
METHOD OF COOLING	: IC81W
MAXIMUM WEIGHT TO BE HANDLED FOR MAINTENANCE	: 32500 Kg

LOADING ON MOTOR FOUNDATION

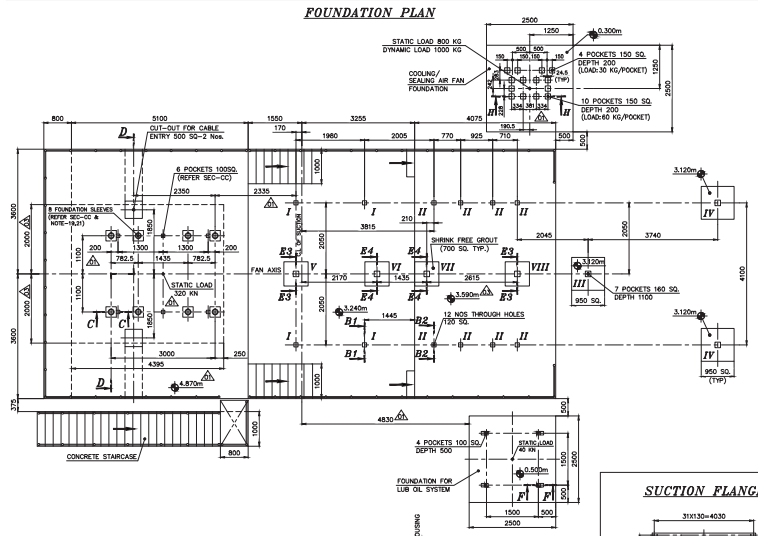
REACTION DUE TO WEIGHT ON EACH SIDE (G)		= 170 kN
MAX. SHORT CIRCUIT FORCE (MS)		= 460 kN
REACTION DOWNWARD	(MS+G)	= 630 kN
REACTION UPWARDS	(MS-G)	= 290 kN

MOTOR NOTES:

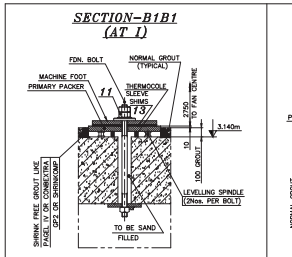
01. THE FORCES OCCUR ALTERNATELY INDEPENDENT OF THE DIRECTION OF ROTATION. (REFER LOADING ON FOUNDATION TABLE)
02. THE TRANSFER OF VIBRATIONS FROM SURROUNDING EQUIPMENT HAS TO BE AVOIDED BY SUITABLE LAYOUT OF FOUNDATION.
03. THE FIRST NATURAL FREQUENCIES OF THE FOUNDATION AFTER ERECTION OF THE MACHINE MUST DIFFER ATLEAST +25% & -20%, FROM ONE & TWO TIMES RUNNING SPEED FREQUENCIES & TWO TIMES THE ELECTRICAL FREQUENCY.

CUSTOMER No. : R836

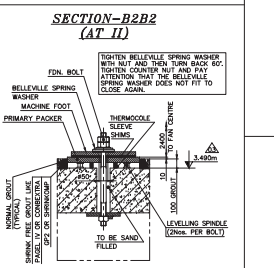
FOUNDATION PLAN



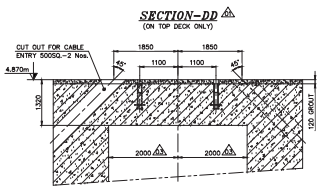
SECTION-B1B1 (AT I)



SECTION-B2B2 (AT II)

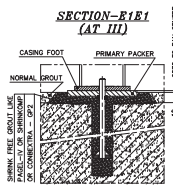


SECTION-DD (ON TOP DECK ONLY)

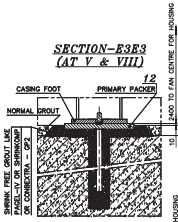


VIII			±2500	±12400	±21100 ±350800
VII			+318800 -90800	±12400	±21100 ±350800
VI			±81300	±18500	±4700
V			±3700	±18500	±4700
IV	+61100	±4900	±12300	±12300	±4900
III	+91400	±8000	±18300	±12900	±8000
II	+126500	±6200 ±108400	±25300	±25300	±5300 ±93400
I	+96900	±4700	±19400	±19400	±4700
Point Forces in [N]	Dead Load Vertical	Dynamic Load Vertical	Stat. horiz. Dead Load horiz. in axial Direction	Stat. horiz. Dead Load horiz. across to the axis	Dyn. horiz. Dyn. Load horiz. across to the axis

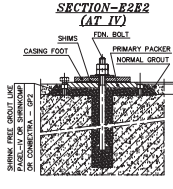
SECTION-E1E1 (AT III)



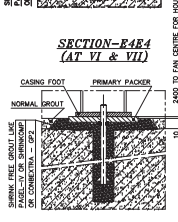
SECTION-E3E3 (AT V & VIII)



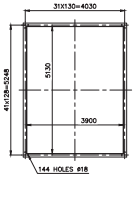
SECTION-E2E2 (AT IV)



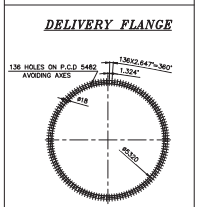
SECTION-E4E4 (AT VI & VII)



SUCTION FLANGE



DELIVERY FLANGE



30/2		-116225	Stat. and dyn. forces caused by air stream of suction box in vert. direction	
30/1		-8097	Stat. and dyn. forces caused by air stream of suction box in horiz. direction	
16		113975	Axial thrust of the fan (due to pressure increase)	
15		807210	Load during starting sequence by short-circuit torque of the motor	
14	--		Foundation	
13/2		114470	Max. load when lifting the fan housings upper part	
13/1		178310	Max. load when lifting the rotor assembly	
12		701410	Unbalance in case of damage	
11		42176	Max. rotating load due to unbalance of the fan rotor	
10	--		Oil supply unit with oil filling	
9	--		Frame of the motor	
8	--		Drive motor	
7		16610	Radial load on motor shaft	
6		15496	Axial thrust on motor shaft for motor with fixed bearing	
5	3020		Intermediate shaft with coupling	
4	17640		Diffuser with tail fairing	
3	18176		Complete rotor assembly	
2	25930		Fan housing with straightener vane section	
1	18620		Suction box nose fairing and inlet nozzle and intermediate shaft cover	
ID. NO.	(m) MASS IN (KG)	(F) FORCE IN (N)	DESIGNATION	

BILL OF MATERIAL

SL NO	DESCRIPTION	MATERIAL	QTY.
13	SHIMS	ASTM A240	AS REQD.
12	PRIMARY PACKER	IS : 2062	AS REQD.
11	FOUNDATION FASTENERS FOR FAN	ASTM A105	19
10	COUPLING GUARD	IS : 1079	1
09	SPACER COUPLING	STEEL	1
08	MOTOR WITH FNDN. FASTENERS	8450 KW/747 RPM	1
07	BLADES	GGG 40 OR EQUIVALENT (NODULAR CAST IRON)	20
06	IMPELLER HUB	P500NH (FINE GRAIN STRUCTURAL STEEL)	1
05	HOUSING CORE (FAN HOUSING HUB)	IS : 2062 OR EQUIVALENT	1
04	DIFFUSER	IS : 2062 OR EQUIVALENT	1
03	OUTLET GUIDE VANE ASSY.	IS : 2062 OR EQUIVALENT	1
02	IMPELLER HOUSING	IS : 2062 OR EQUIVALENT	1
01	SUCTION CHAMBER	IS : 2062 OR EQUIVALENT	1

MOTOR BEARING LUBRICATION DETAILS:

	DE	NDE
BEARING SIZE	ø250	ø250
OIL QTY.	6 LPM	6 LPM
OIL INLET PRESSURE	0.2 TO 0.5 kg/cm^2	0.2 TO 0.5 kg/cm^2
MAX. OIL INLET TEMP.	43°C	43°C
OIL GRADE	ISO VG 68 OR EQUI.	ISO VG 68 OR EQUI.
LUBRICATION TYPE	FORCED OIL LUBRICATION	

REV	DATE	ALTERED	CHECKED	APPROVED
03	05.08.2017	SARAVANAN PRASANNA	P.MJAVID	

01. BASED ON CIVIL FOUNDATION GA DRAWING WAS UPDATED.
02. ELEVATION +2.000m & +1.670m INDICATED.
03. FAN HOUSING HEIGHT ALTERED FROM 2390mm TO 2400mm. CORRESPONDING ELEVATIONS ARE UPDATED.
04. NOTES 04 & 22 CORRECTED.
05. IMPELLER HUB MATERIAL UPDATED IN BOM.

REV	DATE	ALTERED	CHECKED	APPROVED
02	24.03.2017	PRASANNA	P.MJAVID	

01. FOUNDATION LOADING & MASSES UPDATED.
02. KEY PLAN ADDED.

REV	DATE	ALTERED	CHECKED	APPROVED
01	17.01.2017	SARAVANAN	S.AGARWAL	P.MJAVID

01. MOTOR AND ITS FOUNDATION DETAILS UPDATED.
02. NOTE 22 ADDED.
03. TITLE BLOCK UPDATED.
04. COOLING/SEALING AIR FAN FOUNDATION POCKETS UPDATED.

CUSTOMER: TAMILNADU GENERATION & DISTRIBUTION CORPORATION LTD.
5th Floor, Western Wing, NPKRR Maaligai
144, Anna salai, Chennai-600002

CONSULTANT: Fichtner Consulting Engineers (India) Pvt Ltd.
Menon Eternity, 9th Floor, No.165, St. Mary's Road, Alwarpet, Chennai-600018

PROJECT: 1X800 MW TANGEDCO NORTH CHENNAI TPP STAGE-III BTG

BHARAT HEAVY ELECTRICALS LTD.
BOILER AUXILIARIES PLANT
RANIPET - 632 406

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DEPT CODE		NAME	SIGN	DATE
DRN.	P.SARAVANAN	Sd/-		24.11.2016
DES.	S.AGARWAL	Sd/-		24.11.2016
CHD.	P.MJAVID	Sd/-		24.11.2016
APPD.				

TITLE: GA DRAWING FOR ID FAN WITH FOUNDATION PLAN AND LOADING DATA - SAF 41/22.4-2

DEPT. | SCALE N.T.S | SIGN | DRAWING NO. 1-00-099-29103 | SHEET - | REV. 03

Size A1

TANGEDCO NCTPP STAGE-III BTG (1X800MW)

ID FAN DATA SHEET

SL. NO.	ITEM	UNIT	
3.6.4	No. of MIST per fan		4 Nos
3.6.5	No. of RTD per fan		6 Nos
3.6.6	Alarm set point for bearing temp		90 deg C.
3.6.7	Trip set point for bearing temp		110 deg C.
3.7	sealing arrangement		Simmer ring (bearing)
3.8	Hydraulic servo drive		
3.8.1	No., make and type		One No., BHEL Approved Vendor & Hydraulic Actuating Device
4.0	**LUBE OIL SYSTEM**		
4.1	Type		Forced Oil Lubrication
4.2	LOS rating		70 LPM @ 63 BAR
4.3	Oil grade		ISO VG 68
4.4	Tank capacity	Ltr	400
4.5	No. of /type of pumps		Two Nos. / screw type
4.7	No. of motor/efficiency rating		Two No's / IE3
4.8	No. of /type of oil coolers		Two Nos./ shell and tube type –double reversing
4.9	No.of /rating of Oil Tank heater	kW	One no. / 3
4.10	No.of / mesh size of Oil filter		Two no's / SS- 10 micron wire-mesh
5.0	**VIBRATION MONITORING**		
5.1	Probes		2 No's (Radial and axial)
5.2	Alarm set point	mm/s	7 (RMS) (Lead time: Nil)
5.3	Trip set point	mm/s	14 (RMS) (Lead time: 2 min)
		mm/s	20 (RMS) (Lead time: 5 sec)
6.0	**ACTUATOR**		
6.1	Type		Electrical

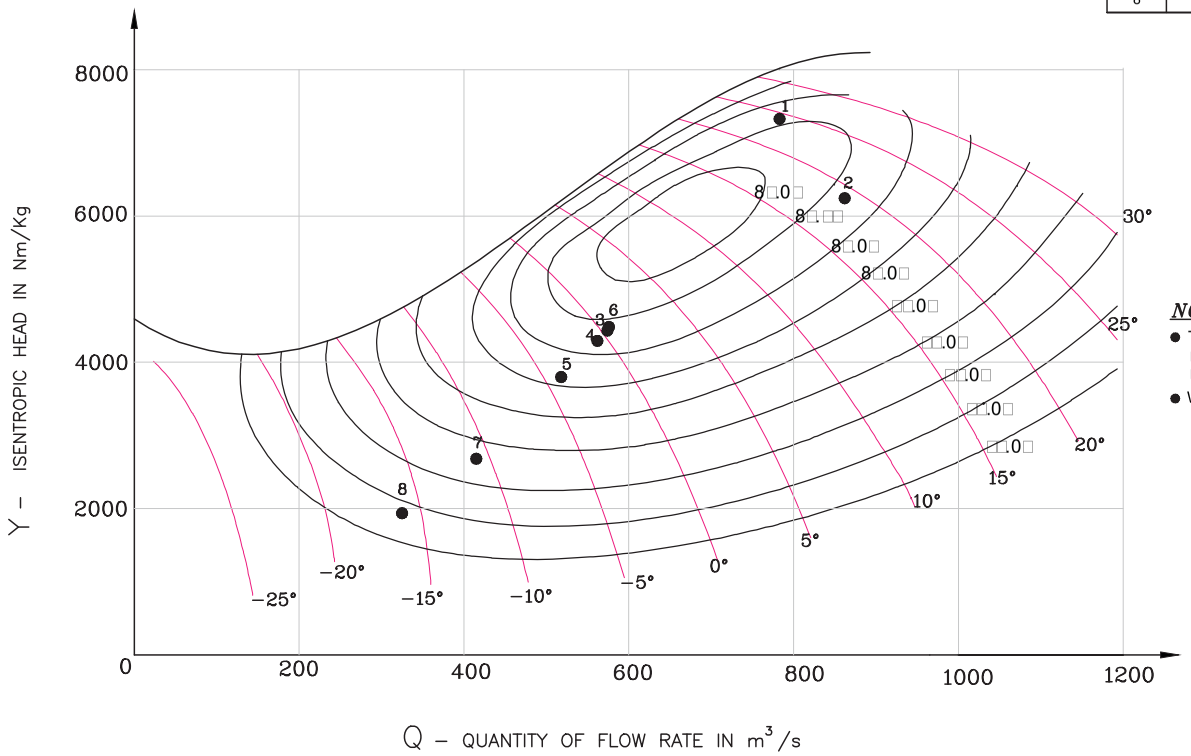
TANGEDCO NCTPP STAGE-III BTG (1X800MW)

ID FAN DATA SHEET

SL. NO.	ITEM	UNIT	
6.2	Actuating torque	Kg.m	10
6.3	Angle of travel	Deg.	0 - 90
6.4	Radius of lever	mm	150
7.0	**COOLING/SEALING AIR FAN**		
7.1	Type & no.		Radial, 2 no.
7.2	Total head	mmwc	380
7.3	Flow	m^3 / s	0.83

REFERENCE DRAWING NO.	
DRAWING DESCRIPTION	**DOCUMENT NO**
GA Drawing for ID Fan with Foundation Plan and Loading data.	1-00-099-299103
Performance curve of ID Fan.	3-00-103-39775
Lube Oil scheme for ID Fan.	2-00-107-30163
Outline & general arrangement of ID Fan Motor.	BP-DG-423-203-0001
ID Fan Motor Data sheet.	BP-DG-423-203-0002
Scheme of Air & Flue gas path with instrumentation.	0-97-288-90960
Scheme of Cooling water supply & Return system for boiler auxiliaries.	0-00-303-31609
ID Fan Foundation – GA of Top deck on VIS	PE-DG-423-618-C211

POINT	LOAD	V□□□ □ □□□ r□□□ □ □□□□□□ □□ □	D□□r□□□□□ □r□□□□r□ □ □ WC "ΔP"	I□□□r□□□ □□d □ N□ □□□ □Y□	D□□□□□ □ □□□ □□ □	T□□ □. □ D□-C □T□	E□□□□□□ □ □ □□	F□□ S□□□ P□□r □ KW □P□
1	DESIGN POINT 1	□8□	□0□	□□□□	0.□□□	1□0	8□.□	□□□□
□	DESIGN POINT □ □1 FAN □ □0□ BMCR□	8□□	□0□	□□□□	0.□8□	1□0	8□.□	□□0□
□	BMCR DC	□□□	□8□	□□□1	0.8□□□	1□□	8□.□	□□□0
□	VWO DC	□□□	□□0	□□8□	0.8□□□	1□□	8□.□	□□□1
□	TMCR DC	□18	□□□	□□□□	0.8□0□	1□8	8□.□	□0□8
□	BMCR DC	□□□	□8□	□□80	0.8□01	1□1	8□.□	□□0□
□	80□ TMCR DC	□1□	□□0	□□□□	0.8□1□	1□□	□□.□	1□□□
8	□0□ TMCR DC	□□□	1□□	1□□□	0.8□□□	11□	□□.0	11□□



FAN DETAILS

OUTER DIA: 4100 mm
TYPE: SAF 41/22.4–1
18NA18–1–3–531–562
+4.67/+7.0 , 0.546
MOTOR RATING : 8450 kW

NOTE:

- T□□ ID □□□ □r□r□r□ □□□□ □□r□□ □□ □□ □□r □□□r □□□Lr.N□.CE□P□SE□E□THP□E□AEE□F.NCTPP, S□III □BTG□D.1□□□1□ D□18.08.1□. T□□□ P□r□□r□ □□□□ □□r□□ □ □□□□□□ □□□□r □□B□□□r dr□□H□□ □□□r □□□ □□□ □□d M□□□r □□ □□□□d □□ □□□□ □□r□ □□ □□□□r□ SCR □□□d r□□□r□□ □□□□□r□d □□□d□.
- W□□□ SCR □□r□r□□□□d, □□□□□d □□□□□ □□□d□□ □□□□□ □ □□□ □□□□d □□□□□OGV□□□ □□ □□□□□□d.

POWER CONSUMPTION AT THE FAN SHAFT (KW) : $\frac{Q.Y.\gamma}{1000.\eta}$

n–SPEED : 745 RPM

CUSTOMER NO □R 8□□

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PROJECT	TANGEDCO□NORTH CHENNAI TPP ,S□□□□ III-1X800 MW
OWNER	TAMILNADU GENERATION & DISTRIBUTION CORPORATION LTD.
CONSULTANT	LAHMEYER INTERNATIONAL □INDIA□PVT. LTD CONSULTING ENGINEERS, GURGAON,INDIA
EPC CONTRACTOR	BHARAT HEAVY ELECTRICALS LIMITED BOILER AUXILIARIES PLANT RANIPET - □□□ □0□

TITLE: PERFORMANCE CURVE OF INDUCED DRAFT FAN SAF □1 □□□.□-1

	NAME	DATE
DRAWN	A.KIRAN	1□.11.1□
CHECKED	UMASHANKAR	1□.11.1□
APPROVED	P.M□AVID	1□.11.1□

ALL DIMENSIONS ARE IN MILLIMETRES

BHEL DRAWING NO. 3–00–103–39775

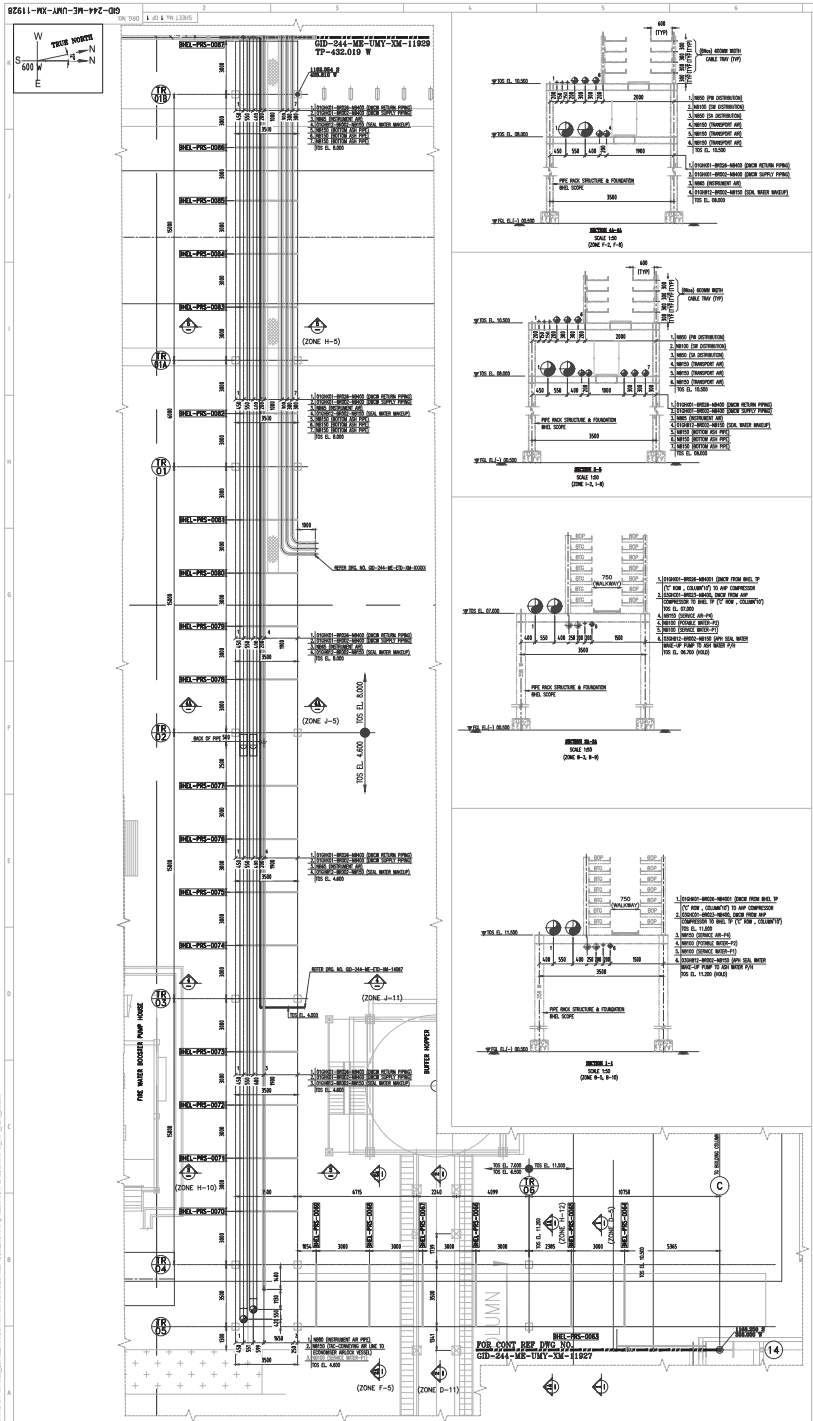
REV 00

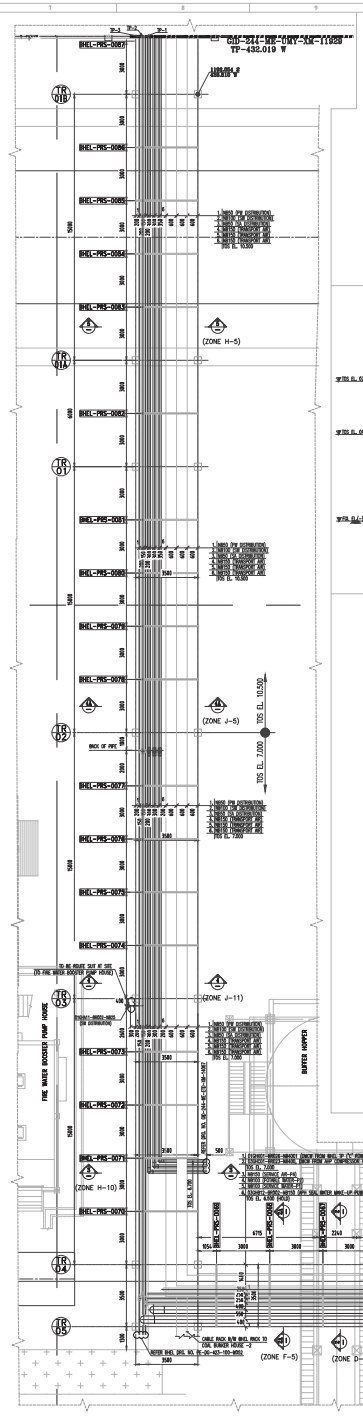
PROJECTION | SCALE NTS

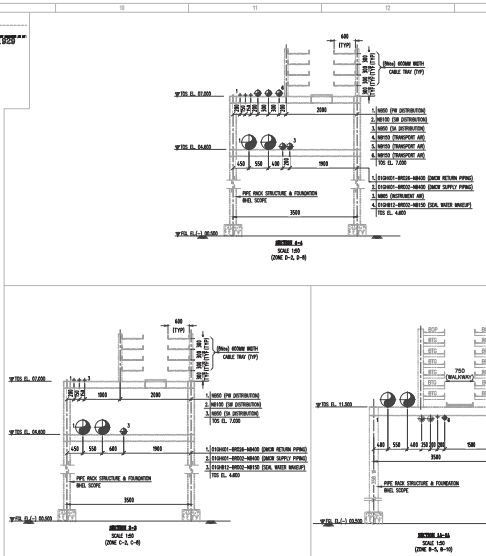
Size A3

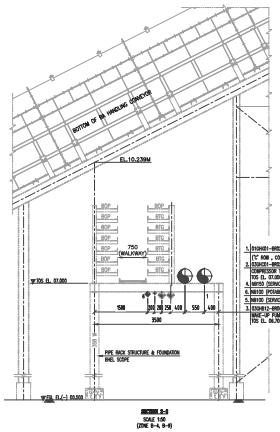
FIRST ANGLE PROJECTION

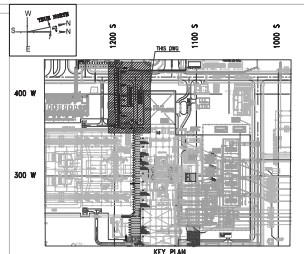
GID-244-ME-UMY-XM-11928











NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATION, COORDINATES ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL ELEVATIONS MARKED ARE WITH RESPECT TO TG HALL FINISHED FLOOR ELEVATION OF EL. 0.000M WHICH CORRESPONDS TO EL. 15.0M.
3. PIPING SHALL BE ROUTED IN PIPE RACKS WITH A MINIMUM HEADROOM CLEARANCE OF 2.5 METRE FROM FGL AND IN ROAD/RAIL CROSSING AREA CLEAR HEIGHT SHALL BE 5.0 METRE.
4. FUEL OIL PIPING SHALL BE ROUTED IN PIPE RACKS WITH A MINIMUM HEADROOM CLEARANCE OF 4.5 METRE FROM FGL.
5. FOR CABLE TRAY ROUTING AND ITS DETAILS REFER CORRESPONDING ELECTRICAL DRAWING NO. GID-244-EL-UMY-XE-XXXXXX
6. LOCATION OF COLUMN IS TENTATIVE ONLY. IT MAY BE CHANGED DURING THE CIVIL DETAIL ENGINEERING.
7. WHEREVER SIZE ORADING IS NOT SPECIFIED, BOPP AND HDPE OF PIPE RACK IS BASED ON THE NB.

LEGEND:

FGL	–	FINISHED GROUND LEVEL
EL	–	ELEVATION LEVEL
TOS	–	TOP OF STEEL
NGL	–	NATURAL GROUND LEVEL

ENGG. REF. DWGS.:

A. BGR DWGS.:

	TITLE
GID-244-ME-U-XF-10001	PLOT PLAN FOR STAGE-III
GID-244-ME-ETD-98-14001	PAND FOR FLY ASH HANDLING SYSTEM
GID-244-ME-ETD-98-14002	PAND FOR SLD SYSTEM
GID-244-ME-WW-98-11070	PAND FOR SERVICE WATER DISTRIBUTION SYSTEM
GID-244-ME-QW-98-11075	PAND FOR POTABLE WATER SYSTEM
GID-244-ME-SCW-98-11303	PAND FOR PLANT SERVICE AIR DISTRIBUTION SYSTEM
GID-244-ME-DMW-98-11303	PAND FOR FILTER WATER DISTRIBUTION SYSTEM
GID-244-ME-DW-98-14002	PAND FOR EFFLUENT TREATMENT PLANT
GID-244-ME-ETD-98-14001	PIPING LAYOUT FROM BUFFER HOPPER TO SLD PLAN
GID-244-ME-ETD-98-14002	PIPING LAYOUT FROM BUFFER HOPPER TO SLD PLAN
GID-244-ME-UMY-98-11800,01,02,03	DUCT ALL PIPE RACK PLAN & SECTIONS (1 OF 4)
GID-244-ME-ES-98-13001	COMPOSITE LAYOUT FOR HYDRANT & SPRINT SYSTEM
GID-244-ME-WSS-98-13305	LAYOUT OF AUTO WW SPRAY SYSTEM FOR HFO & HSD TANKS
GID-244-ME-ETD-30-14200,01	GA OF FLY ASH BUFFER HOPPER TOWER (1 OF 2)
GID-244-ME-ETC-XC-14300,01	ESIMPSON & PIPING LAYOUT OF AHP COMPRESSOR & BLOWER HOUSE BUILDING
GID-244-ME-ETD-30-14200 TO 14206	GA OF FLY ASH SILO (SHT-1,2,3,4,5,6&7)
GID-244-ME-ETW-98-14008	PIPING LAYOUT FROM INTERMEDIATE BA HOPPER TO BA SILO

B. BHEL DWGS.:

	TITLE
1. PE-DG-423-100-M051	YARD PIPING AND TRESTLE LAYOUT – 1 (C-ROW)
2. PE-DG-423-100-M052	YARD PIPING AND TRESTLE LAYOUT – 2
3. PE-DG-423-100-M002	MAIN EQUIPMENT LAYOUT
4. PE-DG-423-100-M042	LAYOUT OF PIPING IN & AROUND CS TANK & PUMP AREA

S.No.	DESCRIPTION	SIZE	TP–1195.354 M	TP–432.019 M	REMARKS
			SOUTH	WEST	
			CO–ORDINATE		
3	SERVICE WATER	NB50	TP–1195.354 M	TP–432.019 M	
2	POTABLE WATER	NB100	TP–1195.154 M	TP–432.019 M	
1	SERVICE AIR	NB50	TP–1195.004 M	TP–432.019 M	

TERMINAL POINT DETAILS

* BHEL TO FURNISH INFORMATION

SPACE FOR STAMP

ISSUED FOR INFORMATION

DO NOT SCALE THE DRAWING | POWER PROJECTS DIVISION-CH

OWNER: TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT: 1 X 800MW - NCTPP - STAGE - III
ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT: FICHTNER CONSULTING ENGINEERS(INDIA) PRIVATE LIMITED
CHENNAI - INDIA

BOP CONTRACTOR: BGR ENERGY SYSTEMS LIMITED
CHENNAI, INDIA

	NAME	SIGN	DATE
DRN.	PKM		21-08-2018
CHD.	VB		21-08-2018
APPD.	TYS		21-08-2018
DEPT.	LSS / AM		21-08-2018

SHEET SIZE: A0

SCALE: 1:1

BOP CONTRACTOR'S DRAWING NO.: GID-244-ME-UMY-XM-11928 | REV.: 0

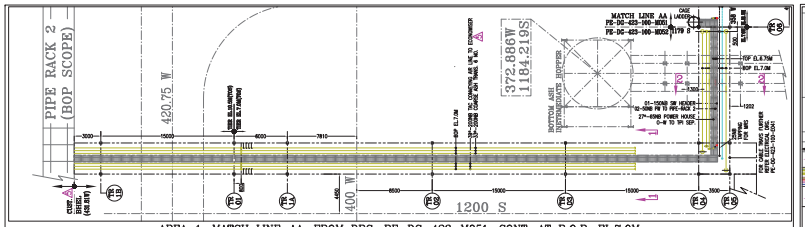
OWNER'S DRAWING NO.: –

TITLE: DETAILED PIPING LAYOUT ON PIPE RACK BETWEEN TG BUILDING TO TP @ 432.019 W [PR-03] SHT.1 OF 1

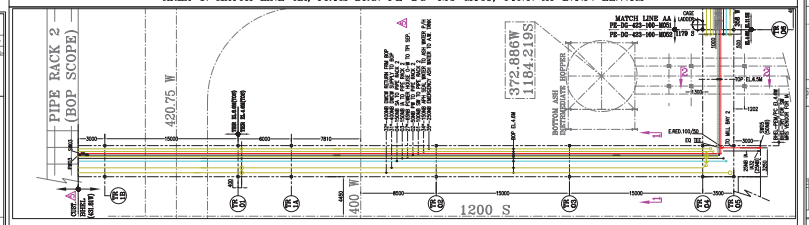
SHEET No. 1 OF 1

ZONE	REV.	DESCRIPTION	DATE	DRN.	CIVIL	MECH.	ELEC.	C&I	H.O.D.
	-	ISSUED FOR INFORMATION	21-08-18						

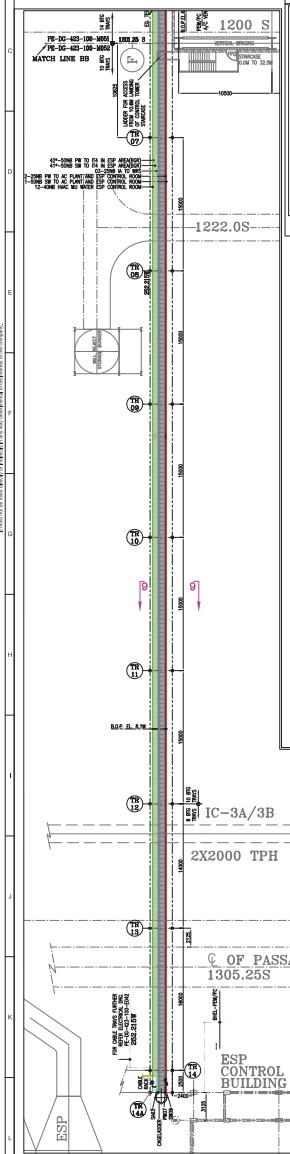
REVISIONS | APPROVED



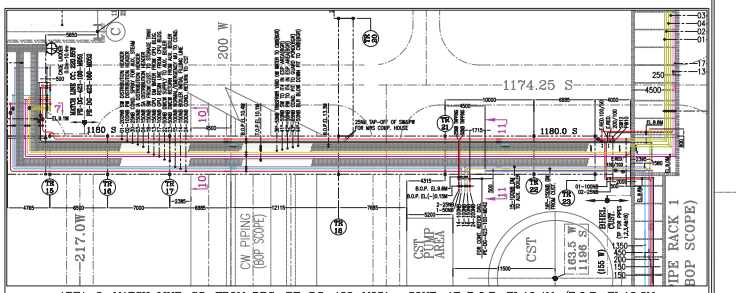
AREA–1: MATCH LINE–AA, FROM DRG. PE–DG–423–M051, CONT. AT B.O.P. EL.7.0M



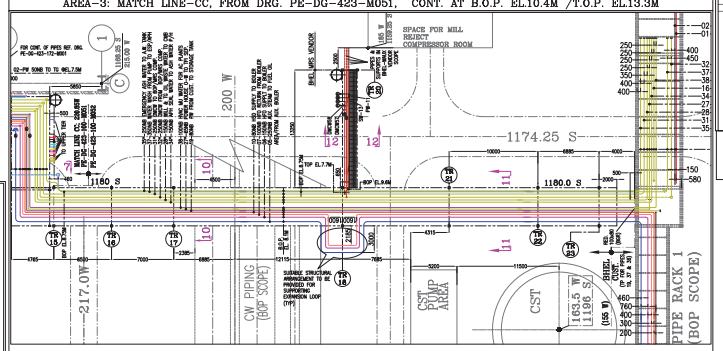
AREA–1: MATCH LINE–AA, FROM DRG. PE–DG–423–M051, CONT. AT B.O.P. EL.4.6 M



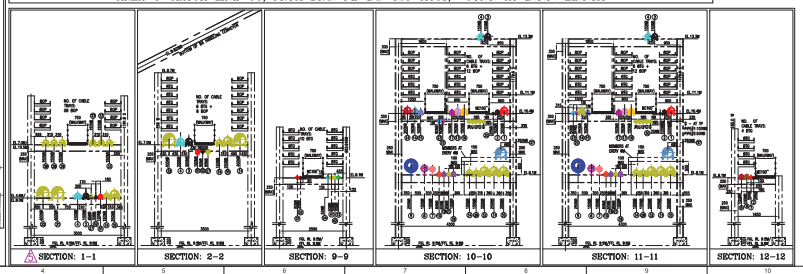
AREA–2: MATCH LINE–BB, FROM DRG. PE–DG–423–M051, CONT. AT B.O.P. EL.8.1M

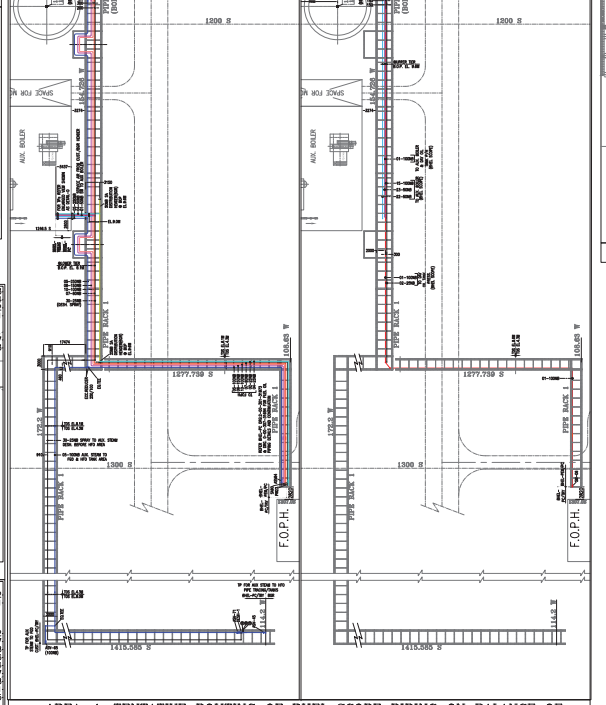


AREA–3: MATCH LINE–CC, FROM DRG. PE–DG–423–M051, CONT. AT B.O.P. EL.10.4M /T.O.P. EL.13.3M

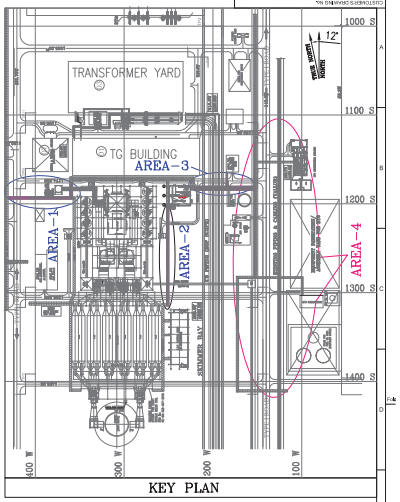


AREA–3: MATCH LINE–CC, FROM DRG. PE–DG–423–M051, CONT. AT B.O.P. EL.8.1M





AREA–4: TENTATIVE ROUTING OF BHEL SCOPE PIPING ON BALANCE OF PLANT CONTRACTOR (BGR) PIPE RACK AT BOP EL.8.1M & BOP EL. 9.6M

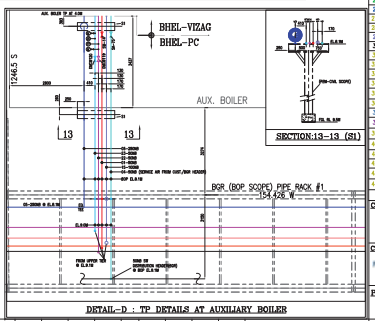


KEY PLAN

PIPE No.	SIZE (NB)	DESCRIPTION	MOC/SPEC (SG/M)	SCOPE
01	200/100/65/40	SERVICE WATER DISTRIBUTION	70/35/10/0	PDR / PC
02	100/65/50/40/25	POTABLE WATER DISTRIBUTION	35/20/10/5	PDR / PC
03	150/25	INSTRUMENT AIR	65/5	PDR / PC
04	150/50/25	SERVICE AIR	65/10/5	PDR / PC
05	250/100	AUXILIARY STEAM TO FDPH/HFO TANK AREA/FOD	125/28	PC/RP
06	150	HFO SUPPLY (CS) FROM PMH UNIT TO BOILER	65	PC/RP
07	100	HFO RETURN FROM BOILER	35	PC/RP
08	100	DMCW SUPPLY TO MFG COMP.	35	PDM/PC
09	100	DMCW RETURN FROM MFG COMP.	35	PDM/PC
10	80	HSD SUPPLY (CS) FROM PMH UNIT TO BOILER	20	PC/RP
11	40	SERVICE BUILDING HVAC MAKE–UP	8	PDR / PC
12	40	ESP BUILDING HVAC MAKE–UP	8	PDR / PC
13	150	CPU DM WATER LINE FROM CPU BUILDING	50	BHEL–BRUK VENDOR
14	150	BOILER INITIAL FILLING LINE	50	PDM/PC
15	100	NORMAL/EMERGENCY MU TO CONDENSER/AUXILIARY BOILER	28	PDM/PC
16*	150	DM FROM CUSTOMER	50	CUST.(BOD)
17	100	CPU RESIN TRANSFER FROM CPU BUILDING	28	BHEL–BRUK VENDOR
18	150	SERVICE WATER FROM CUSTOMER	50	PDM/PC
19	80	POTABLE WATER FROM CUSTOMER	20	PDM/PC
20	50	DMCW SUPPLY TO SWAS ROOM CHILLER & AUX. BLR (COMMON)	10	PDM/PC
21	50	DMCW RETURN FROM SWAS ROOM CHILLER & AUX. BLR (COMMON)	10	PDM/PC
22	50	DMCW SUPPLY TO AC PLANT & AUX BOILER (INDIVIDUAL)	10	PDM/PC
23	50	DMCW RETURN FROM AC PLANT & AUX BOILER (INDIVIDUAL)	10	PDM/PC
24	200	CONDENSATE RETURN TO CST	75	PDM/PC
25	300	DMCW–SG SUPPLY	135	PDM/PC
26	300	DMCW–SG RETURN	135	PDM/PC
27*	65	POWER HOUSE, O–R TRANSFER PUMPS TO TPI SEPARATOR	15	CUST.(BOD)
28*	150	MILL AND TG AREA OIL WASTE WATER TO CMB	50	CUST.(BOD)
29	450	SG START–UP DRAIN	250	PDM/PC
30	25	CONDENSATE SPRAY FOR AUX STEAM TO FUEL OIL AREA	5	PDM/PC
31*	400/250	DMCW SUPPLY TO BOP	200/100	CUST.(BOD)
32*	400/250	DMCW RETURN FROM BOP	200/100	CUST.(BOD)
33*	200	COARSE ASH TRANSPORTATION LINES– 06 NUMBERS	75	CUST.(BOD)
34*	150	APH SEAL WATER MAKE–UP PUMP TO ASH WATER P/H	50	CUST.(BOD)
35*	250	EMERGENCY ASH WATER MAKE–UP PUMP TP ASH WATER TANK	100	CUST.(BOD)
36*	50	TRANSFORMER YARD OIL WASTE WATER TO CMB	10	CUST.(BOD)
37	350	WATER WASH FROM PUMP TO APH	165	PC
38	100	HVAC MAKE–UP PUMP TO AC PLANT VENTILATION (HEADER)	28	PDR / PC
39*	200	TAC CONVEYING AIR LINE TO ECONOMIZER AIR LOCK HOSES	75	CUST.(BOD)
40*	–	ESP LINE FROM PIPE SETTLING PIT IN ESP(S)/G AREA(S) CIP–TUBE SETTLER	–	CUST.(BOD)
41*	50	SW FROM BOOSTER PUMP TO IT4 IN ESP AREA	10	CUST.(BOD)
42*	50	FW FROM BOOSTER PUMP TO IT4 IN ESP AREA	10	CUST.(BOD)
43*	65	CONDENSER COLLECTION PIT TO SUMPD PUMP(2)	15	CUST.(BOD)
44*	50	BOILER BLOW DOWN PIT TO CMB	10	CUST.(BOD)

NOTES:–

1. FOR NOTES AND REFERENCE DRAWINGS REFER DRAWING PE–DG–423–100–M051.



DETAIL–D : TP DETAILS AT AUXILIARY BOILER

REV.	DATE	ALTD	CHD	APPD
05	18/12/18	AMS	RC/BVA	JJ/BVA
01	REVISED AS PER REVISED AS PER DIR REQUIREMENT TO CHANGE THE PIPE RACKS & PIPE RACKS 'P'			
03	20/04/18	AMS	RC/BVA	JJ/BVA
01	REVISED AS PER CUSTOMER COMMENTS DATED 05/01/2018 ON RDX10			
02	DRAWING GENERALLY MODIFIED AS PER THE REVISED P&ID & REFERENCE DRAWINGS			
03	BHEL–VIZAG ON BGR SCOPE RACK REVISED AS PER THE INPUTS/DRAWINGS RECEIVED.			

REV.	DATE	ALTD	CHD	APPD
04	14/08/18	AMS	RC/BVA	JJ/BVA
01	REVISED AS PER CUSTOMER COMMENTS ON REVISED DATED 05/01/2018 ON RDX10			
02	REVISED AS PER REVISED BGR PIPE RACKS@ NEAR FUEL OIL AREA.			
01	15/12/17	AMS	RC/BVA	BVA/JJ
01	REVISED AS PER CUSTOMER COMMENTS DATED 01/12/2017 ON RDX01			

REV.	DATE	ALTD	CHD	APPD
01	02/09/17	AMS	RC/BVA	BVA/JJ
	REVISED AS PER CUSTOMER COMMENTS VIDE LETTER NO. 268/17 DATED 12/09/17			
	REVISED AS PER MEETING WITH BHEL AT PDN HELD ON 27–08/07/2017			

JOB NO. 423
STATUS CONTRACT
DISTRIBUTION

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DEPT	NAME	SIGN	DATE
DRN	RMS		24.03.2017
DESN	AMS/RJ		24.03.2017
CHD	BVA/RJ		24.03.2017
APPD	JJ/CGE (BHEL)		24.03.2017

CUSTOMER: TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED
5th Floor, Western Wing, NPKRR Maaligai,
144, Anna Salai, Chennai–600002

CONSULTANT: Fichtner Consulting Engineers (India) Pvt Ltd.
Menon Eternity, 9th Floor, No.165, St. Mary's Road,
Alwarpet, Chennai–600018

PROJECT: 1X800 MW TANGEDCO NORTH CHENNAI TPP
STAGE III–BTG

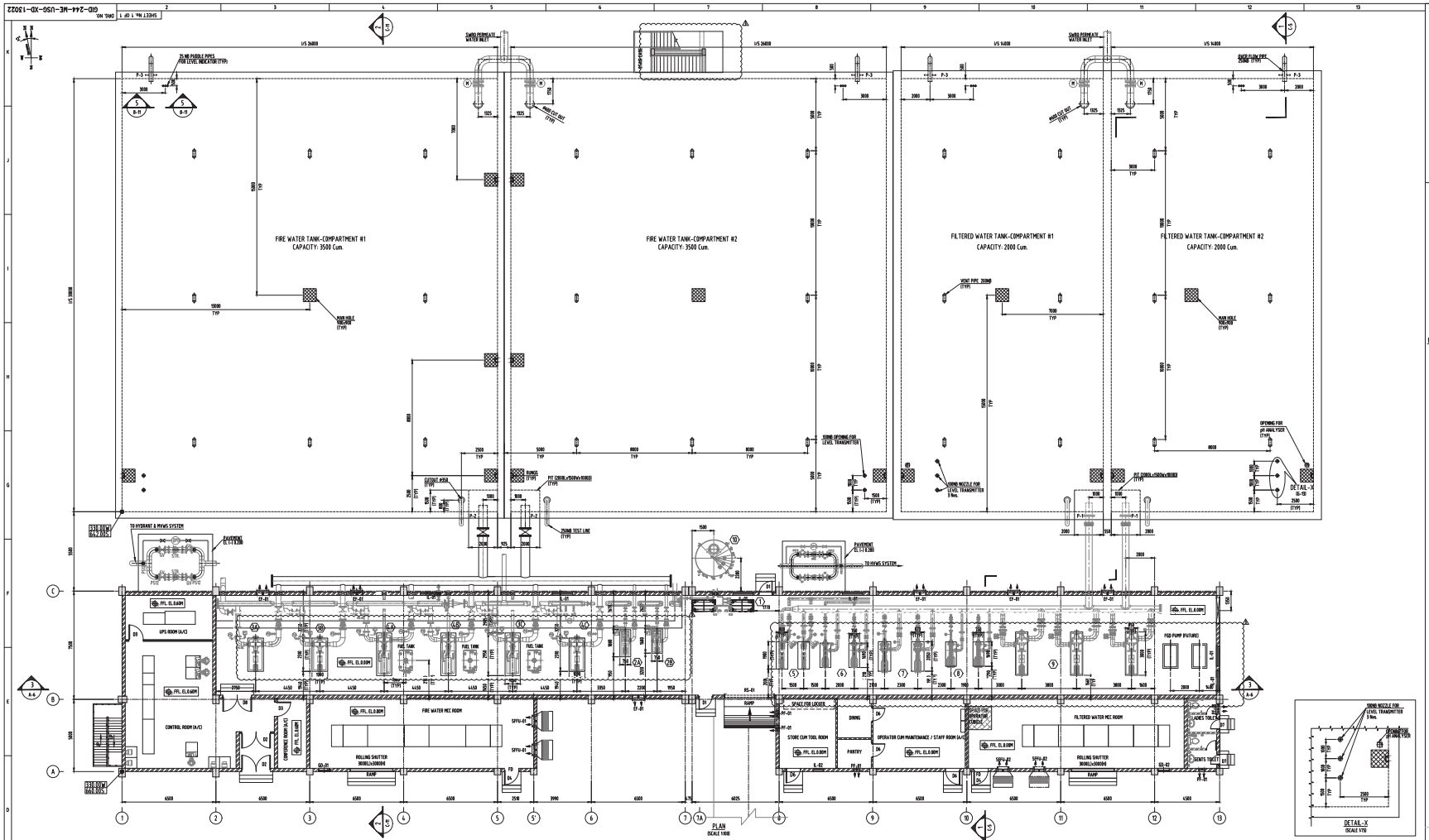
BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA

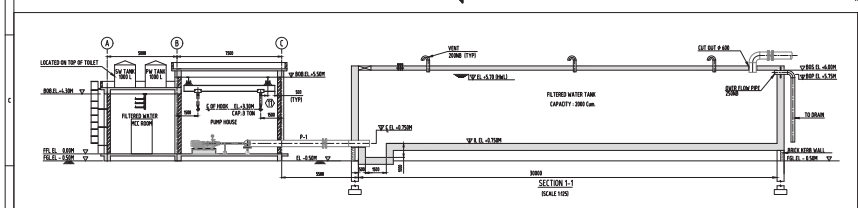
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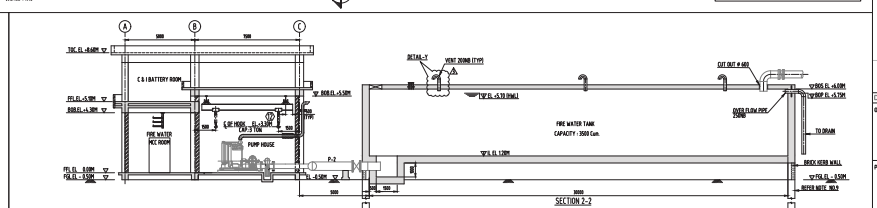
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DRN
SHEET 1 OF 1 REV. 05P

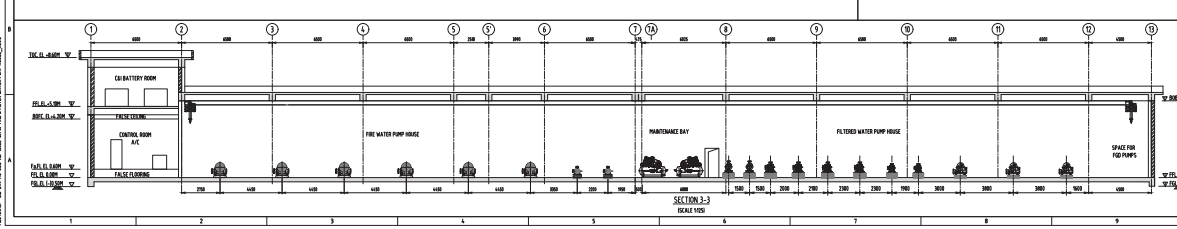
FIRST ANGLE PROJECTION

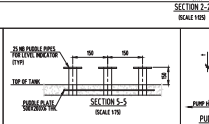
DWG. NO. GID-244-ME-USG-XD-13022 | SHEET No. 1 OF 1

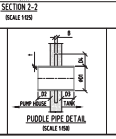


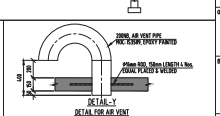






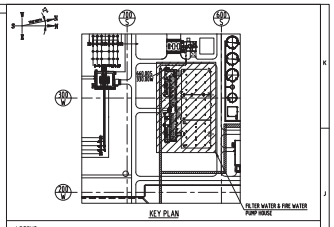






ZONE	REV	DESCRIPTION	DATE	DRN.	CIVIL	MECH.	ELEC.	C&I	H.O.D.
-	3	REVISED AS PER TANGEDCO COMMENTS VIDE LT.D.NO/TT DT. 28.04.17	03-07-17						
-	2	REVISED AS PER TANGEDCO COMMENTS VIDE LT.D.NO/TT dt 30.03.17, TANK&PH ELEVATED TO ABOVE GROUND LEVEL AS COMMENTED ACCORDINGLY TANK SIZE/HEIGHT REVISED	07-04-17	Sd/-	Sd/-	Sd/-	Sd/-	Sd/-	Sd/-
-	1	REVISED AS PER TANGEDCO COMMENTS	14-02-17	Sd/-	Sd/-	Sd/-	Sd/-	Sd/-	Sd/-
-	0	FIRST ISSUE FOR APPROVAL	03-12-16	Sd/-	Sd/-	Sd/-	Sd/-	Sd/-	Sd/-

REVISIONS | APPROVED



LEGEND:

FGL	FINISHED GROUND LEVEL		BRICK WALL
FFL	FINISHED FLOOR LEVEL		RCC WALL/FLOOR/COLUMN
BOB	BOTTOM OF BEAM		
U/S	UNDER SLUNG	SWRO	SEA WATER REVERSE OSMOSIS
RL	REDUCED LEVEL	LWL	LOW WATER LEVEL
R	RIVET LEVEL	NWL	NORMAL WATER LEVEL
SW	SERVICE WATER	HWL	HIGH WATER LEVEL
PW	PORTABLE WATER	BOS	BOTTOM OF SLAB
SPFU	SUPPLY FAN FILTER UNIT	EF	EXHAUST FAN
GD	GRAVITY DAMPER	IL	INLET AIR LOUVERS
PF	PROPELLER FAN		

ENGG. REF. DWG.

BGR DWGS:

	TITLE	DWG. NO.
1.	GID-244-ME-U-XT-10001	PLOT PLAN FOR STAGE III
2.	GID-244-ME-U-XB-10060	P&ID FOR FILTER WATER DISTRIBUTION SYSTEM
3.	GID-244-EL-UMA-XE-20513	ELECTRICAL LAYOUT FOR FIRE WATER & FILTER WATER PUMPHOUSE SWGR. ROOM
4.	GID-244-ME-XGE-XE-35806	COMPOSITE LAYOUT OF WATER TREATMENT PLANT

NOTES:

1. ALL DIMENSIONS ARE IN MM AND ELEVATIONS IN METERS UNLESS OTHERWISE NOTED.
2. FINISHED FLOOR LEVEL (FFL) OF TG BUILDING IS EL.0.00M, WHICH CORRESPONDS TO RL 10.0M THE FINISHED GRADE LEVEL (FGL) OF PLANT AREA IS EL9.5M
3. FOR DETAILS OF DOORS, WINDOWS & ROLLING SHUTTERS REFER CIVIL GA DRAWINGS.
4. FOR DETAILS OF STAIR CASE REFER CIVIL DRAWING.
5. PIPING SHOWN IS FOR REFERANCE ONLY. FOR DETAILS REFER SEPERATE PIPING LAYOUT.
6. UNDERSLUNG CRANE DIMENSION, LIFT, ELEVATION AND CLEARANCE FROM ROOF SHALL BE CONFIRMED/MODIFIED
7. AS PER VENDOR DATA AFTER ORDERING. FOR HVAC DETAILS REFER SEPARATE DRAWING
8. MCC ROOM & CONTROL ROOMS SHOWN ARE INDICATIVE FOR MORE DETAILS REFER. DRAWING NO:GID-244-EL-UMA-XE-20515
9. SUPPORT SHOWN FOR TANKS ARE INDICATIVE WOULD BE DETAILED AS PART OF CIVIL DWG.

HOLD POINTS:

1. NIL

TABLE-A LIST OF EQUIPMENT.

Sl.No.	EQUIPMENT	Qty	CAP.
1	AIR COMPRESSOR	2 Nos.	$2.7 m^3/hr$
2A,B	JOCKEY PUMPS	2 Nos.	$10 m^3/hr$
3A,B,C	MOTOR DRIVEN FIRE PUMPS	3 Nos.	$420 m^3/hr$
4A,B,C	DIESEL ENGINE DRIVEN FIRE PUMPS	3 Nos.	$420 m^3/hr$
5	AHP SEAL WATER MAKEUP PUMPS	2 Nos.	$18 m^3/hr$
6	SERVICE WATER PUMPS	2 Nos.	$30 m^3/hr$
7	CHP DUST SUPPRESSION WATER PUMPS	2 Nos.	$150 m^3/hr$
8	HVAC MAKEUP PUMPS	2 Nos.	$5 m^3/hr$
9	AHP / ESP WASH & EMERGENCY ASH WATER MAKEUP PUMPS	3 Nos.	$420 m^3/hr$
10	HYDRO PNEUMATIC TANK	2 Nos.	$22.5 m^3$
11	U/S CRANE	2 Nos.	3 TONS

TABLE-B SCHEDULE OF DOORS

ITEM NO.	DESCRIPTION	Qty	SIZE (b)x(h)
RS-1	ROLLING SHUTTER	1 No.	3500mmx4000H
RS-2	ROLLING SHUTTER	1 No.	3000mmx3000H
D-1	SINGLE LEAF DOOR	2 Nos.	900Wmx2100H
D-2	DOUBLE LEAF 12MM THICK TOUGHNED GLASS DOOR	1 No.	2000mmx2100H
D-3	SINGLE LEAF 12MM THICK TOUGHNED GLASS DOOR	2 Nos.	900mmx2100H
D-4	DOUBLE LEAF DOOR (FIRE PROOF)	1 No.	2000mmx2100H
D-5	SINGLE LEAF DOOR (FIRE PROOF)	3 Nos.	1000mmx2100H
D-6	SINGLE LEAF DOOR	4 Nos.	750mmx2100H

TABLE - C PUDDLE PIPE SCHEDULE

TAG.No.	DESCRIPTION	SIZE DI (NB)	SIZE DI (NB)	SIZE DI (NB)	SIZE DI (NB)	SIZE DI (NB)	SIZE DI (NB)
P-1	FILTERED WATER PUMP SUCTION HEADER	450	300	300	250	11	20
P-2	FIRE WATER PUMP SUCTION HEADER	600	200	200	250	8	20
P-3	OVER FLOW PIPE	250	150	200	200	8	20

TABLE-D OPENING DETAILS

ITEM NO.	EQUIPMENT	SIZE (M m	CL OF OPENING IN METRE
1	EF-01	1000W x 1000H	RL 13.5 M
2	SPFU-01	1000W x 1000H	RL 11.6 M
3	IL-01	1500W x 1000H	RL 10.5 M
4	GD-01	650W x 500H	FLUSH WITH BOTTOM OF BEAM
5	PF-01	Φ920	FLUSH WITH BOTTOM OF BEAM

SPACE FOR STAMP

ISSUED FOR APPROVAL

DO NOT SCALE THE DRAWING | POWER PROJECTS DIVISION-CH

Owner: TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT: 1 X 800MW - NCTPP - STAGE - III
ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT: FICHTNER CONSULTING ENGINEERS(INDIA) PRIVATE LIMITED
CHENNAI - INDIA

BOP CONTRACTOR: BGR ENERGY SYSTEMS LIMITED
CHENNAI, INDIA

	NAME	SIGN	DATE
DRN.	D.DINESH	Sd/-	30-12-2016
DSN.	P. SATHISH	Sd/-	30-12-2016
CHD.	A. SATHIRAPPAN	Sd/-	30-12-2016
APPD.	A.N. RAJNAVAN	Sd/-	30-12-2016

SHEET SIZE: A0

DEPT.: MECH, CIVIL, C&I/C | SCALE: 1:100 | BOP CONTRACTOR'S DRAWING NO.: GID-244-ME-USG-XD-13022 | REV.: 3

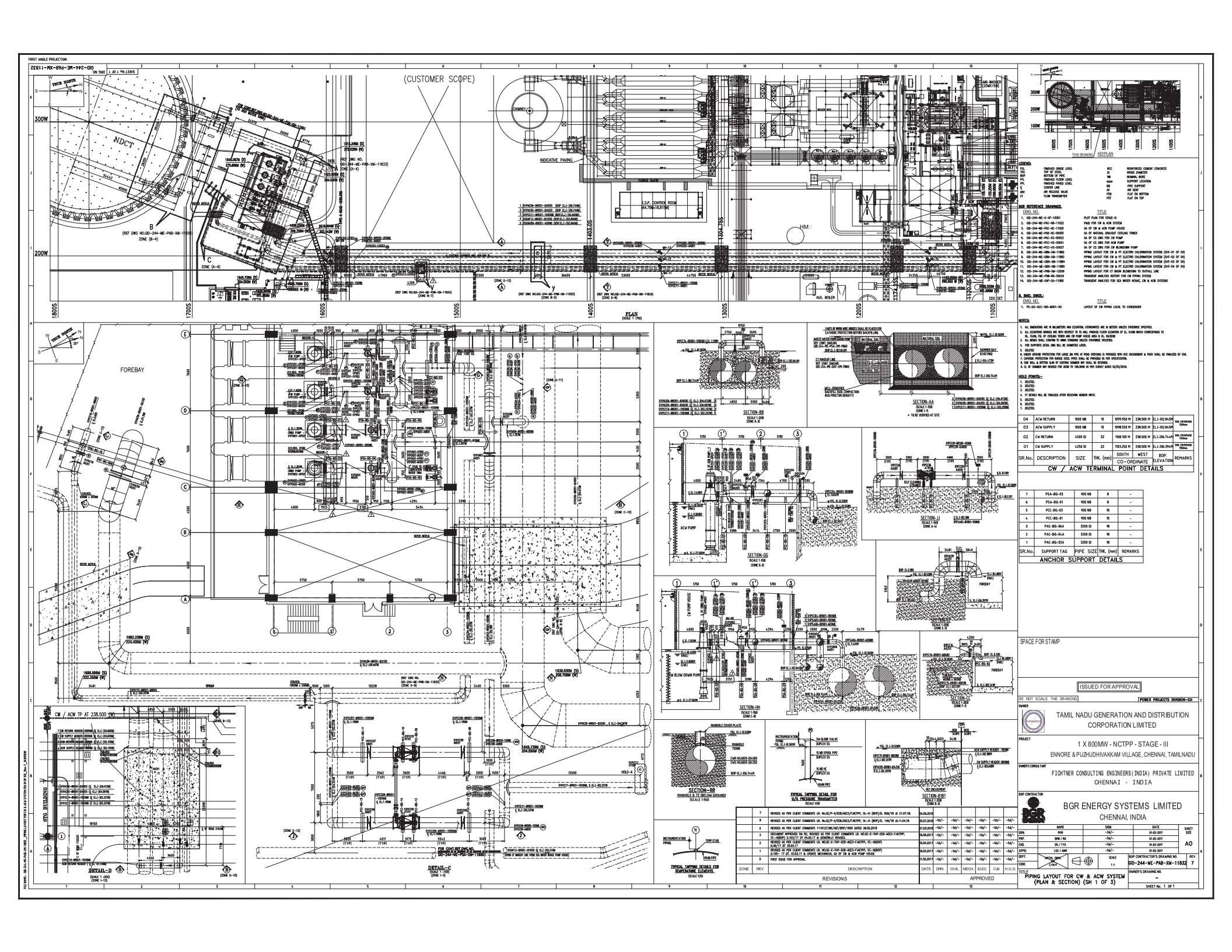
CODE:

TITLE: GA OF FILTERED WATER AND FIRE WATER TANK & PUMP HOUSE

OWNER'S DRAWING NO.: —

SHEET No. 1 OF 1

FILENAME: GID-244-ME-USG-XD-13022-GA OF FIRE & FILTER WATER PUMP HOUSE_3.dwg



THIS DRAWING/ KEYPLAN

LEGEND:

TOL	FINISHED GRADE LEVEL	RCC	REINFORCED CEMENT CONCRETE
TOS	TOP OF STEEL	ID	INSIDE DIAMETER
BOP	BOTTOM OF PIPE	NB	NOMINAL BORE
FFL	FINISHED FLOOR LEVEL	<-->	SUPPORT LOCATION
FPL	FINISHED PAVED LEVEL	PS	PIPE SUPPORT
CL	CENTER LINE	AV	AIR VENT
ARV	AIR RELEASE VALVE	FOB	FLAT ON BOTTOM
FT	FLOW TRANSMITTER	FOT	FLAT ON TOP

BGR REFERENCE DRAWINGS.

DWG NO.	TITLE
1. GD-244-ME-G-XF-10001	PLOT PLAN FOR STAGE-III
2. GD-244-ME-PAC-XM-11522	P&ID FOR CW & ACW SYSTEM
3. GD-244-ME-PAC-XD-11505	GA OF CW & ACW PUMP HOUSE
4. GD-244-ME-PAB-XE-56000	GA OF NATURAL DRAUGHT COOLING TOWER
5. GD-244-ME-PCC-XS-00023	GA OF CS 2MG FOR CW PUMP
6. GD-244-ME-PCC-XS-00031	GA OF CS 2MG FOR ACW PUMP
7. GD-244-ME-PCC-XS-00027	GA OF CS 2MG FOR CW BLOWDOWN PUMP
8. GD-244-ME-GBN-XM-11882	PIPING LAYOUT FOR CW & PT ELECTRO CHLORINATION SYSTEM (SHT-01 OF 04)
9. GD-244-ME-GBN-XM-11883	PIPING LAYOUT FOR CW & PT ELECTRO CHLORINATION SYSTEM (SHT-02 OF 04)
10. GD-244-ME-GBN-XM-11884	PIPING LAYOUT FOR CW & PT ELECTRO CHLORINATION SYSTEM (SHT-03 OF 04)
11. GD-244-ME-GBN-XM-11885	PIPING LAYOUT FOR CW & PT ELECTRO CHLORINATION SYSTEM (SHT-04 OF 04)
12. GD-244-ME-PAB-XM-12206	PIPING LAYOUT FOR CT BASIN BLOWDOWN TO OUTFALL LINE
13. GD-244-ME-PAB-XN-53024	TRANSIENT ANALYSIS REPORT FOR CW PIPING SYSTEM
14. GD-244-ME-GNF-XA-11085	TRANSIENT ANALYSIS FOR SEA WATER INTAKE, CW & ACW SYSTEMS

B. BHEL DWGS.:

DWG NO.	TITLE
1. PE-DG-423-145-M001-R2	LAYOUT OF CW PIPING LOCAL TO CONDENSER

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS, CHAINAGES ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL ELEVATIONS MARKED ARE WITH RESPECT TO TG WALL FINISHED FLOOR ELEVATION OF EL. 0.00M WHICH CORRESPONDS TO RL. 13.00L FG OF COOLING TOWER AND CW PUMP HOUSE AREA IS RL 26.00M
3. ALL BENDS SHALL CONFORM TO 90MM STANDARD UNLESS OTHERWISE SPECIFIED.
4. FOR SUPPORTS DETAIL ONE WILL BE SUBMITTED LATER.
5. DELETED.
6. UNDER GROUND PROTECTION FOR LARGE DIA PIPE AT ROAD CROSSING IS PROVIDED WITH RCC ENCASEMENT & THICK SHALL BE FINALIZED BY CIVIL.
7. CATHODIC PROTECTION FOR BURIED STEEL PIPES SHALL BE PROVIDED AS PER SPECIFICATION.
8. SIDE WALL & BOTTOM SLAB OF EXISTING SUMMER BAY SHALL BE RETAINED.
9. EL OF SUMMER BAY REVISED FOR 200M TO 198.50M AS PER SURVEY DATED 03/03/2016.

HOLD POINTS:-

1. DELETED.
2. DELETED.
3. DELETED.
4. FT DETAILS WILL BE FINALIZED AFTER RECEIVING VENDOR INPUT.
5. DELETED.
6. DELETED.
7. DELETED.

SR.No.	DESCRIPTION	SIZE	THK. (mm)	CO-ORDINATE SOUTH	CO-ORDINATE WEST	BOP ELEVATION	REMARKS
04	ACW RETURN	1600 NB	10	1099.950 M	238.500 M	EL(-)302.845M	500L COVERAGE 1529mm
03	ACW SUPPLY	1600 NB	10	1098.550 M	238.500 M	EL(-)302.845M	500L COVERAGE 1515mm
02	CW RETURN	4500 ID	22	1108.100 M	238.500 M	EL(-)306.744M	500L COVERAGE 1515mm
01	CW SUPPLY	4250 ID	22	1103.250 M	238.500 M	EL(-)306.395M	500L COVERAGE 1515mm

CW / ACW TERMINAL POINT DETAILS

SR.No.	SUPPORT TAG	PIPE SIZE	THK. (mm)	REMARKS
7	PSA-BQ-03	900 NB	8	-
6	PSA-BQ-01	900 NB	8	-
5	PCC-BQ-03	900 NB	10	-
4	PCC-BQ-01	900 NB	10	-
3	PAC-BQ-06A	3200 ID	18	-
2	PAC-BQ-04A	3200 ID	18	-
1	PAC-BQ-02A	3200 ID	18	-

ANCHOR SUPPORT DETAILS

SPACE FOR STAMP

ISSUED FOR APPROVAL

DO NOT SCALE THE DRAWING | POWER PROJECTS DIVISION-CH

OWNER
TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT
1 X 800MW - NCTPP - STAGE - III
ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT
FICHTNER CONSULTING ENGINEERS(INDIA) PRIVATE LIMITED
CHENNAI - INDIA

BOP CONTRACTOR
BGR ENERGY SYSTEMS LIMITED
CHENNAI, INDIA

	NAME	SIGN	DATE	SHEET SIZE
DRN.	PKN	-Sd/-	01-03-2017	
PRP.	BMD / RS	-Sd/-	01-03-2017	A0
CHD.	DS / TYS	-Sd/-	01-03-2017	
APPD.	LSS / AMK	-Sd/-	01-03-2017	

SCALE 1:1 | BOP CONTRACTOR'S DRAWING NO. GD-244-ME-PAB-XM-11832 | REV. 7

OWNER'S DRAWING NO. -

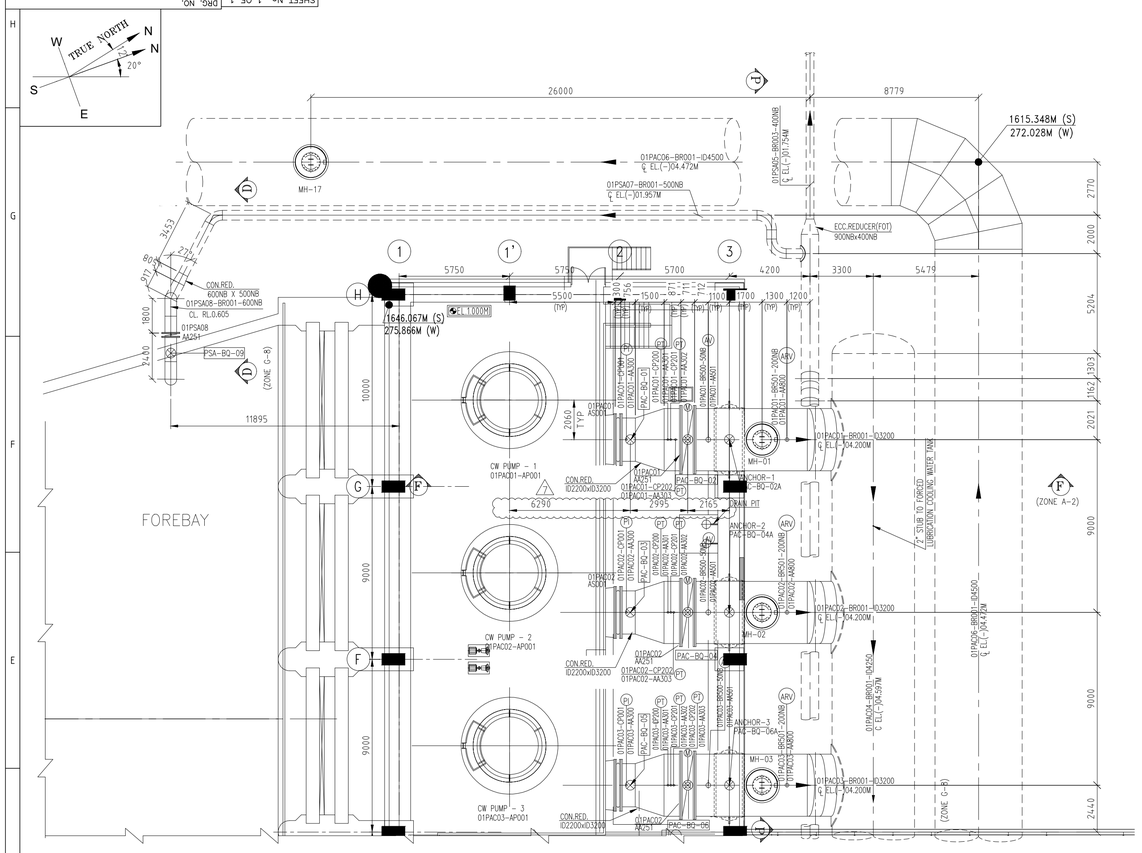
TITLE
PIPING LAYOUT FOR CW & ACW SYSTEM (PLAN & SECTION) (SH 1 OF 3)

SHEET No. 1 OF 1

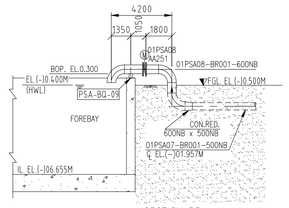
ZONE	REV	DESCRIPTION	DATE	DRN.	CIVIL	MECH	ELEC.	C&I	H.O.D.
	7	REVISED AS PER CLIENT COMMENTS LR. No.SE/P-I-A/EDE/AECI/FACTPP, SL-II (BOP)/D. 806/18 dt. 21.07.18.	04.09.2018	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	6	REVISED AS PER CLIENT COMMENTS LR. No.SE/P-I-A/EDE/AECI/FACTPP, SL-II (BOP)/D. 140/18 dt.11.04.18	26.07.2018	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	5	REVISED AS PER CLIENT COMMENTS 1116127/ME/AGT/BOP/1850 DATED 24.02.2018	27.03.2018	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	4	DOCUMENT APPROVED VIA RIL REVISED AS PER CLIENT COMMENTS LR. NO.SE-C-THP-EER-AECI-FACTPP, ST.-II(BOP)/ D.703/17 DT 04.05.17 & GENERALLY REVISED.	06.06.2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	3	REVISED AS PER CLIENT COMMENTS LR. NO.SE-C-THP-EER-AECI-FACTPP, ST.-II(BOP)/ D.467/17 DT 28.03.17	05.04.2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	2	REVISED AS PER CLIENT COMMENTS LR. NO.SE-C-THP-EER-AECI-FACTPP, ST.-II(BOP)/ D.455/ 17 DT. 03.03.17 & UPDATE MECHANICAL SA OF CW & ACW PUMP HOUSE	03.03.2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	1	REVISED AS PER CLIENT COMMENTS LR. No.SE/P-I-A/EDE/AECI/FACTPP, ST.-II(BOP)/ D.455/ 17 DT. 03.03.17 & UPDATE MECHANICAL SA OF CW & ACW PUMP HOUSE	01.02.2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	0	FIRST ISSUE FOR APPROVAL							

REVISIONS | APPROVED

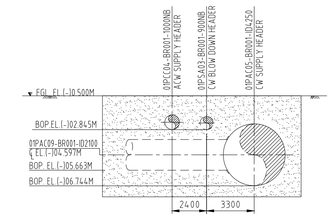
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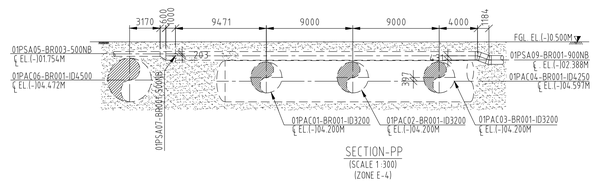
DETAIL–A
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(REF DWG NO.GID–244–ME–PAB–XM–11832)
(ZONE J–4)



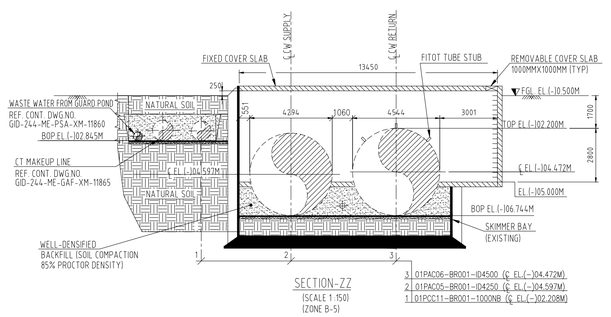
SECTION–DD
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(ZONE F–2)



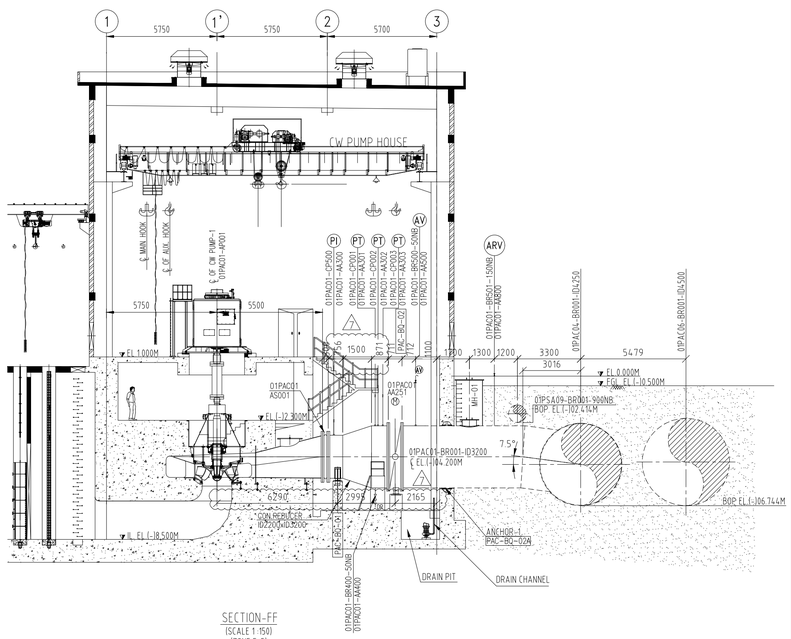
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(REF DWG NO.GID–244–ME–PAB–XM–11832)
(ZONE C–6)



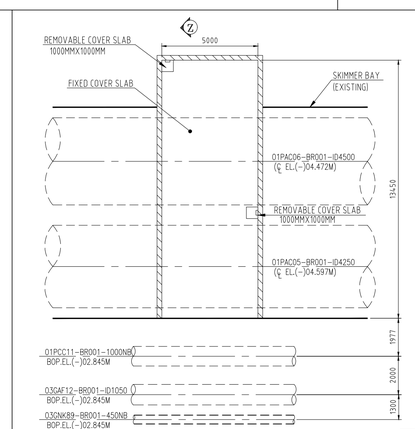
SECTION–PP
(SCALE 1:300)
(ZONE E–4)



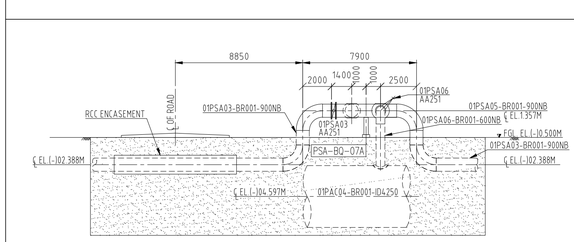
SECTION–ZZ
(SCALE 1:150)
(ZONE B–5)
• TO BE VERIFIED AT SITE



SECTION–FF
(SCALE 1:150)
(ZONE F–5)



DETAIL–Y
(SCALE 1 :150)
(REF DWG NO.GID–244–ME–PAB–XM–11832)
(ZONE I–7)



SECTION–QQ
(SCALE 1:300)
(REF DWG NO.GID–244–ME–PAB–XM–11832)
(ZONE E–7)

ZONE	REV	DESCRIPTION	DATE	DRN	CIVIL	MECH.	ELEC.	C&I	HOD
	7	REVISED AS PER CLIENT COMMENTS LR. No.SE/P–II/EE8/AEE3/F.NCTPP, St.–III (BOP)/D. 826/18 dt 21.07.18.	04.09.2018						
	6	REVISED AS PER CLIENT COMMENTS LR. No.SE/P–II/EE8/AEE3/F.NCTPP, St.–III (BOP)/D. 149/18 dt.11.04.18	05–07–2018	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–
	5	REVISED AS PER CLIENT COMMENTS 11161127/ME/VDT/BOP/1850 DATED 26.02.2018	27–03–2018	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–
	3	DOCUMENT APPROVED ON R2, REVISED AS PER CLIENT COMMENTS LR. NO.SE–E–THP–EE8–AEE3–F.NCTPP, ST.–III(BOP) D.103/17 DT 04.05.17 & GENERALLY REVISED.	09–06–2017	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–
	2	REVISED AS PER CLIENT COMMENTS LR. NO.SE/E/THP/EE8/AEE3/F.NCTPP, St.–III(BOP)/ D.46/17 dt 30.03.17 & UPDATE MECHANICAL GA OF CW & ACW PUMP HOUSE	05–04–2017	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–
	1	REVISED AS PER CLIENT COMMENTS LR. NO.SE–E–THP–EE8–AEE3–F.NCTPP, ST.–III(BOP) D.100– 17 DT. 03.02.17 & UPDATE MECHANICAL GA OF CW & ACW PUMP HOUSE	09–03–2017	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–
	0	FIRST ISSUE FOR APPROVAL	01–02–2017	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–	–Sd/–

REVISIONS | APPROVED

NOTES

1. FOR LEGENDS NOTES, AND ENGG. PLEASE REF.DWG.NO.GID–244–ME–PAB–XM–11832

SPACE FOR STAMP

ISSUED FOR APPROVAL

DO NOT SCALE THE DRAWING | POWER PROJECTS DIVISION–CH

OWNER

TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT

1 X 800MW - NCTPP - STAGE - III

ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT

FICHTNER CONSULTING ENGINEERS □INDIA□PRIVATE LIMITED
CHENNAI - INDIA

BOP EPC CONTRACTOR

BGR ENERGY SYSTEMS LIMITED
CHENNAI - INDIA

	NAME	SIGN	DATE	SHEET SIZE
DRN.	PKM	–Sd/–	01–02–2017	A1
DGN.	BMB	–Sd/–	01–02–2017	
CHD.	DS / TYS	–Sd/–	01–02–2017	
APPD.	LSS / ANM	–Sd/–	01–02–2017	
DEPT.	UNTOL. DIMS. GR C/M/F	SCALE AS SHOWN	BOP EPC CONTRACTOR'S DRAWING NO. GID–244–ME–PAB–XM–11833	REV. 7
CODE.				

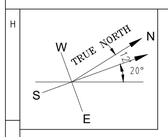
TITLE: PIPING LAYOUT FOR CW & ACW SYSTEM (PLAN & SECTION) (SH 2 OF 3)

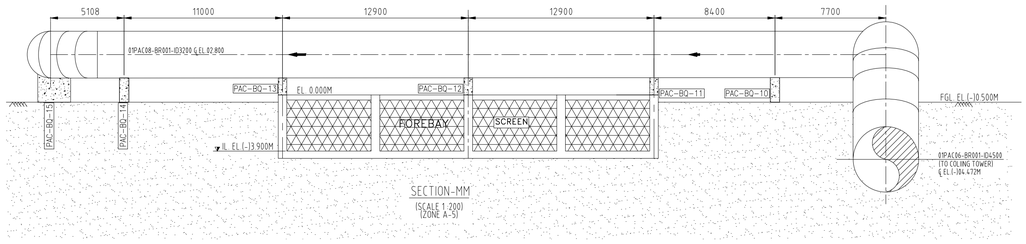
OWNER'S DRAWING NO. –

SHEET No. 1 OF 1

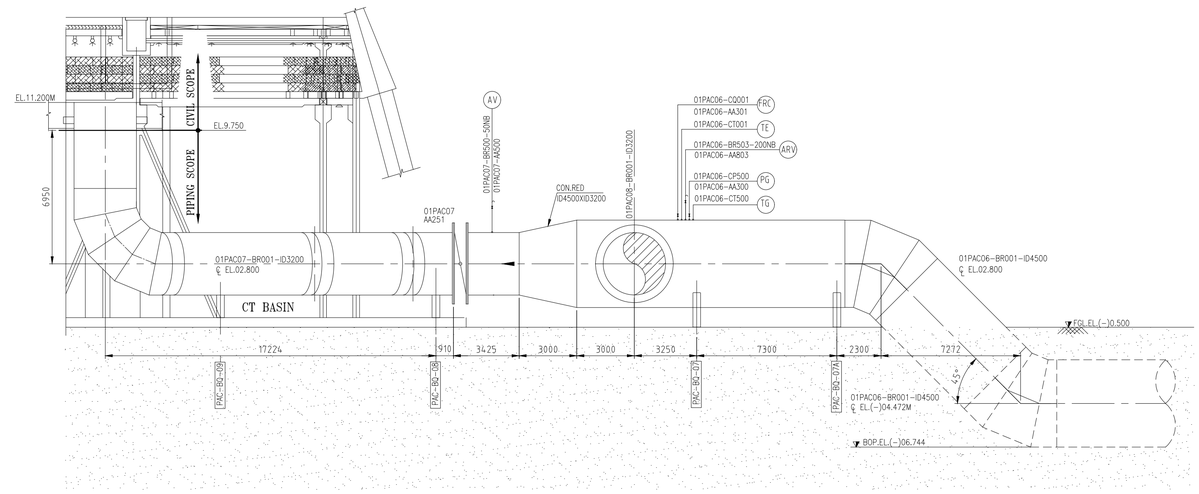
FILE NAME:- GID-244-ME-PAB-XM-11833_PIPING LAYOUT FOR CW & ACW SYSTEM (SH 02 OF 03)_Rev-7_04092018

DRG. NO. GID-244-ME-PAB-XM-11834 | SHEET No. 1 OF 1

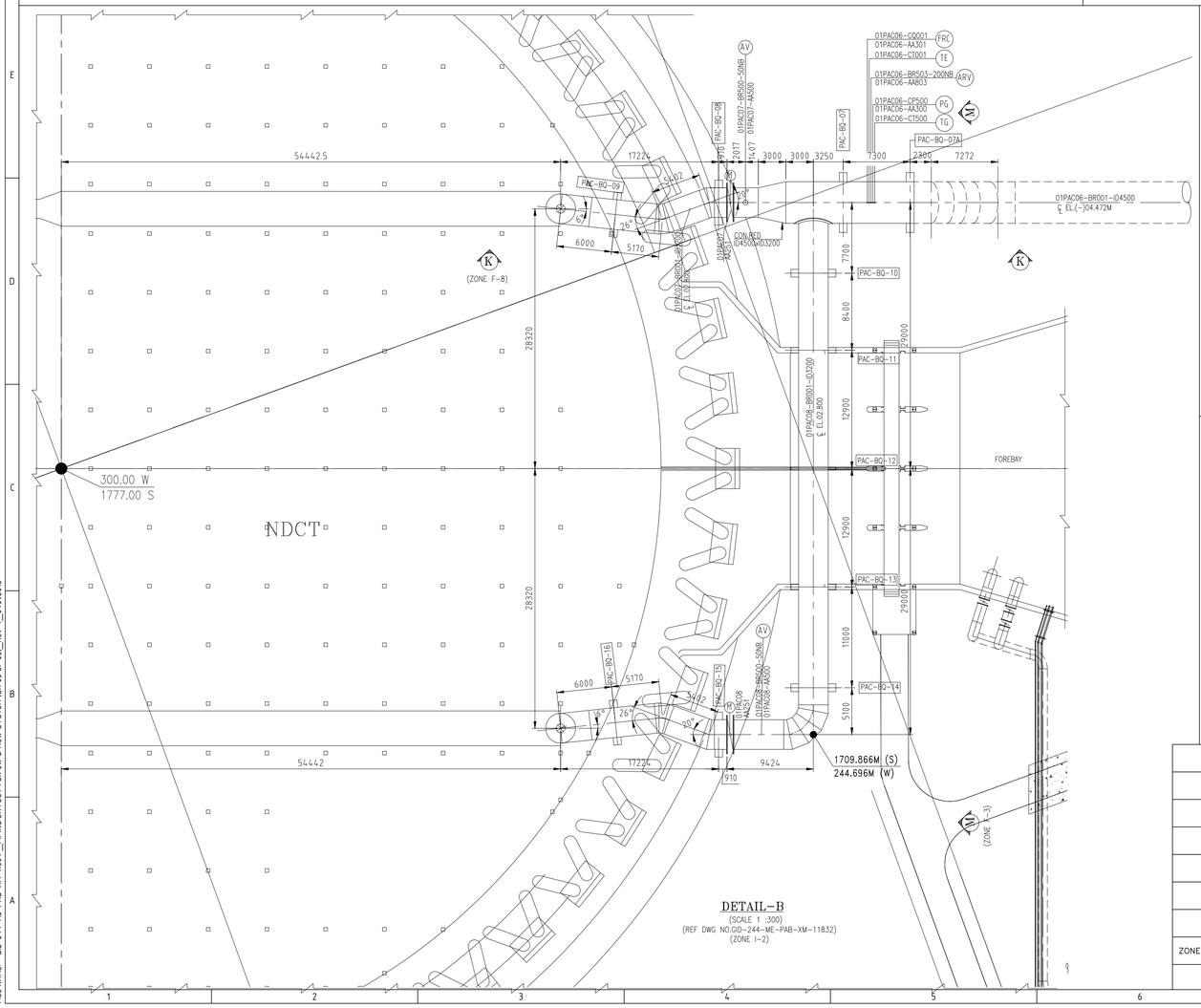




SECTION-MM
(SCALE 1:200)
(ZONE A-5)

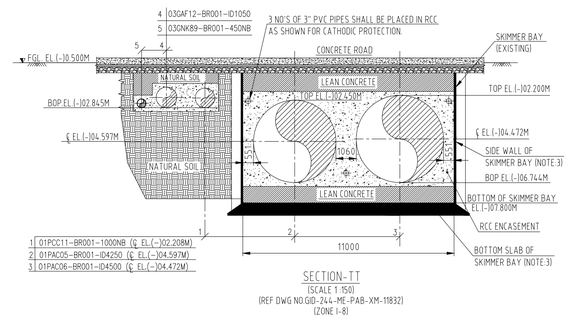


SECTION-KK
(SCALE 1:150)
(ZONE D-3)

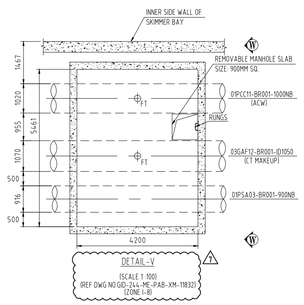


DETAIL-B
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(REF DWG NO.GID-244-ME-PAB-XM-11832)
(ZONE I-2)

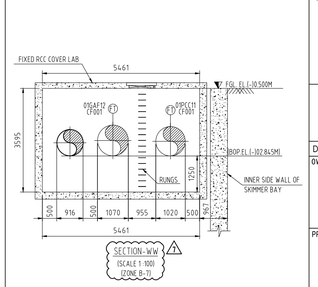
TYP. DETAIL FOR ROAD CROSSING IN SKIMMER BAY



SECTION-TT
(SCALE 1:150)
(REF DWG NO.GID-244-ME-PAB-XM-11832)
(ZONE I-8)



DETAIL-V
(SCALE 1:100)
(REF DWG NO.GID-244-ME-PAB-XM-11832)
(ZONE I-8)



SECTION-WW
(SCALE 1:100)
(ZONE B-7)

NOTES

1. FOR LEGENDS NOTES, AND ENGG. PLEASE REF.DWG.NO.GID-244-ME-PAB-XM-11832
2. HOLD WILL BE RELEASED AFTER GETTING INPUTS FROM FT VENDOR.
3. SIDE WALL & BOTTOM SLAB OF EXISTING SKIMMER BAY SHALL BE RETAINED. TOP COVER SHALL BE DEMOLISHED SUITABLY FOR PIPE INSTALLATION.
4. FT DETAILS WILL BE FINALIZED AFTER RECEIVING VENDOR DETAILS.

ZONE	REV	DESCRIPTION	DATE	DRN	CIVIL	MECH.	ELEC.	C&I	HOD
	7	REVISED AS PER CLIENT COMMENTS LR. No.SE/P-II/EE8/AE3/F.NCTPP, St.-III (BOP)/D. 826/18 dt 21.07.18.	04.09.2018						
	6	REVISED AS PER CLIENT COMMENTS LR. No.SE/P-II/EE8/AE3/F.NCTPP, St.-III (BOP)/D. 149/18 dt.11.04.18	05-07-2018	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	5	REVISED AS PER CLIENT COMMENTS 1116127/ME/VDT/BOP/1850 DATED 26.02.2018	27-03-2018	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	3	DOCUMENT APPROVED ON R2, REVISED AS PER CLIENT COMMENTS LR. NO.SE-E-THP-EE8-AE3-F.NCTPP, ST.-III(BOP) D.103/17 DT 04.05.17 & GENERALLY REVISED.	09-06-2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	2	REVISED AS PER CLIENT COMMENTS LR. NO.SE-E-THP-EE8-AE3-F.NCTPP, ST.-III(BOP) D.46/17 DT 30.03.17 & UPDATE MECHANICAL GA OF CW & ACW PUMP HOUSE	05-04-2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	1	REVISED AS PER CLIENT COMMENTS LR. NO.SE-E-THP-EE8-AE3-F.NCTPP, ST.-III(BOP) D.100- 17 DT. 03.02.17 & UPDATE MECHANICAL GA OF CW & ACW PUMP HOUSE	09-03-2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
	0	FIRST ISSUE FOR APPROVAL	01-02-2017	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-

REVISIONS | APPROVED

SPACE FOR STAMP

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DO NOT SCALE THE DRAWING | POWER PROJECTS DIVISION-CH

OWNER

TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT

1 X 800MW - NCTPP - STAGE - III

ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

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CHENNAI - INDIA

BOP EPC CONTRACTOR

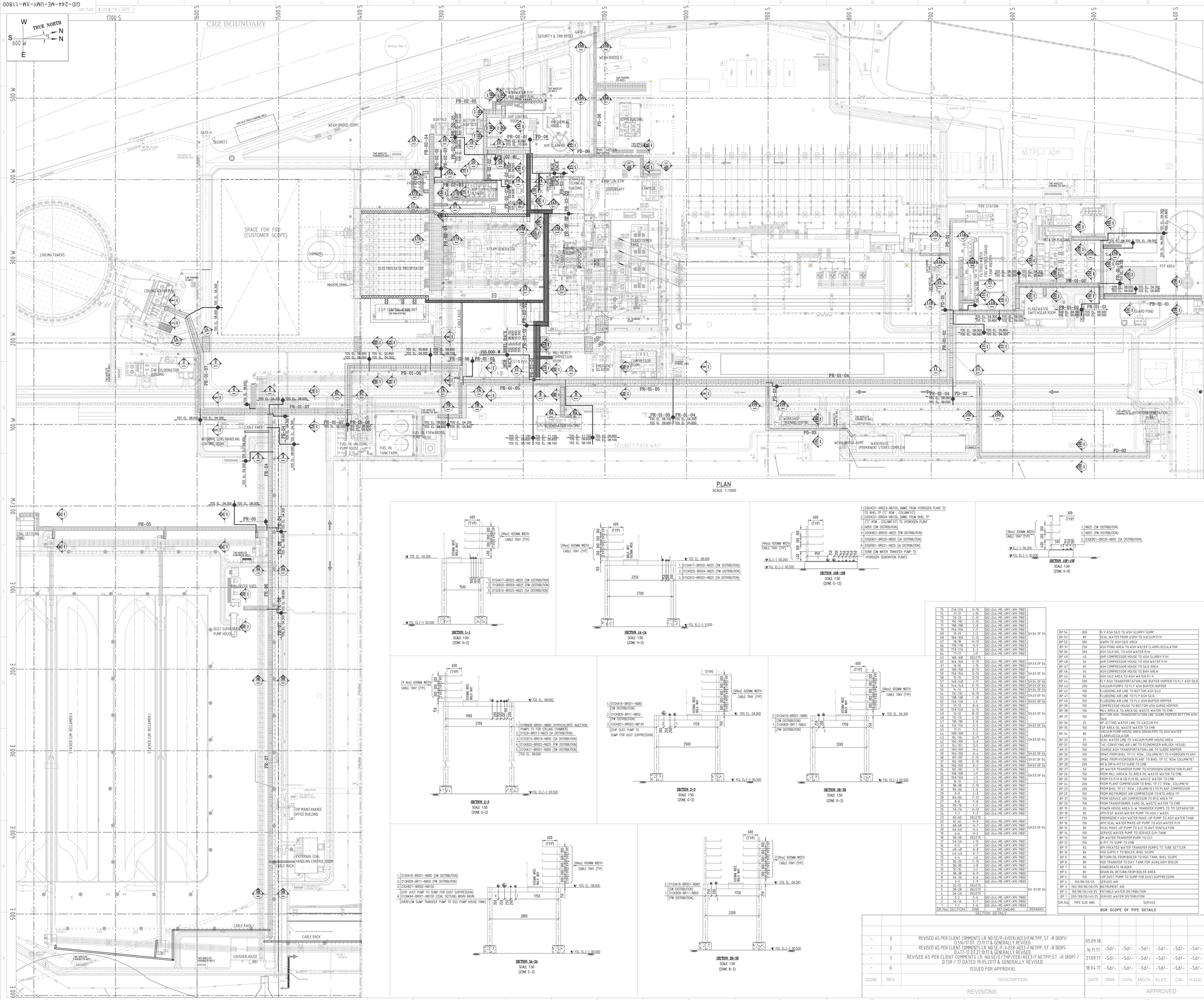
BGR ENERGY SYSTEMS LIMITED
CHENNAI - INDIA

	NAME	SIGN	DATE	SHEET SIZE
DRN.	PKM	-Sd/-	01-02-2017	A1
DGN.	BMB	-Sd/-	01-02-2017	
CHD.	DS / TYS	-Sd/-	01-02-2017	
APPD.	LSS / KNM	-Sd/-	01-02-2017	
DEPT.	UNTOL. DIMS: CIVIL / MECH / C/M/F	SCALE: AS SHOWN	BOP EPC CONTRACTOR'S DRAWING NO.: GID-244-ME-PAB-XM-11834	REV.: 7
CODE.			OWNER'S DRAWING NO.: –	

TITLE: PIPING LAYOUT FOR CW & ACW SYSTEM (PLAN & SECTION) (SH 3 OF 3)

SHEET No. 1 OF 1

FILE NAME:- GID-244-ME-PAB-XM-11834__PIPING LAYOUT FOR CW & ACW SYSTEM (SH 03 OF 03)_Rev-7_04092018



PLAN
SCALE 1:1500

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATION, COORDINATES ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL ELEVATIONS MARKED ARE WITH RESPECT TO TG HALL FINISHED FLOOR ELEVATION OF EL. 0.00M WHICH CORRESPONDS TO RL. 10.0M.
3. PIPING SHALL BE ROUTED IN PIPE RACKS WITH A MINIMUM HEADROOM CLEARANCE OF 2.5 METRE FROM FGL AND IN ROAD/RAIL CROSSING AREA CLEAR HEIGHT SHALL BE 8.0 METRE.
4. FUEL OIL PIPING SHALL BE ROUTED IN PIPE RACKS WITH A MINIMUM HEADROOM CLEARANCE OF 4.5 METRE FROM FGL.
5. FOR CABLE TRAY ROUTING AND ITS DETAILS REFER CORRESPONDING ELECTRICAL DRAWING NO. GID-244-EL-UMY-XE-20551, GID-244-EL-UMY-XE-21551 TO GID-244-EL-UMY-XE-21555 & GID-244-EL-UMY-XE-21591
6. SEQUENCE OF PIPE INDICATED IN ALL SECTIONS ARE TENTATIVE ONLY. IT MAY BE CHANGED DURING DETAILED PIPE RACK DRAWING.
7. PIPE SIZE CONSIDER ARE TENTATIVE AND MAY CHANGE LATER BASED ON BASIC ENGINEERING PROGRESS.
8. PIPE RACK COLUMN LOCATION, LADDER LOCATION & EXPANSION LOOP LOCATION SHALL BE FURNISHED LATER.
9. BHEL SCOPE OF PIPES & CABLE TRAY SHOWN TENTATIVELY IN THE PIPE RACK, IT WILL BE FINALIZED AFTER GETTING THE BHEL FINAL INPUTS.
10. PIPE RACK SECTION 12-12, 12A-12A, 13-13 13A-13A, 13B-13B, 13C-13C, 14-14 & 14B-14B WHICH ARE IN SCOPE OF BHEL HAS BEEN MODIFIED TO ACCOMMODATE THE PIPES THAT ARE IN SCOPE OF BOP CONTRACTOR, BHEL SHALL CONFIRM THE SAME.
11. LOCATION OF COLUMN IS TENTATIVE ONLY. IT MAY BE CHANGED DURING THE CIVIL DETAIL ENGINEERING.
12. WHEREVER SITE GRADING IS NOT SPECIFIED, BOBP AND HEIGHT OF PIPE RACK IS BASED ON THE NGL.
13. INTERMEDIATE BEAM FOR PIPE SUPPORTS BASED ON PIPE SUPPORT SPAN OF LOWEST PIPE SIZE.

LEGEND:

- BTG PIPE RACK
- BOP PIPE RACK
- FGL – FINISHED GROUND LEVEL
- EL – ELEVATION LEVEL
- TOS – TOP OF STEEL
- NGL – NATURAL GROUND LEVEL
- PR-XX – PIPE RACK NUMBER
- PD-XX – PIPE PEDESTAL NUMBER

ENGG. REF. DWGS.:

A. BGR DWGS.:

	TITLE
GID-244-ME-U-XF-10001	PLOT PLAN FOR STAGE-III
GID-244-ME-GHB-XB-11060	P&ID FOR FILTER WATER DISTRIBUTION SYSTEM
GID-244-ME-GHC-XB-11038	P&ID FOR DM WATER TRANSFER SYSTEM
GID-244-ME-SC-XB-11301	P&ID FOR PLANT COMPRESSED AIR SYSTEM
GID-244-ME-GAF-XB-11004	P&ID OF SEA WATER INTAKE SYSTEM
GID-244-ME-PAC-XB-11022	P&ID FOR CW & ACW SYSTEM
GID-244-ME-GAF-XB-11004	P&ID FOR SEA WATER INTAKE SYSTEM
GID-244-ME-GHC-XB-11039	P&ID FOR DMCW SYSTEM
GID-244-ME-GCF-XB-55071 TO 55077	P&ID FOR DM PLANT (SHEET 1 OF 7)
GID-244-ME-GCF-XB-55046 TO 55050	P&ID FOR ULTRA FILTRATION PLANT (SHEET 1 OF 5)
GID-244-ME-GCF-XB-55041	P&ID FOR UF PLANT (SHEET 1 OF 2)
GID-244-ME-GCF-XB-55042	P&ID FOR UF PLANT (SHEET 2 OF 2)
GID-244-ME-SCA-XB-51252	P&I DIAGRAM FOR INSTRUMENT AND SERVICE AIR COMPRESSOR
GID-244-ME-EGT-XB-11203	P&ID FOR STEAM AND CONDENSATE SYSTEM
GID-244-ME-SC-XB-11301	P&ID FOR PLANT COMPRESSED AIR SYSTEM
GID-244-ME-EGC-XB-11202	P&ID FOR HSD UNLOADING & TRANSFER SYSTEM
GID-244-ME-EGA-XB-11201	P&ID FOR HFO UNLOADING SYSTEM
GID-244-ME-GCF-XB-55051 TO 55057	P&ID FOR SWRO PLANT (SHEET 1 OF 7)
GID-244-ME-GCB-XB-55058 TO 55063	P&ID FOR BWRO PLANT (SHEET 1 OF 6)
GID-244-ME-GCB-XB-55043 TO 55045	P&ID FOR FILTRATION PLANT (SHEET 1 OF 3)
GID-244-ME-GB-XB-55001 TO 55003	P&ID FOR PER-TREATMENT PLANT (SHEET 1 OF 3)
GID-244-ME-SCB-XB-11303	P&ID FOR PLANT SERVICE AIR DISTRIBUTION SYSTEM
GID-244-ME-SCB-XB-11302	P&ID FOR PLANT INSTRUMENT AIR DISTRIBUTION SYSTEM
GID-244-ME-SG-XM-13010	COMPOSITE LAYOUT FOR HYDRANT & SPRAY SYSTEM – SH 1/8

B. BHEL DWGS.:

	TITLE
1. PE-DG-423-100-M051	YARD PIPING AND TRESTLE LAYOUT – 1 (C-ROW)
2. PE-DG-423-100-M052	YARD PIPING AND TRESTLE LAYOUT – 2
3. PE-DG-423-100-M002	MAIN EQUIPMENT LAYOUT

PIPE SIZES OF S.NO. 11, 12, 27 28, 37 & 38 ARE ON HOLD & 36 TO BE ROUTED THROUGH TRANSFORMER YARD

P40	250	SERVICE WATER TO LP START-UP SYSTEM QUENCHING	100	PC
P39	200	TAC CONVEYING AIR LINE TO ECONOMISER AIR LOCK VESSEL	75	CUST (BGR)
P38	80	HVAC MAKE-UP PUMP TO AC PLANT VENTILATION (HEADER)	20	BHEL-MAUX VENDOR
P37	350	WATER WASH FROM PUMP TO ESP/APH	165	PC
P36	150	TRANSFORMER YARD OIL WASTE WATER TO CMB	50	CUST (BGR)
P35	250	EMERGENCY ASH WATER MAKE-UP PUMP TO ASH WATER TANK	100	CUST (BGR)
P34	150	APH SEAL WATER MAKE-UP PUMP TO ASH WATER P/H	50	CUST (BGR)
P33	200	COARSE ASH TRANSPORTATION LINES- 06 NUMBERS	75	CUST (BGR)
P32	400	DMCW RETURN FROM BOP	200	CUST (BGR)
P31	400	DMCW SUPPLY TO BOP	200	CUST (BGR)
P30	25	CONDENSATE SPRAY FOR AUX STEAM TO FUEL OIL AREA	5	PEM/PC
P29	250	SG STRT - UP DRAIN	250	PEM / PC
P28	150	MILL AND TD AREA OIL WASTE WATER TO CMB	50	CUST (BGR)
P27	65	POWER HOUSE O/W TRANSFER PUMPS TO TPI SEPARATOR	15	CUST (BGR)
P26	300	DMCW – SG RETURN	130	PEM / PC
P25	300	DMCW – SG SUPPLY	130	PEM / PC
P24	200	CONDENSATE RETURN TO CST	80	PEM / PC
P23	50	DMCW RETURN TO AC PLANT AND AUXI BOILER (INDIVIDUAL)	9	PEM / PC
P22	50	DMCW SUPPLY TO AC PLANT AND AUXI BOILER (INDIVIDUAL)	9	PEM / PC
P21	50	DMCW RETURN TO SWAS COMP. ROOM CHILLER AND AUXILIARIES	16	PEM / PC
P20	50	DMCW SUPPLY TO SWAS COMP. ROOM CHILLER AND AUXILIARIES	16	PEM / PC
P19	80	POTABLE WATER FROM CUSTOMER	16	PEM / PC
P18	150	SERVICE WATER FROM CUSTOMER	41	PEM / PC
P17	100	CPU RESIN TRANSFER FROM CPU BUILDING	41	MAXU VENDOR
P16	100	DM FROM CUSTOMER	23	PEM / PC
P15	100	NORMAL / EMERGENCY MU TO CONDENSER / AUXILIARY BOILER	23	PEM / PC
P14	150	BOILER INITIAL FILLING LINE	41	PEM / PC
P13	150	CPU DM WATER LINE FROM CPU BUILDING	23	BHEL-MAUX VENDOR
P12	80	ESP BUILDING HVAC MAKE-UP	20	BHEL-MAUX VENDOR
P11	80	SERVICE BUILDING HVAC MAKE-UP	20	BHEL-MAUX VENDOR
P10	80	HSD SUPPLY (CS) FROM P&H UNIT TO BOILER	28	PC/TRY
P9	400/350	DMCW RETURN FROM MISC COMP. AND BOP AUXILIARIES	185/16/23	PEM / PC
P8	400/350	DMCW SUPPLY TO MISC COMP. AND BOP AUXILIARIES	185/16/23	PEM / PC
P7	100	HFO RETURN FROM BOILER	35	PC / TRY
P6	150	HFO SUPPLY (CS) FROM P&H UNIT TO BOILER	41	PC / TRY
P5	250	AUXILIARY STEAM TO FUEL OIL HEATING AND PUMPING UNIT	98	PC / TRY
P4	150	SERVICE AIR	41	PEM / PC
P3	100	INSTRUMENT AIR	23	PEM / PC
P2	100/80/50/40/25	POTABLE WATER DISTRIBUTION	23/16/9/6/3	PEM / PC
P1	200/100/50/40	SERVICE WATER DISTRIBUTION	80/23/9/6	PEM / PC

PIPE No.	PIPE SIZE (NB)	DESCRIPTION	PIPE WT (KG/M)	SCOPE

BHEL SCOPE OF PIPE DETAILS

BP 54	300	FLY ASH SILO TO ASH SLURRY SUMP	SH.04 OF 04
BP 53	80	SEAL WATER FROM ASPH TO VACUUM P/H	
BP 52	300	AWPH TO ASH SILO AREA	
BP 51	250	ASH POND AREA TO ASH WATER CLARIFLOCCULATOR	
BP 50	300	ASH SILO DIS. TO ASH WATER P/H	
BP 49	40	AHP COMPRESSOR HOUSE TO ASH SLURRY P/H	
BP 48	50	AHP COMPRESSOR HOUSE TO ASH WATER P/H	
BP 47	65	ASH COMPRESSOR HOUSE TO SILO AREA	
BP 46	65	ASH COMPRESSOR HOUSE TO BAH AREA	
BP 45	65	ASH SILO AREA TO ASH WATER P/ H	
BP 44	200	FLY ASH TRANSPORTATION LINE BUFFER HOPPER TO FLY ASH SILO	SH.04 OF 04
BP 43	200	VACUUM PUMPS TO FLY ASH BUFFER HOPPER	SH.03 OF 04
BP 42	150	FLUIDIZING AIR LINE TO BOTTOM ASH SILO	SH.04 OF 04
BP 41	150	FLUIDIZING AIR LINE TO FLY ASH SILO	SH.03 OF 04
BP 40	150	FLUIDIZING AIR LINE TO FLY ASH BUFFER HOPPER	SH.04 OF 04
BP 39	150	COMPRESSOR HOUSE TO BOTTOM ASH SURGE HOPPER	
BP 38	150	MILL AREA & TG AREA OIL WASTE WATER TO CMB	SH.03 OF 04
BP 37	150	BOTTOM ASH TRANSPORTATION LINE SURGE HOPPER BOTTOM ASH SILO	
BP 36	25	HP JETTING WATER LINE TO VACUUM PH	SH.02 OF 04
BP 35	150	ESP AREA OIL WASTE WATER TO CMB	
BP 34	80	VACCUM PUMP HOUSE AREA DRAIN PIPE TO ASH WATER CLARIFLOCCULATOR	
BP 33	25	SEAL WATER LINE TO VACUUM PUMP HOUSE AREA	SH.03 OF 04
BP 32	150	TAC-CONVEYING AIR LINE TO ECONOMISER AIRLOCK VESSEL	
BP 31	150	COARSE ASH TRANSPORTATION LINE TO SURGE HOPPER	
BP 30	100	DMwC FROM BHEL TP ('C' ROW , COLUMN'10') TO HYDROGEN PLANT	SH.02 OF 04
BP 29	100	DMwC FROM HYDROGEN PLANT TO BHEL TP ('C' ROW COLUMN'10')	SH.01 OF 04
BP 28	200	RG & DM N-PITTO SUMP TO CMB	SH.02 OF 04
BP 27	200	DM WATER TRANSFER PUMP TO HYDROGEN GENERATION PLANT	
BP 26	150	FROM MILL AREA & TG AREA OIL WASTE WATER TO CMB	SH.03 OF 04
BP 25	150	FROM FD P/H & LD P/H OIL WASTE WATER TO CMB	
BP 24	200	FROM PLANT COMPRESSOR TO BHEL TP ('C' ROW , COLUMN'9'	
BP 23	200	FROM BHEL TP ('C' ROW , COLUMN'10') TO PLANT COMPRESSOR	
BP 22	150	FROM INSTRUMENT AIR COMPRESSOR TO BTG AREA TP	
BP 21	150	FROM SERVICE AIR COMPRESSOR TO BTG AREA TP	
BP 20	150	FROM TRANSFORMER YARD OIL WASTE WATER TO CMB	
BP 19	65	POWER HOUSE AREA O-W TRANSFER PUMPS TO TPI SEPARATOR	
BP 18	80	APH/ESP WASH WATER PUMP TO ASH / WASH	
BP 17	250	EMERGENCY ASH WATER MAKE-UP PUMP TO ASH WATER TANK	
BP 16	150	APH SEAL WATER MAKE-UP PUMP TO ASH WATER P/H	
BP 15	80	HVAC MAKE-UP PUMP TO A/C PLANT VENTILATION	SH.02 OF 04
BP 14	100	SERVICE WATER PUMP TO SERVICE O/H TANK	
BP 13	150	DM WATER TRANSFER PUMP TO CST	
BP 12	150	N-PIT TO SUMP TO CMB	
BP 11	65	API TREATED WATER TRANSFER PUMPS TO TUBE SETTLER	
BP 10	80	HSD SUPPLY TO BOILER, BHEL SCOPE	
BP 9	80	RETURN OIL FROM BOILER TO HSD TANK, BHEL SCOPE	
BP 8	80	HSD TRANSFER TO DAY TANK FOR AUXILIARY BOILER	
BP 7	50	CONDENSATE HEADER	
BP 6	80	DRAIN OIL RETURN FROM BOILER AREA	
BP 5	150	CHP DUST PUMP TO SUMP FOR DUST SUPPRESSION	
BP 4	150/80/50/25	SERVICE AIR	SH. 01 OF 04
BP 3	150/100/80/50/25	INSTRUMENT AIR	
BP 2	100/80/50/40/25	POTABLE WATER DISTRIBUTION	
BP 1	200/150/50/40/25	SERVICE WATER DISTRIBUTION	

SR.No	PIPE SIZE (NB)	SERVICE

BGR SCOPE OF PIPE DETAILS

SR.NO	SECTION	ZONE	REF DWG.NO	REMARKS

SECTION DETAILS

ZONE	REV	DESCRIPTION	DATE	DRN.	CIVIL	MECH.	ELEC.	C&I	H.O.D.
–	3	REVISED AS PER CLIENT COMMENTS LR. NO.SE/P-II/EEB/AEE3/F NCTPP, ST.-III (BOP)/ D.516/17 DT. 23.11.17 & GENERALLY REVISED.	05.09.18						
–	2	REVISED AS PER CLIENT COMMENTS LR. NO.SE-P-II-EEB-AEE3-F NCTPP, ST.-III (BOP)-D.417-17 DT.21.10.17 & GENERALLY REVISED.	16.11.17	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
–	1	REVISED AS PER CLIENT COMMENTS LR. NO.SE/Z/THP/EEB/AEE3/F NCTPP,ST.-III (BOP) / D.139 / 17 DATED 19.05.2017 & GENERALLY REVISED.	21.09.17	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
–	0	ISSUED FOR APPROVAL	18.04.17	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-

REVISIONS | APPROVED

SPACE FOR STAMP

ISSUED FOR APPROVAL

DO NOT SCALE THE DRAWING

POWER PROJECTS DIVISION-CH

OWNER

TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT

1 X 800MW - NCTPP - STAGE - III

ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT

FICHTNER CONSULTING ENGINEERS(INDIA) PRIVATE LIMITED

CHENNAI - INDIA

BOP CONTRACTOR

BGR ENERGY SYSTEMS LIMITED

CHENNAI, INDIA

	NAME	SIGN	DATE
DRN.	PKM	-Sd/-	18-04-2017
PRP.	GR	-Sd/-	18-04-2017
CHD.	DS / TYS	-Sd/-	18-04-2017
APPD.	LSS / AM	-Sd/-	18-04-2017

SHEET SIZE: A0

DEPT. CODE: VALCH, CHMC, CHMT

SCALE: 1:1

BOP CONTRACTOR'S DRAWING NO.: GID-244-ME-UMY-XM-11800

REV: 3

TITLE: OVERALL PIPE RACK PLAN AND SECTIONS (1 OF 4)

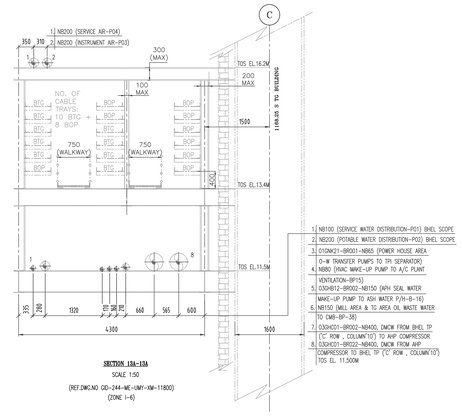
OWNER'S DRAWING NO.: –

SHEET No. 1 OF 1

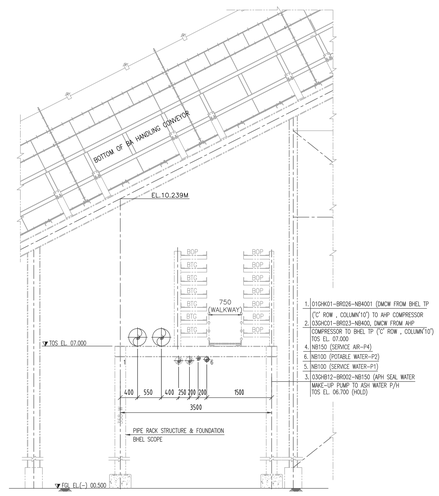
FILE NAME : GID-244-ME-UMY-XM-11800_3PKMGLA1A0.DGT FOR PLOT ALL PIPE RACK PLAN SHT-1 of 1_Rev-3_20/07/18

FIRST ANGLE PROJECTION

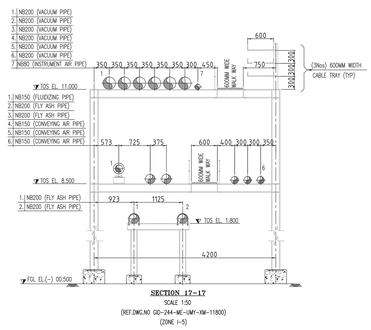
DRG NO GID-244-ME-UMY-XM-11803 SHEET NO 1 OF 1



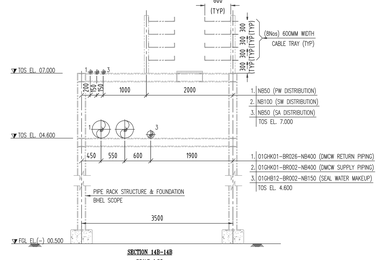
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(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE I-6)



SECTION 13B-13B
SCALE 1:50
(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE I-6)



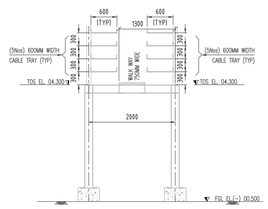
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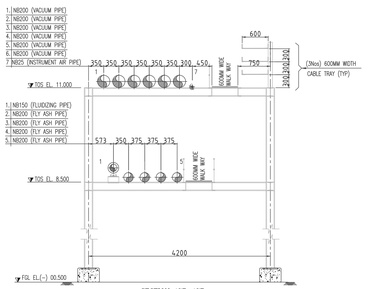
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(ZONE I-5)

NOTES:

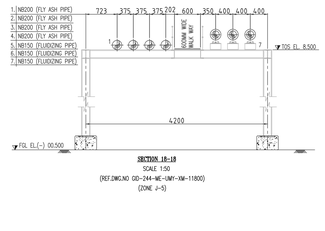
FOR GENERAL NOTES, LEGEND & REFERENCE DWGS REFER DRG. NO. GID-244-ME-UMY-XM-11800



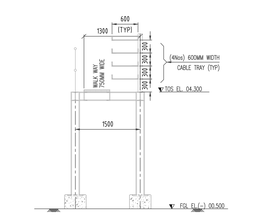
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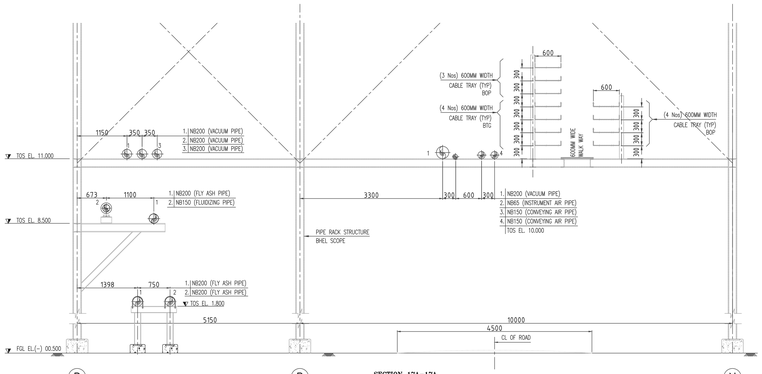
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(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE I-5)



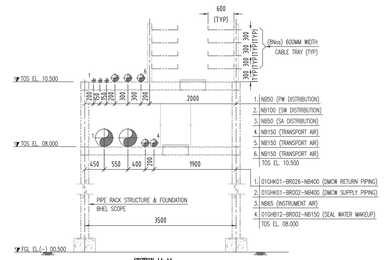
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(ZONE J-5)



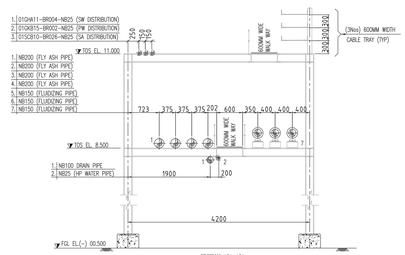
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(REF.DWG.NO GID-244-ME-UMY-XM-11800)



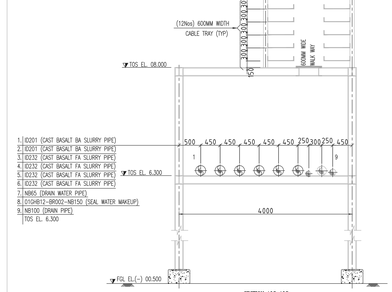
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(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE I-5)



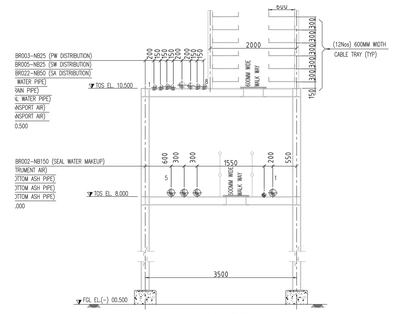
SECTION 14-14
SCALE 1:50
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(ZONE I-6)



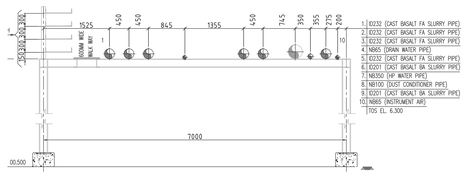
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SCALE 1:50
(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE J-5)



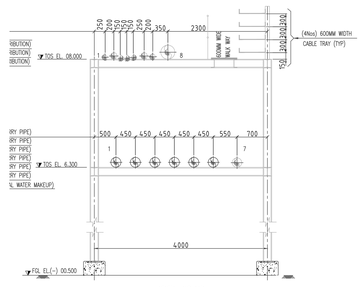
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(ZONE J-6)



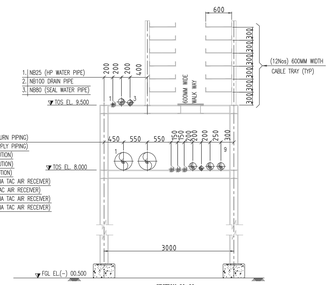
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SCALE 1:50
(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE J-6)



SECTION 19A-19A
SCALE 1:50
(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE J-6)



SECTION 19B-19B
SCALE 1:50
(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE J-6)



SECTION 20-20
SCALE 1:50
(REF.DWG.NO GID-244-ME-UMY-XM-11800)
(ZONE J-6)

ZONE	REV	DESCRIPTION	DATE	DRN.	CIVIL	MECH.	ELEC.	C&I	H.O.D.
-	3	REVISED AS PER CLIENT COMMENTS LR. NO.SE/P-II/EEB/AEE3/F.NCTPP, ST.-III (BOP)/ D.136/17 DT. 23.11.17 & GENERALLY REVISED.	05.09.18						
-	2	REVISED AS PER CLIENT COMMENTS LR. NO.SE-P-II-EEB-AEE3-F.NCTPP, ST.-III (BOP)-D.477-17 DT.27.10.17 & GENERALLY REVISED.	16.11.17	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
-	1	REVISED AS PER CLIENT COMMENTS LR. NO.SE/E/THP/EEB/AEE3/F.NCTPP,ST.-III (BOP) / D.139 / 17 DATED.19.05.2017 & GENERALLY REVISED.	21.09.17	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-
-	0	ISSUED FOR APPROVAL	18.04.17	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-	-Sd/-

REVISIONS | APPROVED

SPACE FOR STAMP

ISSUED FOR APPROVAL

DO NOT SCALE THE DRAWING | POWER PROJECTS DIVISION-CH

OWNER

TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT

1 X 800MW - NCTPP - STAGE - III
ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT

FICHTNER CONSULTING ENGINEERS(INDIA) PRIVATE LIMITED
CHENNAI - INDIA

BOP CONTRACTOR

BGR ENERGY SYSTEMS LIMITED
CHENNAI, INDIA

	NAME	SIGN.	DATE
DRN.	PKM	-Sd/-	18-04-2017
PRP.	GR	-Sd/-	18-04-2017
CHD.	DS / TYS	-Sd/-	18-04-2017
APPD.	LSS / AM	-Sd/-	18-04-2017

SHEET SIZE: AO

DEPT. | CODE | SCALE 1:1 | BOP CONTRACTOR'S DRAWING NO. GID-244-ME-UMY-XM-11803 | REV. 2.-A

TITLE: OVERALL PIPE RACK PLAN AND SECTIONS (4 OF 4)

OWNER'S DRAWING NO. -

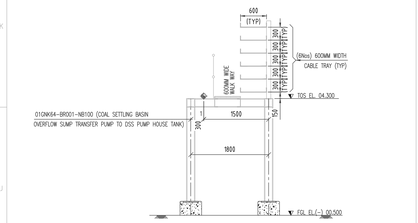
SHEET No. 1 OF 1

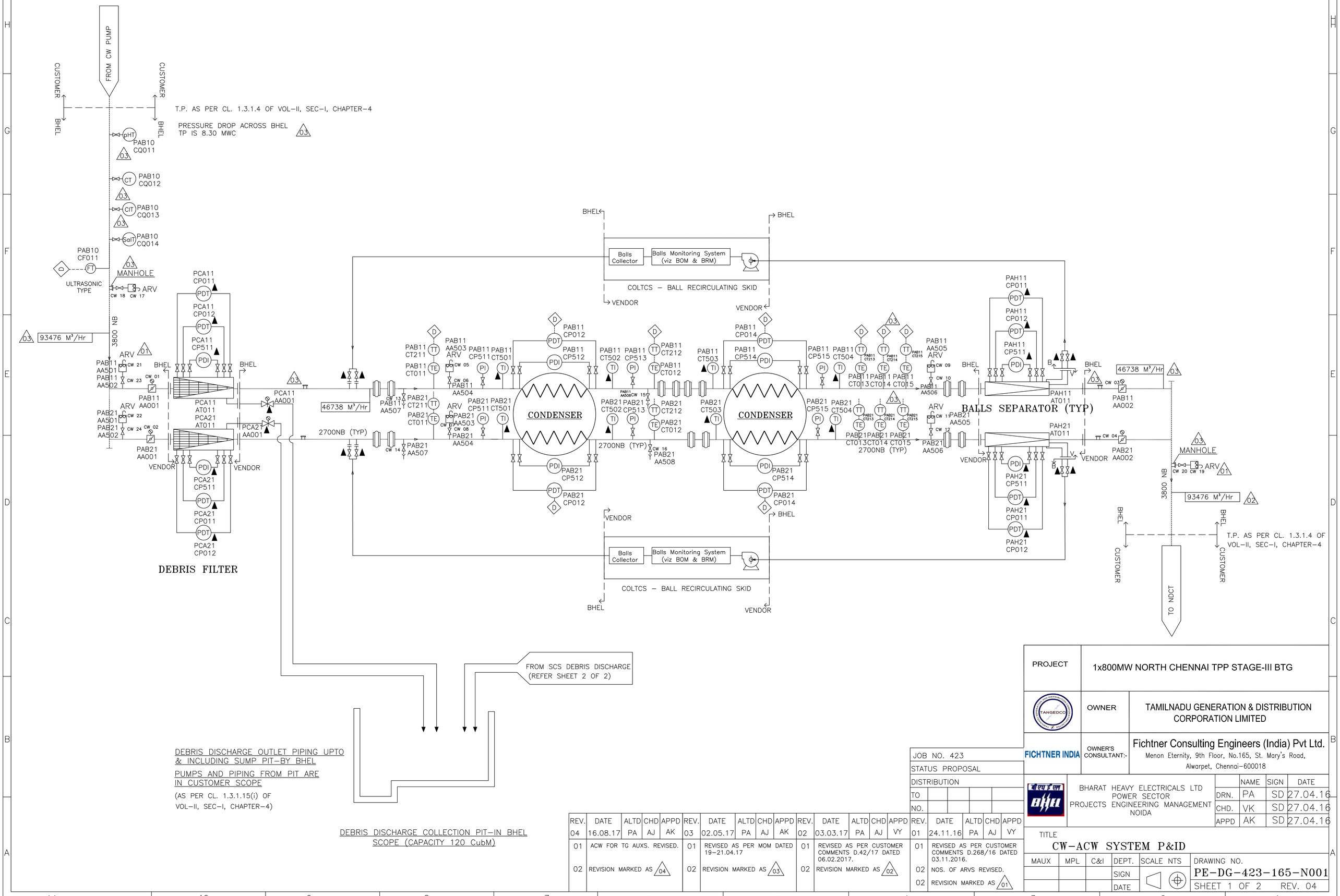
FILE NAME : GID-244-ME-UMY-XM-11803_(PIPING LAYOUT FOR SYSTEM ALL PIPE RACK PLAN SHTs 4 of 4)_(of 1)_Rev-2_250209

FIRST ANGLE PROJECTION

GID-244-ME-UMY-XM-11801

SHEET No. 1 OF 1 DWG NO.


600 (TYP)
300 300 300



REV.	DATE	ALTD	CHD	APPD
04	16.08.17	PA	AJ	AK
01	ACW FOR TG AUXS. REVISED.			
02	REVISION MARKED AS 04			

REV.	DATE	ALTD	CHD	APPD
03	02.05.17	PA	AJ	AK
01	REVISED AS PER MOM DATED 19–21.04.17			
02	REVISION MARKED AS 03			

REV.	DATE	ALTD	CHD	APPD
02	03.03.17	PA	AJ	VY
01	REVISED AS PER CUSTOMER COMMENTS D.42/17 DATED 06.02.2017.			
02	REVISION MARKED AS 02			

REV.	DATE	ALTD	CHD	APPD
01	24.11.16	PA	AJ	VY
01	REVISED AS PER CUSTOMER COMMENTS D.268/16 DATED 03.11.2016.			
02	NOS. OF ARVS REVISED.			
02	REVISION MARKED AS 01			

JOB NO. 423
STATUS PROPOSAL
DISTRIBUTION
TO
NO.

PROJECT	1x800MW NORTH CHENNAI TPP STAGE-III BTG			
OWNER	TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED			
OWNER'S CONSULTANT:-	Fichtner Consulting Engineers (India) Pvt Ltd. Menon Eternity, 9th Floor, No.165, St. Mary's Road, Alwarpet, Chennai–600018			
BHARAT HEAVY ELECTRICALS LTD POWER SECTOR PROJECTS ENGINEERING MANAGEMENT NOIDA		NAME	SIGN	DATE
	DRN.	PA	SD	27.04.16
	CHD.	VK	SD	27.04.16
	APPD	AK	SD	27.04.16

TITLE
CW–ACW SYSTEM P&ID

MAUX	MPL	C&I	DEPT.	SCALE NTS	DRAWING NO.
			SIGN		PE–DG–423–165–N001
			DATE		SHEET 1 OF 2 REV. 04

WATER-REQUIREMENTS

S.NO.	EQUIPMENT	NOS. WORK. + STANDBY	CW REQD. PER COOLER CUB.M/Hr.	CW REQD. PER UNIT CUB.M/Hr	PRESS. DROP MWC	TEMP. RISE °C	REMARKS
1	CONDENSER	2+0	46738(For each Condenser half)	93476 △01	2*2.76 △03	8.11 △03	
2	VACUUM PUMPS	2 + 2	100	400*	3.5	2	*DURING START UP BOTH PUMPS ARE WORKING
3	TG–PHE's	2+1	1626 △04	3252 △05	7.0	8.5	
4	SG–PHE's	1+1	546 △02	546 △02	7.0	6.11 △01	

NOTES:

1. CW SYSTEM DESIGN PRESSURE : 5.0 Kg/sq.cm (g), ACW SYSTEM DESIGN PRESSURE : 10.0 Kg/sq.cm (g)
   DESIGN CW INLET TEMP. TO CONDENSER & VACUUM PUMP HEAT EXCH. = 32.5 °C
   DESIGN ACW INLET TEMP. TO PHE'S = 36 °C
   DESIGN MECHANICAL TEMPERATURE : 60 °C

△02 2. MATERIALS OF CONSTRUCTION :
   A) PIPING UPTO 300Nb SHALL BE DUPLEX SS (AS PER SCH 40S FOR PIPE UPTO 50 NB & SCH 10S FOR PIPE SIZE ABOVE 50 NB).
   B) PIPING 350 NB AND ABOVE SHALL BE CARBON STEEL AS PER IS 3589 FABRICATED FROM IS 2062 PLATES INTERNALLY LINED WITH CORROCOAT OR POLYUREA COATING INSIDE OF 2000 MICRONS DFT.

3. DRAIN/VENT VALVES – △01
   – CW SYSTEM : 200 NB
   – ACW SYSTEM : 50NB FOR SIZES ABOVE 350 NB & 25 NB FOR LOWER PIPE SIZES
   DRAIN / VENT SHALL BE PROVIDED AS PER LAYOUT REQTS.

4. EXTERNAL PAINTING/PROTECTION FOR CARBON STEEL PIPE SHALL BE AS FOLLOWS:–
   4.1 OVERGROUND PIPING
   REFER PIPING CENTER DOC. NO. 7311:QPC:12 (PAINTING SCHEME FOR LP PIPING FABRICATION)

   4.2 BURIED PIPING:
   a) SURFACE CLEANIG BY SAND BLASTING.
   b) COAL TAR PRIMER COMPATIBLE WITH COAL TAR ENAMEL GRADE. THE NUMBER OF COATS SHALL BE TWO WITH A DFT OF 35 MICRONS EACH.
   c) COAL TAR ENAMEL SHALL BE APPLIED. A SINGLE SPIRAL INNER WRAP OF GLASS FIBRE TISSUES SHALL BE APPLIED OVERLAPPING AT LEAST 25 MM ENSURING IMPREGNATION OF GLASS FIBRE TISSUES IN THE FIRST COAT. THE SECOND COAT OF ENAMEL AND SECOND OUTER WRAP OF GLASS FIBRE FELT, TYPE – I TO IS: 7193–1974 WILL BE APPLIED IN THE SAME WAY CONFIRMING TO TABLE – 10 OF IS – 10221 – 1982.

   d) ALTERNATIVELY WRAPPING WITH COAL TAR BASED ANTICORROSION TAPE CONFORMING TO IS 15337:2003. THICKNESS SHALL BE 4.0 MM.

   TEST TO BE CARRIED OUT AFTER APPLICATION: BOND/ADHESION TEST, HOLIDAY TEST.

5. CATHODIC PROTECTION (SACRIFICIAL ANODE TYPE) SHALL BE PROVIDED FOR CW PIPING, WATER BOX, COLTCS & DEBRIS FILTER . △02

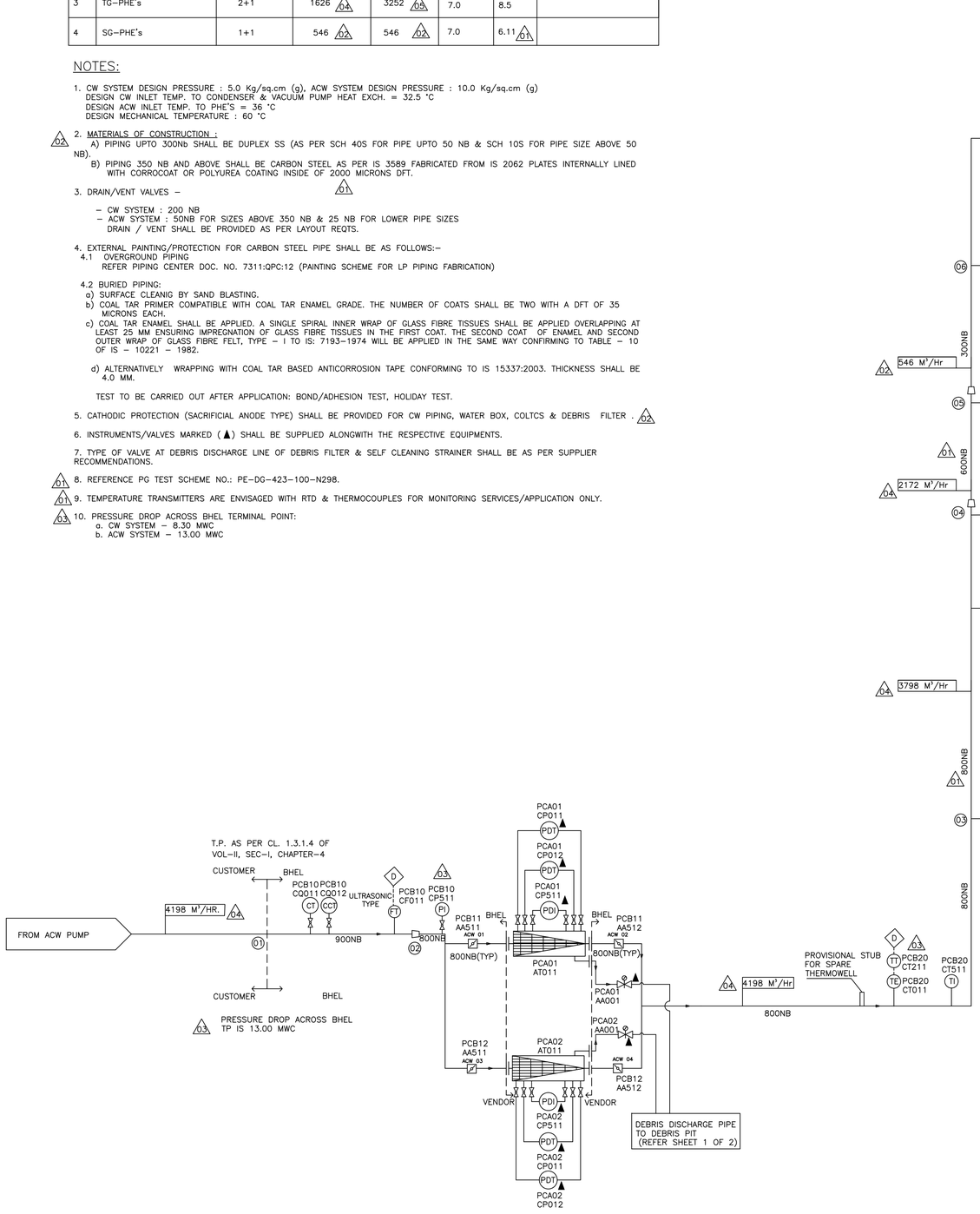
6. INSTRUMENTS/VALVES MARKED (▲) SHALL BE SUPPLIED ALONGWITH THE RESPECTIVE EQUIPMENTS.

7. TYPE OF VALVE AT DEBRIS DISCHARGE LINE OF DEBRIS FILTER & SELF CLEANING STRAINER SHALL BE AS PER SUPPLIER RECOMMENDATIONS.

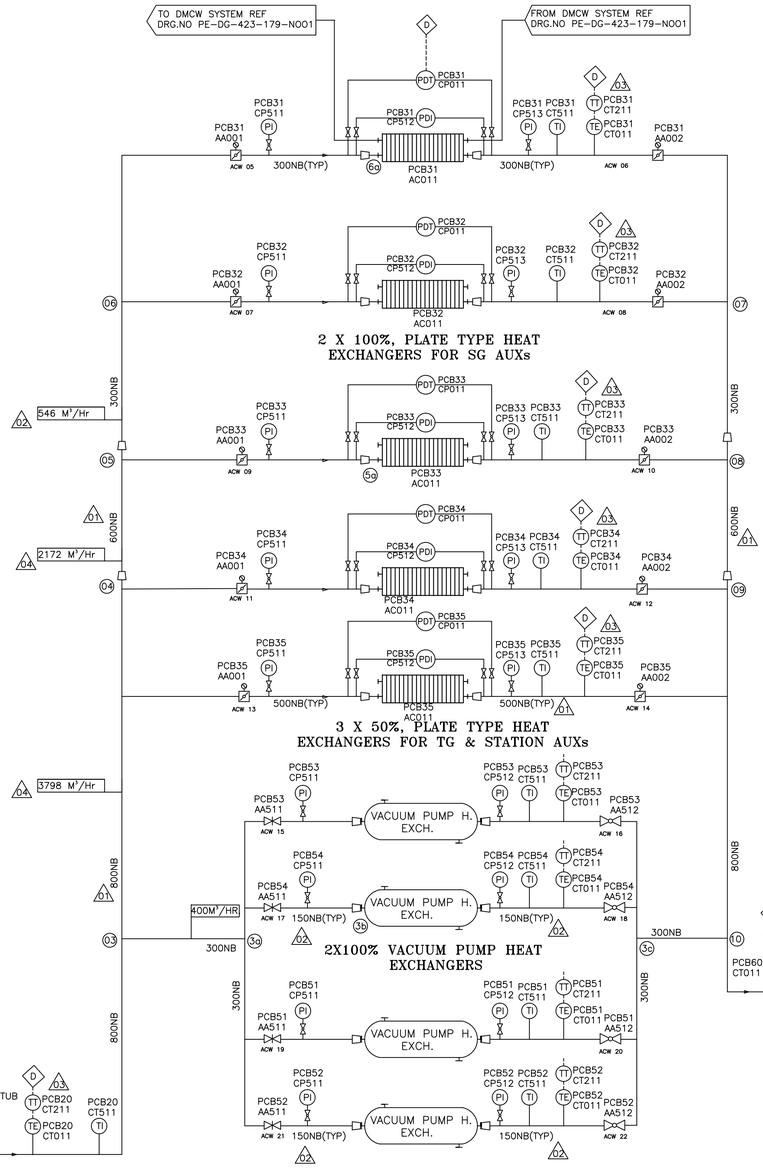
△01 8. REFERENCE PG TEST SCHEME NO.: PE–DG–423–100–N298.

△01 9. TEMPERATURE TRANSMITTERS ARE ENVISAGED WITH RTD & THERMOCOUPLES FOR MONITORING SERVICES/APPLICATION ONLY.

△03 10. PRESSURE DROP ACROSS BHEL TERMINAL POINT:
   a. CW SYSTEM – 8.30 MWC
   b. ACW SYSTEM – 13.00 MWC



2 X 100%, SELF CLEANING STRAINERS



LEGEND

- MOTOR OPERATED GATE VALVE
- MOTOR OPERATED BUTTERFLY VALVE
- MANUAL BUTTERFLY VALVE
- GLOBE VALVE
- GATE VALVE
- PI — PRESSURE GAUGE
- TI — TEMPERATURE GAUGE
- PDT — DIFFERENTIAL PRESS. TRANSMITTER
- PDI — DIFFERENTIAL PRESS. GAUGE
- PT — PRESSURE TRANSMITTER
- FT — FLOW TRANSMITTER (ULTRASONIC TYPE)
- MVN — MEAN VALUE SELECTION
- D — SIGNAL TO DDCMIS
- A — ALARM
- REDUCER/EXPANDER
- TE — TEMPERATURE ELEMENT
- R.E. JOINT (TIED TYPE)
- AIR RELEASE VALVE
- △03 MANHOLE
- △03 TT — TEMPERATURE TRANSMITTER
- △03 pHT — pH TRANSMITTER
- △03 CT — CONDUCTIVITY TRANSMITTER
- △03 CIT — CHLORIDE TRANSMITTER
- △03 SalT — SALINITY TRANSMITTER
- △03 CCT — CATION CONDUCTIVITY TRANSMITTER

PIPE SIZES OF DUPLEX SS PIPING

NB	OD	THICK.
25	33.4	3.38
40	48.3	3.68
50	60.3	3.91
65	73.0	3.05
80	88.9	3.05
100	114.3	3.05
150	168.3	3.40
△02 200	219.1	3.76
250	273.1	4.19
△02 300	323.9	4.57

PIPE SIZES OF CS PIPING

NB	OD	THICK.
350	355.6	8.0
400	406.4	8.0
450	457.0	8.0
500	508.0	8.0
600	610.0	8.0
700	711.0	10.0
△01 800	813.0	10.0
△01 900	914.0	10.0
2700	2740	20.0
3800	3840	20.0

REV.	DATE	ALTD	CHD	APPD
04	16.08.17	PA	AJ	AK
01	ACW FOR TG AUXS. REVISED.			
02	REVISION MARKED AS △04			

REV.	DATE	ALTD	CHD	APPD
03	02.05.17	PA	AJ	AK
01	REVISED AS PER MOM DATED 19–21.04.17.			
02	REVISION MARKED AS △02			

REV.	DATE	ALTD	CHD	APPD
02	03.03.17	PA	AJ	VY
01	REVISED AS PER CUSTOMER COMMENTS D.42/17 DATED 06.02.2017.			
02	MOC OF PIPING REVISED.			
03	REVISION MARKED AS △02			

REV.	DATE	ALTD	CHD	APPD
01	24.11.16	PA	AJ	VY
01	REVISED AS PER CUSTOMER COMMENTS D.268/16 DATED 03.11.2016.			
02	PIPESIZE REVISED TO 900NB FOR BURRIED ACW PIPING.			
03	REVISION MARKED AS △01			

PROJECT	1x800MW NORTH CHENNAI TPP STAGE-III BTG
OWNER	TAMILNADU GENERATION & DISTRIBUTION CORPORATION LIMITED
OWNER'S CONSULTANT:-	Fichtner Consulting Engineers (India) Pvt Ltd. Menon Eternity, 9th Floor, No.165, St. Mary's Road, Alwarpet, Chennai–600018

JOB NO. 423
STATUS: CONTRACT
DISTRIBUTION
TO
NO.

BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NOIDA

	NAME	SIGN	DATE
DRN.	PA	SD	27.04.16
CHD.	VK	SD	27.04.16
APPD	AK	SD	27.04.16

TITLE
CW–ACW SYSTEM P&ID

MAUX	MPL	C&I	DEPT.	SCALE NTS	DRAWING NO.
			SIGN		PE–DG–423–165–N001
			DATE		SHEET 2 OF 2 REV. 04

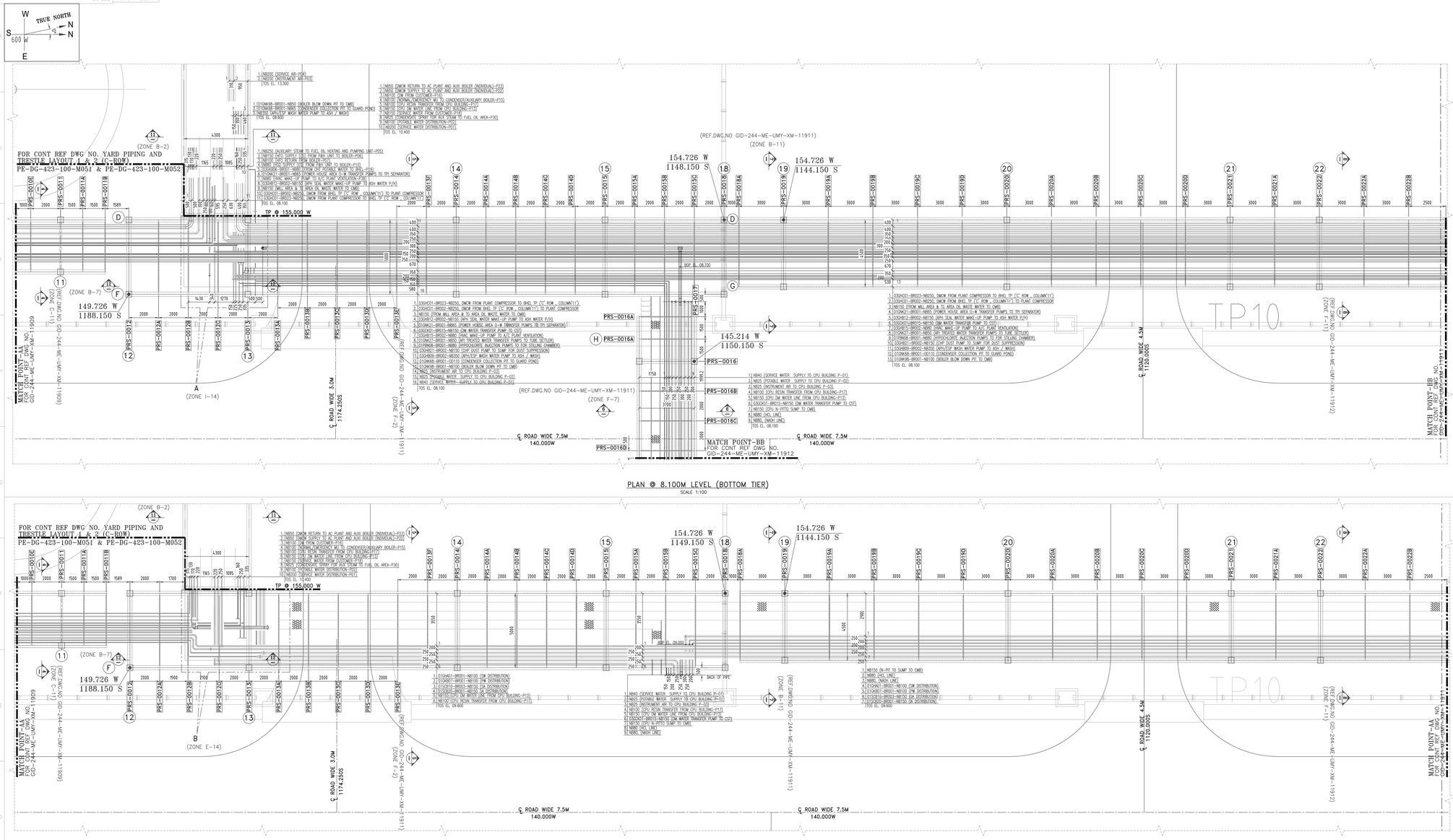
FIRST ANGLE PROJECTION

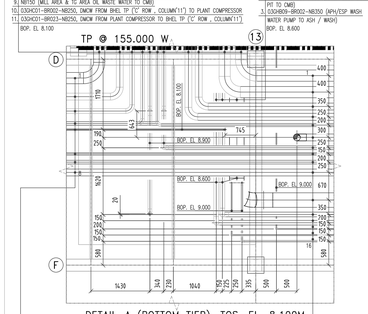
GID-244-ME-UMY-XM-11910

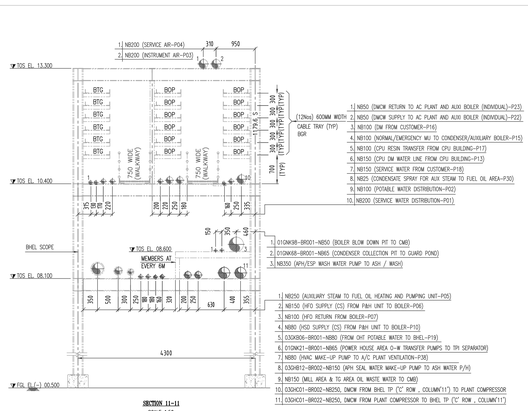
SHEET No. 1 OF 1

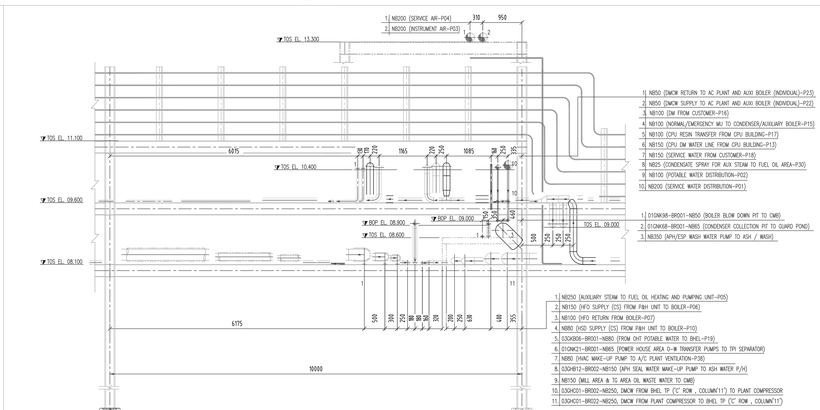
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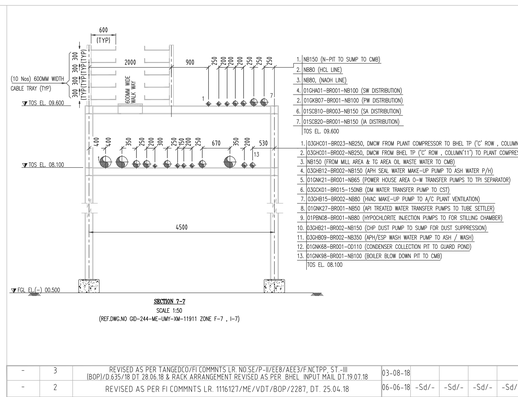
FOR GENERAL NOTES, LEGEND KEY PLAN & REFERENCE DWGS REFER GID-244-ME-UMY-XM-11909











-	3	REVISED AS PER TANGEDCO/FI COMMNTS LR NO.SE/P-II/EEB/AEE3/F.NCTPP. ST.-III (BOP)/D.635/18 DT. 28.06.18 & RACK ARRANGEMENT REVISED AS PER BHEL INPUT MAIL DT.19.07.18	03-08-18				--		
-	2	REVISED AS PER FI COMMNTS LR. 1116127/ME/VDT/BOP/2287, DT. 25.04.18	26-06-18	-Sd/-	-Sd/-	-Sd/-	-Sd/-	--	-Sd/-
-	1	REVISED AS PER FI COMMNTS LR. 1116127/ME/VDT/BOP/1585, DT. 04.01.18	10-04-18	-Sd/-	-Sd/-	-Sd/-	-Sd/-	--	-Sd/-
-	0	ISSUED FOR APPROVAL	16-11-17	-Sd/-	-Sd/-	-Sd/-	-Sd/-	--	-Sd/-
ZONE	REV	DESCRIPTION	DATE	DRN.	CIVIL	MECH.	ELEC.	C&I	H.O.D.
		REVISIONS		APPROVED					

ISSUED FOR INFORMATION

DO NOT SCALE THE DRAWING

POWER PROJECTS DIVISION-CH

OWNER

TAMIL NADU GENERATION AND DISTRIBUTION CORPORATION LIMITED

PROJECT

1 X 800MW - NCTPP - STAGE - III

ENNORE & PUZHUDHIVAKKAM VILLAGE, CHENNAI, TAMILNADU

OWNER'S CONSULTANT

FICHTNER CONSULTING ENGINEERS(INDIA) PRIVATE LIMITED

CHENNAI - INDIA

BOP CONTRACTOR

BGR ENERGY SYSTEMS LIMITED

CHENNAI, INDIA

	NAME	SIGN	DATE	SHEET SIZE
DRN.	PKM	-Sd/-	16-11-2017	A0
PRP.	GR	-Sd/-	16-11-2017	
CHD.	TYS	-Sd/-	16-11-2017	
APPD.	LSS / AM	-Sd/-	16-11-2017	

DEPT. | CODE | SCALE 1:1 | BOP CONTRACTOR'S DRAWING NO. GID-244-ME-UMY-XM-11910 | REV. 3

TITLE: DETAILED PIPING LAYOUT ON PIPE RACK BETWEEN FORWARDING PUMP HOUSE AND COMPRESSOR HOUSE [PR-01-05 SH.2 OF 4]

OWNER'S DRAWING NO. –

SHEET No. 1 OF 1

VOLUME: II B

SECTION - D

SUB-SECTION – D1

EARTHWORK IN EXCAVATION AND BACKFILLING

SPECIFICATION NO. PE-TS-457-600-C001

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.
1.00.0	SCOPE	3
2.00.00	GENERAL	3
3.00.00	EXECUTION	6
4.00.00	TESTING AND ACCEPTANCE CRITERIA	19
5.00.00	RATES AND MEASUREMENTS	19
6.00.00	INFORMATION TO BE SUBMITTED BY THE BIDDER	20

STANDARD TECHNICAL SPECIFICATION FOR EARTHWORK IN EXCAVATION AND BACKFILLING

1.0.0 SCOPE

This specification covers earth work excavation in all types of soil, soft rock and hard rock including setting out, clearing and grubbing, shoring, dewatering, back filling around foundations/pipelines to grade, watering, compaction of fills, testing, approaches, disposal of surplus earth, protective fencing, lighting etc relevant to the structures and locations covered under this contract.

2.0.0 GENERAL

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the contractor unless specified otherwise shall include but not be limited to the following.

a) Supplying and providing all labour, supervision services, earth moving machineries, surveying instruments including facilities as required under statutory labour regulations, materials, scaffolds, equipment, tools and plants, transportation, etc. required for the work.

b) Preparation and submission of working drawings showing the approaches, slopes, berms, shoring, sumps for dewatering including drainage, space for temporary stacking of soils, disposal area, fencing etc and all other details as may be required by the engineer.

c) To carry tests and submit to the Engineer, test results of fill materials and degree of soil compaction of fill whenever required by the Engineer to assess the quality of fill.

d) Design, construction and maintenance of Magazine of proper capacity for storage of explosives for blasting work and removal of the same after completion of the work etc. including procurement of necessary licenses from proper authorities.

2.2.0 Work to be provided by others

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

2.3.0 Codes and Standards

All works 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.

IS-1200	Method of measurement of building and civil engineering works, Part-I: Earthwork
IS-2720	Method of test for soils (Relevant parts)
IS-3764	Excavation work - Code of safety
IS-4081	Safety code for blasting and related drilling operations
IS-4701	Indian Standard Code of Practice for earthwork on Canals
IS:6922	Criteria for safety and design of structures subject to underground blasts
IS: 3764	Excavation work – code of safety

In case of conflict between this specification and those (IS Codes) referred to herein, the former shall prevail. In case any particular aspect of work is not covered specifically by this specification/IS Codes, any other standard practice as may be specified by the engineer shall be followed.

2.4.0 Conformity with Designs

The contractor shall carry out the work as per the approved drawings, specification and as directed by the engineer.

2.5.0 Materials

2.5.1 General

All materials required for the work shall be of the best commercial variety and approved by the engineer.

2.5.2 Material for Excavation

For the purpose of identifying the various strata encountered during the course of excavation, refer clause no. 3.4.0 for the classification of earth strata.

2.5.3 Material for Filling

Material to be used for back filling shall be free from vegetations, roots, salts, rubbish, lumps, organic matter and any other harmful chemicals etc and shall be got approved by the engineer. Normally excavated earth shall be used for back filling. In case such earth contains deleterious salts, the same shall not be used. All clods of earth shall be broken or removed. Where the excavated material is mostly rock and if filling with the same is permitted by the engineer in writing, then the filling with rock shall be done in the following

manner. The boulders shall be broken into pieces not exceeding 150mm size in any direction and mixed with fine materials consisting of decomposed rock, moorum or any approved earth to fill the voids as for as possible and the mixture shall then be used for filling.

In case the earth required for backfilling is over and above the earth available from the compulsory excavations within the project area, then borrow areas for obtaining suitable fill material shall be arranged by the contractor himself from outside the plant boundary limits and all expenses including royalties, taxes, duties etc shall be borne by him. The selected earth from the borrow areas shall be got approved by the engineer. The borrowed material shall be free from roots, vegetations, decayed organic matter, harmful salts and chemicals, free from lumps and clods etc. The contractor shall obtain and submit necessary clearances/permissions from the concerned authorities for the borrow areas/materials acquired to the engineer.

If specified, the back filling shall be done with clean well graded sand from approved quarries free from harmful and deleterious materials.

2.6.0 Quality Control

All works shall confirm to the lines, levels, grades, cross sections and dimensions shown on the approved drawings and/or as directed by the engineer. The contractor shall establish and maintain quality control for the various aspects of the work, method of construction, materials and equipments used etc. The quality control operation shall include but not be limited to the following.

Sl. No.	Activity	Check
1	Lines, levels & grades	a) By periodic surveys b) By establishing markers, boards etc
2	Back filling	(a) On quality of fill material (b) On moisture content of back fill (c) On degree of compaction achieved

2.7.0 Information regarding site conditions

Surface and Sub-surface data regarding the nature of soil, rock, sub-soil water etc. shown on drawing or otherwise furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. The Contractor must satisfy himself regarding the character and volume of all work under this contract and expected surface, sub-surface and / or sub-soil water to be encountered. He must also satisfy himself about the general conditions of site and ascertain the existing and future construction

likely to come up during the execution of the contract so that he may evolve a realistic programme of execution.

3.0.0 EXECUTION

The contractor shall prepare and submit the detailed drawings/schemes for excavation and back filling works as proposed to be executed by him showing the dimensions as per the construction drawings and specification adding his proposal of slopes, shoring, approaches, dewatering, drainage, berms etc. for the approval of engineer.

3.1.0 Setting out

On receiving the approval from the engineer with modifications and corrections if any, the contractor shall set out the work from the control points furnished by the engineer and fix permanent points and markers for ease of periodic checking as the work proceeds. These permanent points and markers shall be fixed at the interval as prescribed by the engineer and shall be got checked and certified by the engineer after whom the contractor shall proceed with the work. It should be noted that this checking by the engineer prior to the start of the work will in no way relieve the contractor of his responsibility of carrying out the work to true lines, levels and grades as per the drawings and specification. If any errors are noticed in the contractor's work at any stage, the same shall be rectified by the contractor at his own risk and cost.

3.2.0 Initial Levels

Initial levels of the ground either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross-sections for volume measurement or for cross-checking the depths obtained from tape measurements. All records of levels, measurements etc. and also any drawing, cross-section etc. made therefrom, shall be jointly signed by the authorised representative of the contractor and the Engineer before the commencement of work and they shall form the basis of all payments in future.

3.3.0 Clearing and Grubbing

The area to be excavated shall be cleared out of fences, trees, logs, stumps, bushes, vegetation, rubbish, slush etc. Trees upto 300mm girth shall be uprooted. Trees above 300mm girth to be cut shall be approved by the engineer and marked. Cutting of trees shall include removing roots as well. After the tree is cut and roots taken out, the pot holes formed shall be filled with good earth in 250mm layers and compacted unless directed otherwise by the engineer. The trees shall be cut in to suitable pieces as instructed by the

engineer. Before earthwork is started, all the spoils, unserviceable materials and rubbish shall be burnt or removed and disposed to the approved disposal area(s) as specified by the engineer. Useful materials, saleable timber, fire woods etc shall be the property of the owner and shall be stacked properly at the worksite in a manner as directed by the engineer.

3.4.0 Classification

All earthwork shall be classified under the following categories:

No distinction will be made whether the material is dry or wet.

a) **Ordinary Soil**

This shall comprise vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

b) **Hard Soil**

This shall include :
i) stiff heavy clay, hard shale, or compact moorum requiring grafting tool or pick or both and shovel, closely applied ;
ii) gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm ;
iii) soling of roads, paths, etc., and hard core ;
iv) macadam surfaces such as water bound, and bitumen/tar bound;
v) lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar, below ground level ;
vi) soft conglomerate, where the stones may be detached from the matrix with picks ; and
vii) generally any material which requires the close application of picks, or scarifiers to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) and (vi) above.

c) **Soft and Decomposed Rock**

This shall include :
i) limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with crowbars ;
ii) unreinforced cement concrete which may be broken up with crowbars or picks and stone masonry in cement mortar below ground level ;
iii) boulders which do not require blasting having maximum diameter in any direction of more than 300 mm, found lying loose on the surface or embedded

in river bed, soil, talus, slope wash and terrace material of dissimilar origin ; and
iv) any rock which in dry state may be hard, requiring blasting, but which when wet becomes soft and manageable by means other than blasting.

d) **Hard Rock (requiring blasting)**

This shall include :
i) any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required ;
ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and
iii) boulders requiring blasting.

e) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

In case of any dispute regarding classification, the decision of the Engineer shall be final.

3.5.0 Excavation for Foundations and Trenches

3.5.1 General

All excavation shall be done to the minimum dimensions as required for the safety and working facility. In each individual case, the contractor shall obtain prior approval of the engineer for the method he proposes to adopt for the excavation including dimensions, side slopes, shoring, dewatering, drainage and disposal etc. This approval however shall not in any way make the engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. All excavation in open cuts shall be made true to the line, slopes and grades as shown on the drawings and/or as directed by the engineer. No material shall project within the dimension of minimum excavation lines marked. Boulders (if any) projecting out of the excavated surfaces shall be removed if they are likely to be a hindrance to the work/workers in the opinion of the engineer.

Method of excavation shall in every case be subject to the approval of the engineer. The contractor shall ensure the stability and safety of the excavation, adjacent structures, services and works etc including the safety of the workmen. If any slip occurs, the contractor shall remove all the slipped materials from the excavated pit without any extra cost to the engineer/owner. All loose boulders and semi detached rocks which are not inside but so close to the area to be excavated and may liable to fall or otherwise endanger the

workmen, equipment of the work etc during excavation in the opinion of the engineer shall be stripped off and removed away from the area of excavation. The method to be used for removal shall be such that it should not shatter or render unstable or unsafe the portion which was originally sound and safe. In case any material not required to be removed initially but later to become loose or unstable in the opinion of the engineer shall also be promptly and satisfactorily removed.

The rough excavation may be carried out upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the engineer. If the excavation (in all types of soil and rock) is done to a depth greater than that shown on the drawing or as directed by the engineer, the excess depth up to the required level shall be filled with cement concrete not leaner than 1:4:8 or richer as directed by the engineer at the own risk and cost of the contractor. In case where excavation in soil, soft rock (including weathered rock) and hard rock are involved, the excavation in each stratum shall be carried out separately with the approved methodology and as per the instructions of the engineer.

All excavated materials such as rock, boulders, bricks, dismantled concrete blocks etc shall be the property of the owner and shall be stacked separately as directed by the engineer. All gold, silver, oil, minerals, archeological 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 upon the site shall be the property of the owner and the contractor shall duly preserve the same to the satisfaction of the engineer/owner. The contractor shall deliver the same to such person or persons as may be authorized or appointed from time to time by the owner to receive the same.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the engineer.

3.5.2 Excavation in All Type of Soil and in Soft Rock

The excavation in all type of soil, soft rock including decomposed rock etc shall be carried out as per the approved proposal and as directed by the engineer. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to any other activities in the area. Foundation pits shall not be excavated to the full depth unless construction is imminent. The last 150mm depth shall be excavated once concreting work is imminent. At the discretion of the engineer, the full depth may be excavated and the bed be covered with lean concrete as specified after watering and compacting the bed. As the excavation reaches the required dimensions, lines, levels and grades

etc, the work shall be got checked and approved by the engineer. In cases where deterioration of the ground, upheaval, slips etc are expected, the engineer may order to suspend the work at any stage and instruct the contractor to carry out the protection works before the excavation will be restarted.

3.5.3 Excavation in Hard Rock

Hard rocks shall normally be excavated by means of blasting. In case where blasting is prohibited for any reasons, the excavation shall be carried out by chiselling or any other approved method as directed by the engineer. Personnel deployed for rock excavation shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is not stable against sliding, necessary supports such as props, bracings or bulkheads shall be provided and maintained during the period of construction. Where the danger of falling loose rock/boulder from the excavated surfaces deeper than 2m exist, steel mesh anchored to the lower edge of the excavation and extending over and above the rock face adequate to retain the dislodged material shall be provided and maintained.

3.5.4 Blasting

Storage, handing and use of explosives shall be governed by the current explosive rules/regulations laid down by the Central and the State Governments. The contractor shall ensure that these rules/regulations are strictly adhere to. The following instructions are also to be strictly followed and the instructions wherever found in variance with the above said rules/regulations, the former (instructions) shall be superseded with the later (above said rules/regulations).

No child under the age of 16 and no person who is in a state of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives. The contractor shall obtain licence from the District Authorities for undertaking the blasting work as well as for obtaining and storing the explosives as per Explosives Rules, 1940 corrected upto date. The contractor shall purchase the explosives, fuses, detonators etc only from a licensed dealer and shall be responsible for the safe custody and proper accounting of the explosive materials. The engineer or his authorized representative shall have the access to check the contractor's store of explosives and his accounts at any time. It is the full responsibility of the contractor to transport the explosives as and when required for the work in a safe manner to the work spot.

Further, the engineer may issue modifications, alterations and new instructions to the contractor from time to time. The contractor shall comply with the same without these being made a cause for any extra claim.

3.5.4.1 Materials

All materials such as explosives, detonators, fuses, tamping materials etc proposed to be used in the blasting operation shall have the prior approval of the engineer. Only explosives of approved make and strength are to be used. The fuses known as instantaneous fuse must not be used. The issue of fuse with only one protective coat is prohibited. The fuse shall be sufficiently water resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and shall be not less than 4 seconds per inch of length with 10% tolerance on either side. Before use, the fuse shall be inspected. Moist, damaged or broken ones shall be discarded. When the fuses are in stock for long, the rate of burning of fuses shall be tested before use. The detonators shall be capable of giving an effective blasting of the explosives. Moist and damaged detonators shall be discarded.

3.5.4.2 Storage of Explosives

The current Explosive Rules shall govern the storage of explosives. Explosives shall be stored in a clean, dry and well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400m of the actual work site or any source of fire. The space surrounding the magazine shall be fenced and the ground inside shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be through a single gate only and no person shall be allowed without the permission of the officer-in-charge. The clear space between the fence and the magazine shall not be less than 90m. The magazine shall be well drained. Two lightning conductors, one at each end shall be provided to the magazine. The lightning conductors shall be tested once in every year.

Explosives, fuses and detonators shall each be separately stored. Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides. Special care shall be taken to keep the floor free from any grains of explosives. Cases containing explosives shall not be opened inside the magazine and the explosives in open cases shall not be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine but must be removed without delay to a safe distance and be destroyed.

Artificial light, matches, inflammable materials, oily cotton, rag waste and articles liable to spontaneous ignition shall not be allowed inside the magazine. Illumination shall be obtained from an electric storage battery lantern. No smoking shall be allowed within 100m distance from any magazine.

Magazine shoes without nails shall be used while entering the magazine. The persons entering the magazine must put on the magazine shoes which shall be

provided at the magazine for this purpose and should be careful

* not to put their feet on the clean floor unless the magazine shoes on.

* not to touch the magazine shoes on ground outside the clean floor.

* not to allow any dirt or grit to fall on the clean floor.

Persons with bare feet shall dip their feet in water before entering the magazine and then step directly from the tub to the clean floor. No person having article of steel or iron with/on him shall be allowed to enter the magazine. Workmen shall be examined before entering the magazine to check none of the prohibited articles are with them. A brush broom shall be kept in the lobby of the magazine for cleaning the magazine. Cleaning shall be done immediately after each occasion whenever the magazine is opened for receipt, delivery or inspection of the explosives.

The mallets, levers, wedges etc for opening the barrels or cases shall be of wood. The cases of explosives are to be carried by hand and shall not be rolled or dragged inside the magazine. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been stored long in the store are to be issued first. Neither the magazine shall be opened nor any person shall be allowed in the vicinity of the magazine during any dust storm or thunderstorm. All magazines shall be officially inspected at definite intervals and a record of such inspections shall be kept.

3.5.4.3 Carriage of Explosives

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from direct rays of the sun, artificial lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each case or package shall be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on the vehicle conveying explosives. No explosive shall be transported in a carriage or vessel unless all iron or steel therein the carriage or vessel which are likely to contact the package containing explosives are effectually covered with lead, leather, wood, cloth or any other suitable material. No light shall be carried on the vehicle carrying explosives and no operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

3.5.4.4 Use of Explosives

The contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with his

responsibilities.

Holes for charging the explosives shall be drilled with pneumatic drills and the drilling pattern shall be so planned that the rock pieces after blasting will be suitable for handling. The hole diameter shall be of such a size that the cartridges can easily pass down through them and any undue force is not required during charging. Charging operation shall be carried out by or under the personal supervision of the shot firer. Wrappings shall never be removed from the explosive cartridges. Only one cartridge at a time shall be inserted in a hole and wooden rods shall only be used for loading and stemming the shot holes. Only such quantities of explosives as are required for a particular work shall be brought to the work site. Should any surplus remain when all the holes have been charged shall be carefully removed to a point at least 300m away from the firing point.

The authorized shot firer himself shall make all the connections. The shot firing cable shall not be dragged along the ground to avoid any damage to the insulation. The shot firing cable shall be tested each time for its continuity and possible short circuiting. The shot firer shall always carry the exploder handle with him until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits. Before any blasting is carried out it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300m radius from the firing point or as required by the statutory regulations at least 10 minutes before the time of firing by sounding a warning siren and the area shall be encircled by red flags.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges, the electric detonators shall be connected with the exploder through the shot firing cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current etc and keep the lead wires short circuited until it is ready to fire. Any kink in the detonator leading wire shall be avoided. For simultaneous firing of a large number of shot holes, use of cordtex may be done. An electric detonator attached to its side with adhesive tape shall initiate cordtex connecting wire or string. Blasting shall only be carried out at certain specified times to be agreed jointly by the contractor and the engineer.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations, the authorized shot firer shall return to the blast area and inspect carefully the work and satisfy himself that all the charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole at a distance of not less than 600mm from the misfired hole and by exploding a new charge. The authorized shot firer shall be present during the removal of debris as it may contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

Where blasting is to be carried out in proximity of other structures, controlled blasting by drilling shallow shot holes and proper muffling arrangements with steel plates loaded with sand bags etc shall be used on top of the blast holes to prevent the rock fragments from causing any damage to the adjacent structures and other properties. Adequate safety precautions as per building byelaws, safety codes, statutory regulations etc shall be taken during blasting operations.

3.5.4.5 Restrictions in Blasting

a) Blasting which may disturb or endanger the stability, safety or quality of the adjacent structures/foundations shall not be permitted.
b) Blasting within 200m of a permanent structure or construction work in progress shall not be permitted.
c) Progressive blasting shall be limited to two third of the total remaining depth of excavation.
d) No large scale blasting operations will be resorted to when the excavation reaches the last one metre and only small charge preferably black powder may be allowed so as not to shatter the parent rock.
e) The last blast shall not be more than 0.50 m in depth.
f) In rocky formations, at locations where specifically indicated or ordered in writing by the engineer, the use of explosives shall be discontinued and excavation shall be completed by chiselling or any other suitable method as approved by the engineer.

3.5.5 Disposal

The excavated spoils shall be disposed of in any (or all) of the following manner as directed by the engineer.

a) By using it straightway for backfilling.

b) By stacking it temporarily to use for backfilling at a later date during execution of the contract.

c) i) By either spreading
or
ii) By spreading and compacting at designated disposal areas.

a) By selecting the useful material and stacking it neatly in designated areas as indicated by the engineer for use in backfilling by some other agency.

3.5.6 Disposal of Surplus Materials

All surplus material from excavation shall be removed and disposed of from the excavation site to the designated disposal area indicated by the engineer.

All good and sound rocks obtained from excavations and all assorted materials of dismantled structures are the property of the owner and if the contractor wants to use it, he shall have to obtain it from the engineer at a mutually agreed rate. All sound rocks and other assorted materials like excavated bricks etc shall be stacked separately.

3.5.7 Protection

The contractor shall notify the engineer as soon as the excavation is expected to be completed within a day so that he shall inspect it at the earliest. Immediately after approval of the engineer, the excavation must be covered up in a shortest possible time. But in no case the excavation shall be covered up or worked on before approval by the engineer. Excavated material shall be placed 1.5m or half the depth (of excavation) whichever is more from the edge of the excavation or further away if directed by the engineer. Excavation shall not be carried out below the foundation level of the structure close by until the required precautions are taken. Adequate fencing is to be made enclosing the excavation. The contractor shall protect all the underground services exposed during excavation. All existing surface drains in the work area shall be suitably diverted by the contractor before taking up excavation to maintain the working area neat and clean.

3.5.8 Dealing with Surface Water

All working areas shall be kept free of surface water as far as reasonably praticable. Works in the vicinity of cut areas shall be controlled to prevent the ingress of surface water.

No works shall commence until surface water streams have been properly intercepted , redirected or otherwise dealt with.

Where works are undertaken in the monsoon period, the Contractor may need to construct temporary drainage systems to drain surface water from working areas.

3.5.9 Dewatering

All excavation shall be kept free of water and slush. Grading in the vicinity shall be controlled to prevent the surface water running into the excavations. The contractor shall remove any water inclusive of rain water and subsoil water etc accumulated in the excavation by pumping or other means as approved by the engineer and keep the excavations dewatered and/or lower the subsoil water level to 300mm below the founding level until the construction of foundation and backfilling are completed in all respects.

Sumps made for dewatering must be kept clear of the foundations. The engineer’s prior approval on the method of pumping to be adopted shall be

taken; but in any case, the pumping arrangement shall be such that there shall be no movement or blowing in of subsoil due to the differential head of water during pumping.

3.5.10 Timber Shoring

Close or open type timber shoring as approved by the engineer depending on the nature of sub-soil, depth of pit or trench and the type of timbering shall be adopted. Timbers made out of approved quality shall only be used. It shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches and pits from collapsing.

3.5.10.1 Close Timbering

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called "polling boards". These shall be of 250mm wide(min.) and 40mm thick(min.) sections as directed by the engineer. The boards shall generally be placed vertically in pairs, one on each side of the cut and shall be kept apart (maximum spacing is limited to 1.20m) by horizontal walers of strong wood cross strutted with wooden struts or as directed by the engineer. The length of wooden struts shall depend on the width of the trench or pit.

In case where the soil is very soft and loose, the boards shall be placed horizontally against the sides of excavation and supported by vertical walers which shall be strutted to similar timber pieces on the opposite face of the trench or pit. The lowest board supporting the sides shall be taken into the ground. No portion of the vertical side of the trench or pit shall remain exposed to avoid any slipping out of earth.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started from one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

3.5.10.2 Open Timbering

In case of open timbering, vertical board of 250mm wide(min.) and 40mm thick(min.) shall be spaced sufficiently apart to leave unsupported strips of maximum 500mm average width. The detailed arrangement, size of timber and the spacing etc shall be subjected to the approval of the engineer. In all other respects, the specification for close timbering shall apply to open timbering as well.

3.6.0 Treatment of Slips

The contractor shall take all precautions to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides of the excavations. These precautions along with proper slopes, berms, shoring and control of ground water should cause no slips to occur. If however slips still occur, the same shall be removed by the contractor with his own risk and cost.

3.7.0 Backfilling

3.7.1 General

The material to be used for backfilling shall be approved by the engineer which shall be obtained directly from the excavation, from the nearby areas where excavation work by the same agency is in progress, from the temporary stacks of excavated spoils or from the borrow pits as directed by the engineer. The material shall be free from lumps and clods, roots and vegetations, harmful salts and chemicals, organic materials etc.

In locations where sand filling is required, the sand used should be clean, well graded and be of the quality normally acceptable for use in concrete.

3.7.2 Filling and Compaction in Pits and Trenches all Around the Structures

As soon as the work in foundation has been accepted, the spaces around the foundation in pits and trenches shall be cleared of all debris, brick bats, mortar droppings etc and filled with approved earth in layers not exceeding 250mm (in loose thickness). Each layer(loose) shall be watered, rammed and properly compacted to the required degree to the satisfaction of the engineer. Earth shall be compacted with approved mechanized compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the engineer. The moisture content of the fill material during compaction shall be controlled near to its optimum moisture content so as to obtain the required degree of compaction. The final surface shall be trimmed and levelled to proper profile as desired by the engineer.

3.7.3 Plinth Filling

The plinth shall be filled with earth in layers not exceeding 250mm (in loose thickness) and each layer shall be watered and compacted to the required degree with approved compaction machine or manually if specifically permitted by the engineer. When the filling reaches the finished level, the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and compacted in order to avoid any settlement at a later stage. The finished surface of fill shall be trimmed to the slope intended to be provided for the floor.

3.7.4 Filling in Trenches for Water Pipes and Drains

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes in layers not exceeding 150mm, watered, rammed and compacted taking care that no damage is caused to the pipe below.

In case of trenches excavated in rock, the filling upto a height of 300mm or the diameter of the pipe whichever is more above the crown of the pipe or barrel shall be done with fine material such as earth, moorum, disintegrated rock or ash as per the availability at site and shall be filled in compacted layers not exceeding 150mm. The remaining filling shall be done in layers with the mixture of boulders (of size not exceeding 150mm) and fine material as specified elsewhere in the specification. Each layer shall be watered, rammed and compacted to the required degree and to the satisfaction of the engineer.

3.7.5 Filling in Disposal Area

Surplus materials from excavation which are not required for backfilling shall be disposed of in the designated disposal areas. The spoils shall not be dumped haphazardly but should be spread in layers approximately 250mm thick when loose, watered and compacted with the help of a compacting equipment as per the directions of the engineer. In wide areas, rollers shall be employed and compaction shall be done to the satisfaction of the engineer at the optimum moisture content which shall be checked and controlled by the contractor. In certain cases the engineer may direct the contractor to dispose the surplus materials without compaction which can be done by tipping the spoils from a high bench neatly maintaining a proper level and grade of the bench.

3.8.0 Approaches and Fencing

The contractor should provide and maintain proper approaches for the workmen and inspection. The roads and approaches around the excavation should be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as around the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress.

3.9.0 Lighting

Full scale area lighting is to be provided if night work is permitted or directed by the engineer. If no night work is in progress, red warning lights should be provided at the corners of the excavated pit and the edges of the fill.

4.0.0 TESTING AND ACCEPTANCE CRITERIA

4.1.0 Excavation

On completion of excavation, the dimension of the pits will be checked as per the drawings after the pits are completely dewatered. The work will be accepted after all undercuts have been set right and all over excavations are filled back to the required lines, levels and grades by placing ordinary cement concrete of 1:4:8 proportion and/or richer and/or by compacted earth as directed by the engineer. The choice of the grade of concrete will be a matter of unfettered discretion of the engineer. Over excavation of the sides shall be made good by the contractor while carrying out the backfilling. The excavation work will be accepted after the above requirements are fulfilled and all the temporary approaches encroaching inside the excavation have been removed.

4.2.0 Backfilling

The degree of compaction required will be as per the stipulation laid down in IS: 4701 and the actual method of measuring the degree of compaction will be as decided by the engineer. The work of back filling will be accepted after the engineer is satisfied with the degree of compaction achieved.

5.0.0 RATES AND MEASUREMENTS

5.1.0 Rates

a) The item of work in the schedule of quantities describe the work very briefly. The various items of the schedule of quantities shall be read in conjunction with the corresponding section in the technical specification including amendments and additions if any. For each item in the schedule of quantities, the bidder's rate shall include all the activities covered in the description of the items as well as for all necessary operations in detail as described in the technical specification.

b) No claims shall be entertained if the details shown on the released for construction drawings differ in any way from those shown on the tender drawings.

c) The unit rate quoted shall include minor details which are obviously and fairly intended and which may not have been included in these documents but are essential for the satisfactory completion of the work.

d) The bidder's quoted rate shall be inclusive of supplying and providing all labour, men, materials, equipments, tools and plants, supervision, services, approaches, schemes etc.

e) In case blasting in hard rock is envisaged, the unit rate quoted for earth work shall include the cost of storage and safety arrangements for the materials required for blasting. No separate payment will be made on this account.

5.2.0 Measurements

Method of measurement are specified in the proceeding sections. Where not so specified, the latest version of IS: 1200, Part-1 shall be applicable.

~~Method of measurements are specified as below:~~

a) The length, breadth and depth shall be measured correct to the nearest centimeter if measurements are taken by tape. Rounding of numerical shall be as per relevant IS Codes. If the measurements are taken with staff and level, the levels shall be recorded correct to 5mm. The area and volume shall be worked out in square meter and cubic meter respectively correct to the nearest of two decimal places.

b) For earth work in excavation, the ground levels shall be taken before and after completion of the work in the actually excavated area. The quantity of earth work in excavation shall be computed from these levels in cubic meter.

~~c) In case of open footings (rafts/ pilecaps/ drains/ cable trench/ pipe trench/ sub soil beams etc.) up to the depth of 2.0 metres from ground level, alround excavation of 30 cm beyond the outer dimension of footing (not the PCC dimension below footing) shall be measured for payment to make allowances for centering and shuttering. Any additional/excess excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment for item of work on excavation, backfilling, carriage, dewatering etc. Required shoring & strutting, side slopes, benching, dewatering sump pits, approaches to the excavated pit etc. are deemed to be included in the quoted rates in the schedule of quantities.~~

~~d) In case of open footings (Rafts/ pilecaps / drains/ cable trench/ pipe trench/ sub soil beams etc.) at a depth of more than 2.0 metre from ground level, alround excavation of 75 cm beyond the outer dimension of footing (not the PCC dimension below footing) shall be measured for payment to make allowances for centering and shuttering. Any additional/excess excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment for item of work on excavation, backfilling, carriage, dewatering etc. Required shoring & strutting, side slopes, benching, dewatering sump pits, approaches to the excavated pit etc. are deemed to be included in the quoted rates in the schedule of quantities.~~

e) Where soft rock and hard rock are mixed, the measurement shall be done as follows. The two types of rock shall be stacked separately and measured in stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in the stacks. If the sum of net quantity of the two types of rock so arrived exceeds the total quantity of excavation, then the quantity of each type of rock shall be worked out from the total quantity (from excavation) in the ratio of net quantities in stack measurements of the two types of rock. If stacking is not feasible, the method as suggested by the engineer shall be followed.

f) Where soil, soft rock and hard rock are mixed, the measurement shall be done as follows. The soft and hard rock shall be removed from the excavated material and stacked separately and measured in stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in stacks. The difference between the entire excavation and the sum of the quantities of soft and hard rock so arrived shall be taken as soil.

~~**g) The authorized quantity (calculated on the basis of authorized width/ working space under clause no. 5.2.0 c & 5.2.0 d) or those actually excavated, whichever, are less, shall be measured for payment.**~~

h) Tree cutting having girth more than 300mm shall be measured in number and are separately payable as deemed not covered in excavation items of work in the schedule of quantities.

i) Measurement for earth work excavation using Well point dewatering

Measurement shall be taken of the quantity of earth work excavation below ground water table observed at site just prior to start the dewatering but after installation of well point dewatering system. Ground water table shall be jointly observed and finalized by BHEL site and contractor.

6.0.0 INFORMATION TO BE SUBMITTED BY THE BIDDER

6.1.0 With Tender

Detail of equipment and machineries proposed to be used for excavation, back-filling and compaction shall be submitted along with the tender.

6.2.0 After Award

After award of the contract the successful bidder shall submit the following for approval.

a) Within 30 days of the award of contract, the contractor shall submit a detailed programme of the work as proposed to be executed giving completion

dates of excavation for the various foundations and the time required for backfilling and compaction after completion of foundation for the structures. The earthwork programme shall be planned in accordance with the foundation programme. The programme should also show how the excavation and backfilling quantities will be balanced minimizing the temporary stacking of spoils. It is to be noted that the engineer even after initial approval of the programme may instruct the contractor to enhance or to retard the progress of work during the actual execution in order to match with the progress of foundations. The initial programme being submitted by the contractor should have sufficient flexibility to take care of such reasonable variations.

b) Within 15 days of the award of contract, the contractor shall submit the drawings for earth work in excavation and backfilling showing detail of slopes, shoring, approaches, sump pits, dewatering lines, fencing etc for the approval of the engineer.

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.
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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 – D3

CARPENTRY AND JOINERY

SPECIFICATION NO. PE-TS-999-600-C003

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	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	5
4.00.00	I.S. CODES	6
5.00.00	RATES AND MEASUREMENTS	6

CARPENTRY AND JOINERY

1.00.00 SCOPE

This section covers supply, fitting and fixing of timber frames to doors and windows with M S holdfasts, flush doors, windows, shutters, partitions, wall panelling, pelmets, shelves, furniture, etc. as shown in drawings, including a prime coat of approved paint, varnish, or fixing of decorative plastic laminate where called for. This shall also include the supply and fixing of all hardware and fixtures shown in drawing or specified.

2.00.00 INSTALLATION

2.00.01 Materials

a) Timber

Unless otherwise specified, all timber shall be best quality well seasoned CP teakwood free from large or loose knots, cracks or any other defects. All timber shall be treated with approved wood preservative before use, unless specified otherwise. The rough timber shall be approved by the Engineer before incorporating in the works and starting the carpenter's work.

b) Plywood

Plywood shall be of commercial quality or with decorative surface veneer. Unless specifically permitted otherwise, the adhesive used in plywood shall be phenol formaldehyde synthetic resin of BWP grade conforming to IS: 848.

c) Decorative Laminated Plastic Sheets

The colour, pattern, finish and texture shall be approved by the Engineer. The bulk supply shall be procured in full sheet sizes which will ensure the least number or joints in one surface.

d) Flush Doors

Flush doors shall be solid core doors with commercial or decorative faces and hardwood edges conforming to IS: 2202 (Part-1). The core for solid core doors shall be of block board or wood particle board. Manufacturer's literature and test certificates shall be submitted for the approval of the Engineer. The Contractor shall give a guarantee that the adhesive used is BWP grade phenol formaldehyde synthetic resin conforming to IS: 848. The thickness shall be as specified.

e) Panel Doors

Panel door shall be of teakwood shutter frame, unless otherwise noted and panels with teakwood/commercial ply/teakwood particle board. Other considerations shall be as mentioned in item (d) above.

f) Windows, Ventilators

Windows and ventilators shall made of teakwood shutter frame, unless specified otherwise and glazing of specified thickness shall be fixed with wooden beadings.

g) Fixtures

Fixtures for doors, windows, furniture etc. shall be as shown on drawing or specified.

2.02.00 Workmanship

2.02.01 General

The work shall be done by skilled carpenters as per details shown on drawing or instructed by the Engineer.

Framing timber and other work shall be close - fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc., which will come in contact with masonry after fixing, shall be given two coats of approved paint before fixing. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood, which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood and particle board. The edge of all plywood, blackboard and particle board shall be finished with teakwood lipping unless otherwise shown on drawings.

Fixing to frames and partitions shall generally be with 40 mm x 6 mm x 300 mm long M S holdfasts bifurcated at end and grouted with 1:2:4 cement concrete. The gap between masonry and external door and window frame shall be caulked with polysulphide mastic. M.S. grills or guard bars shall be provided to windows where called for in the drawings.

2.02.02 Finish

All carpentry work after finishing shall be sand papered smooth. A prime coat paint shall be given after inspection of the Engineer to all surfaces other than those, which shall be subsequently polished or covered with laminated plastic sheet.

2.02.03 Surface Treatment

When shown on drawings or called for, decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of brand and brought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instructions. The edge of sheets shall be protected by teak lipping or bevelled as shown on drawings.

3.00.00 ACCEPTANCE CRITERIA

3.00.01 Door and Window Frames

All frames shall be square and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

3.02.00 Door and Window Shutters

All doors and window shutters shall be of proper size, shape, and design and free of warp. When fixed to frames, these shall operate smoothly without jamming and all latching or locking devices shall engage properly without undue pressure.

3.03.00 Partitions, Paneling, Pelmets, Furniture, etc.

3.03.01 General

These shall conform to drawings in all details. No unsightly nail marks etc. shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

3.03.02 Partition

Shall be checked for rigidity of fixing, plumb and horizontal as well as vertical alignment.

3.03.03 Pelmets

Shall be checked for rigidity of fixing and adequate clearance of fixture.

3.03.04 Cupboard Shutters

Shall operate smoothly without jamming and locks, bolts and double ball catches shall engage securely. Single ball catches shall not be used.

3.03.05 Drawers

Shall operate smoothly and have backstops to prevent them from being pushed too far. Locks shall engage securely.

3.03.06 Loose Furniture

When placed on a level surface, tables tops etc. shall be horizontal and the pieces stand stably on legs or supports.

4.00.00 IS CODES

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: 848	-	Synthetic resin adhesives for plywood (Phenolic and Aminoplastic)
IS: 1003	-	Timber panelled and glazed shutters.
IS: 2191	-	Wooden flush door shutter (Cellular and hollow core type).
IS: 2202	-	Wooden flush door shutters (solid core type).
IS: 4021	-	Timber door, window, and ventilator frames.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall include of all activities mentioned in “Schedule of Item” for completion of the work. No separate payment shall be made for fixing, caulking, application of primer coat, polishing, providing of butt hinges,

holdfasts, sliding/tower bolts, door stoppers, door closers and other fittings and fixtures.

5.02.00 Measurement

Measurement shall be done in Sqm for doors, windows, ventilators, shutters, partitions etc.

Measurement for wooden frame shall be in CuM.

Pelmets shall be measured in RM.

VOLUME: II B

SECTION – D

SUB-SECTION – D4

ROOF AND UNDERGROUND STRUCTURES WATER PROOFING, INSULATION AND ALLIED WORKS

SPECIFICATION NO. PE-TS-999-600-C004

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	INSTALLATION	3
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ROOF AND UNDERGROUND WATER PROOFING, INSULATION AND ALLIED WORKS

1.00.00 SCOPE

This section covers furnishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of roof and underground water-proofing, insulation and allied works for buildings and at locations covered under the scope of this package.

2.00.00 INSTALLATION

2.01.00 GRADING UNDERBED

The surface to receive the underbed shall be roughened and thoroughly cleaned with wire brush and water. Oil patches if any shall be removed with detergent. The surface shall be soaked with water and all excess water removed just before laying of the underbed.

The underbed shall not be laid under direct hot sun and shall be kept in shade immediately after laying so as to avoid quick loss of water from the mix and separation from the roof surface. The underbed shall be cured under water for at least 7 days.

The underbed shall be laid to provide an ultimate run off gradient not less than 1 in 120 and as directed by the Engineer. Upto an average thickness of 25mm the underbed shall usually be composed of cement and sand plaster. For higher thickness the underbed shall be made with cement concrete. The underbed shall be finished to receive the waterproofing treatment direct or insulation as the case may be.

2.01.01 Cement Mortar Underbed

The underbed grading plaster shall be average 25 mm thick maximum. It shall consist of cement and coarse sand in the ratio 1:4 nominal by volume. The sand and cement shall be thoroughly mixed dry and then water added. Each batch of mix shall be consumed before the initial set starts.

The plaster shall be fully compacted to the desired grade in continuous operation. The surface shall be even and reasonably smooth.

2.01.02 Cement Concrete Underbed

The underbed cement concrete shall be used where the subgrade is more than average 25 mm thick. It shall consist of cement concrete 1:2:4 nominal mix

by volume with 12 mm down stone chips and coarse sand. The aggregate shall be mixed dry and minimum quantity of water shall be added to make the mix workable.

The mix shall be laid to proper grade, fully consolidated and surface shall be smooth and even.

2.02.00 INSULATION

The Tenderer shall, along with the tender, send specifications of insulating materials he proposes to use and the proposed method of laying. Before bulk supply, the contractor shall send samples of insulating material to the Engineer, and after approval of the samples, the Contractor shall procure and transport the bulk material to the site. Whenever asked by the Engineer, the Contractor shall furnish test certificates from testing laboratory on the insulating and other properties of the materials.

After laying the insulation, the surface shall be made ready as required to receive the waterproofing treatment. If any plastering is used it shall be not leaner than 1:4 cement sand by volume and not thinner than 12 mm and it shall be cured for seven days.

2.02.01 Foam Concrete

This shall be of lightweight foam concrete of average 50 mm thickness or as specified or as shown on drawings. This may be laid in situ in suitable panels or precast blocks. The insulating properties shall be such that the thermal conductivity shall not exceed 0.125 Kcl/sq.m. hr degree C. Before starting the laying of foam concrete samples shall be prepared at site and got tested for approval of the Engineer.

The foam concrete laid shall be sufficiently strong to withstand the usual workload and standard loads expected on the roof. Any damaged portion shall be removed and replaced forthwith. Approval of the Engineer shall be taken before laying the waterproofing over the insulation.

While laying the foam concrete, samples from each batch of the mix shall be kept for test if so desired by the Engineer.

2.02.02 Expended Polystyrene Blocks

The expanded polystyrene block Insulation shall be fire retardant quality and shall have a maximum thermal conductivity of 0.026 Kcl m/sq.m h °C. It must be strong enough to withstand without any deformation under the workload and standard loads expected on the roof.

The Contractor shall lay the expanded polystyrene block as per manufacturer's approved specification. Only specifically experienced workers shall be used for this work. If the Engineer is not satisfied about the efficiency of the workers the Contractor shall secure manufacturers supervision at no extra cost to the Owner.

2.03.00 Fillets

Fillets at Junction of roofs and vertical walls shall be provided with the same insulating material as provided for the main roof insulation. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

Where there is no insulation over roof slab, fillets shall be cast-in-situ cement concrete (1:2:4) nominal mix volume.

2.04.00 Waterproofing Treatment

2.04.01 Bitumen Felt Treatment

Waterproofing treatment shall be laid by a specialist firm with long experience in the particular trade.

The waterproofing treatment for roofs with bitumen felts shall be done following relevant IS: 1346. Bitumen felt shall conform to IS: 1322 and Bitumen primer to IS: 3384.

The bonding materials shall consist of blown type conforming to IS: 702 or residual bitumen conforming to IS: 73 or a mixture of the two to withstand local conditions of prevailing temperature or gradient of roof surface. The Contractor shall convince the Engineer that the bonding material proposed to be used is suitable for the particular job.

The Contractor shall state the source from where he proposed to procure the materials. Samples of the self-finished felt shall be submitted in advance to the Engineer along with test certificates for his review. Test certificates for the bonding materials shall also be submitted and samples, if desired by the Engineer, shall be provided for confirmatory tests. Samples shall be submitted if instructed by the Engineer.

Minimum overlaps of 100 and 75 mm shall be given at the end and sides of strips of felt and properly bonded with bitumen. Joints in successive layers of felt shall be staggered.

Normal treatment with one layer of felt, heavy treatment with two lavers of felt or Extra Heavy treatment with three layers of felt shall be indicated. Brief details of the various treatments shall be as follows:

a) Normal Treatment - Five courses

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sq.m. (min.)

3) Hessian base self finished felt, type 3, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m. (min.)

5) 20 mm thick pressed precast concrete tiles with 15 mm, thick 1:4 cement-sand mortar underbed.

b) Heavy Treatment - Seven Courses

With Hessian base felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

3) Hessian base self-finished felt, type 3, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

5) Hessian base self-finished felt, type 3, grade I.

6) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

7) 20 mm thick pressed precast concrete tiles with 15 mm thick 1:4 cement: sand mortar underbed.

or

With fiber base felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Not applied bitumen at the rate of 1.2 kg/sq.m (Min.)

3) Fiber base self-finished felt, type 2, grade 2.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

5) Fiber base self-finished felt, type 2, grade 2.

6) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)

7) 20 mm thick pressed precast concrete tiles with 15 mm thick 1:4 cement: sand mortar underbed.

c) Extra Heavy Treatment – Nine courses

With fiber based felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

3) Fiber-base self-finished felt type 2, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sq.m (min.)

5) Fibre base self-finished felt type 2, grade 1.

6) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

7) Fibre base self-finished felt type 2, grade 1.

8) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

9) 20 mm thick pressed precast concrete tiles with 15 mm thick 1:4 cement: sand mortar underbed.

or

With Hessian base felt

1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.

2) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

3) Hessian base self-finished felt, type 3, grade 1.

4) Hot applied bitumen at the rate of 1.2 kg/sqm. (min.)

5) Hessian base self-finished felt, type 3, grade 1.

6) Hot applied bitumen at the rate of 1.2 kg/sqm. min.

7) Hessian base self-finished felt, type 3, grade 1.

8) Hot applied bitumen at the rate of 1.2 kg/sqm. min.

9) 20 mm thick pressed precast concrete tiles with 15 thick 1:4 cement: sand mortar underbed.

However, in special cases, more courses, or a combination of fibre base and hessian base felts may be asked for.

The surface to receive the waterproofing treatment must be cleaned and dried satisfactorily and the Engineer's approval taken before starting the work. If any existing waterproofing treatment is being augmented the existing top course shall be completely removed and all damaged felts or other defects repaired.

The Engineer may instruct the Contractor to lay part of the stipulated courses at the first instant to be followed later on with the balance courses. This interim finish shall be done with a course of hot applied bitumen. While doing the balance again hot bitumen shall be applied to start with after repair of all damages to the already laid course.

After completion the surface shall be cleaned taking care that felt cuttings etc. do not find their way into rainwater down comers.

2.04.02 Elastomeric Membrane

a) Material

The material shall consist of high solid content Polyurethane based cold liquid applied coatings as per ASTMC836-89a comprising of urethane pre-polymers extended with flexible material, which cure by reaction with atmospheric moisture to give a continuous film which is rubbery and elastic or any other equivalent material permitted as per ASTM and approved by the Engineer. The material shall consist of high solid coating designed to give a high-build film. The material shall not be diluted. The coating shall have physical feature like high viscosity, 90% solids, high resistance to impact, abrasion and cracking, superior tensile strength, application limit of 70^0C minimum, 300% elongation and forming a perfectly smooth permanently flexible seamless membrane which should have good adhesion to roof substrates (RCC, tiles, brick, and metals), having a minimum life of 10 years. It should also be resistant to acid (mild concentrated), alkalies and have a very low water absorption rate (0.5%) max. at ambient temp. after 7 days.

The pack shall not be older than 9 months after the date of manufacture and packing.

b) Primer coat

It shall consists of polyurethane (P.U.) or any other equivalent material. Primer coat shall be a special blend of moisture curing urethane pre-polymers in solvent. A single coat of this primer shall be applied by brush over the prepared bed as an adhesion coat of an application rate of minimum 6 sq.m per litre.

The primer shall be allowed to dry for minimum of 2hrs. time before the successive finishing coats of P.U. liquid membrane are applied.

c) Finishing coats :

The finishing coats shall consist of two successive liquid coatings of high solids content urethane pre-polymers or equivalent material to form an elastomeric membrane. The overall dry film thickness shall be 1.5mm subject to minimum 500 gm per sq.m per coat application rate.

Each coat shall be allowed to dry for minimum 12 hours before applying the next coat. The surface should be dry and smooth before application.

The coating shall be continued up the parapets/walls for a minimum of 150mm over the finished roof surface. It shall be continued into rain water pipes by atleast 100mm.

The final coat of P.U. liquid when tacky shall be sprinkled with the sand.

For edges, expansion joints and any vulnerable points a later of polyscrim cloth /fabric to be embedded between 2 finishing coats.

d) Surface Finish :

Areas of roof treatment which are vulnerable to accidental damage shall be provided with wearing course consist of minimum 20 mm thick PCC of Grade M15 (using12.5mm size aggregate) cast in panel of maximum size of 1.20m x 1.20m and reinforced with 0.56mm diameter galvanised chicken wire mesh and sealing of joints using sealant or elastomeric compound.

When the roof surface is subjected to foot traffic or used as a working area, a cement mortar (1:4) shall be applied over the top most layer of roofing treatment. Over this, a layer of chequered cement concrete flooring tiles conforming to IS:13801 shall be provided in place of stone grit and cement painted. The tiles shall be laid as per IS:1443.

2.04.03 Waterproofing By Epoxy Resin Based Application

Exposed surfaces of cement concrete, lime concrete or brickwork to be treated for waterproofing by the resin-based application shall be thoroughly cleaned and the epoxy resin based material to be applied as directed by the manufacturer. The material shall not have any adverse effect on the surface on which it is applied and must stick to it uniformly to make a strong durable bond. It shall not be affected by short duration fire, sun exposure, and light duty traffic. The application shall be resistant to growth of fungus and proof against saltpetre action. If desired by the Engineer, a sample shall be prepared in advance and tested for waterproofness for 48 hours under 300 mm depth of standing water. The Contractor shall arrange the demonstration by providing free the materials and labour for the application as free of cost to Owner. This item shall carry a guarantee as specified.

2.04.02 Flashing

Unless otherwise stated flashing shall be done in the same way as the waterproofing except that the last layer shall be finished with two coats of bituminous primer. The flashing shall be extended up the vertical surfaces as shown on drawing. The flashing shall end in grooves in vertical walls. The grooves shall be at leas 65 mm deep and caulked with waterproof mastic cement. The minimum overlap with horizontal roofing felt shall be 100 mm.

Where specified or directed by the Engineer, metal flashing shall be provided. The materials shall be 18 Gage or 22 G G.I. sheets, as specified or as directed by the Engineer.

2.05.00 WATER-PROOFING OF UNDERGROUND STRUCTURES

Basements, ducts, pits, tunnels (excluding tanks) etc below the ground water table and in contact with soil are covered under this. Bonding material shall be blown bitumen of 65/25 grade conforming to IS: 702.

Waterproofing shall be provided on the outside of walls and top of RCC slab and shall be carried out upto 150mm above ground level. The number of layers of bitumen felt to be used for walls and floor unless otherwise shown in the drawing shall be:

a) 2 layers - for depths up to 5m below ground level

b) 3 layers - for depths beyond 5m below ground level

2.05.01 Method of laying the bitumen felts and workmanship shall be as per IS: 1609 and IS: 3067. Water proofing work shall be taken in hand only when the sub-soil water level is at its lowest; the site shall be kept dry by adequate arrangements for pumping out water till the work has been completed.

For this purpose drains shall be formed along the edges of the excavation but beyond the building line, with suitable collecting sumps.

In case of large excavation areas where it is necessary to dewater under the floor, additional land drains shall be formed across the excavation, to adequately drain the area.

Adequate arrangement shall be made to protect the sides of excavation from slipping while the work is in progress.

The base concrete or mud-mat shall be rendered smooth by a 20mm thick sand-cement plaster (6:1). Any sharp edges/corners, over which the waterproofing course is to be laid, shall be eased out by means of cement.

The surface must be dry before the next operation is carried out.

Water proofing/damp proofing treatment:

A) Heavy Treatment (Two layers of felt)

i) Primer (For vertical faces only), as per I.S. 3384.

ii) Hot applied blown bitumen at the rate of 1.2 Kg/m2

iii) Hessian base, bitumen felt type 3 grades 2

iv) Hot applied blown bitumen @ 1.2 Kg/m2

v) Hessian base, bitumen felt type 3 grade 2

vi) Hot applied blown bitumen @ 1.2 Kg/m2

B) Extra Heavy treatment (Three layers of felt)

i) Primer (for vertical faces only) as per I.S. 3384

ii) Hot applied bitumen at the rate of 1.2 Kg/m2

iii) Hessian base bitumen felt type 3 grades 2

iv) Hot applied bitumen at the rate 1.2 Kg/m2

v) Hessian base bitumen felt type 3 grades 2

vi) Hot applied bitumen at the rate of 1.2 Kg/m2

vii) Hessian base bitumen felt type 3 grades 2

viii) Hot applied bitumen at the rate of 1.2 Kg/m2

The surface must be dry before the next operation is carried out at each stage said above.

The laying of felt over the bitumen so applied that it shall always commence on the floor, and shall be carried over to the walls only after treatment of the floor is complete. The minimum over lapping at sides and ends of strips shall be 10cm. Point for subsequent layers completely sealed by blow lamp.

A protective flooring of either brick flat in cement mortar (1:3) or 6cm thick cement concrete (M 15) or a coat of cement plaster (1:3) 4 cm thick shall be constructed over the bitumen layers to prevent damage to the latter during subsequent construction of the structural floor.

The walls shall be treated in a similar way; the bitumen felts joining at the base with the projecting felt laid over the mud-mat. The wall surface shall be made smooth where necessary with a coat of cement plaster (1:3), the felts laid as for the floor, ensuring that the surface to be treated is dry and then a protective brick wall, 12.5 cm nominal thickness shall be built in cement mortar (1:3) over the projecting mud-mat, the space between the wall and felt being grouted with cement.

3.00.00 ACCEPTANCE CRITERIA AND GUARANTEE

The surface level shall be such as to allow quick draining of rains without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The contractor shall give a guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specified agency for the roof waterproofing treatment work. The guarantee shall be for materials and workmanship as under:

For Bitumen Felt Treatment under clause no. 2.04.01: 5 years in case of normal treatment, 10 years for heavy treatment and 20 years for extra heavy treatment.

For Elastomeric Membrane under clause no. 2.04.02: 10 (ten) years

In case guarantee is more stringent in owner specification, more stringent guarantee shall be applicable. The mode of execution of the guarantee shall be such, which shall be acceptable to the Owner.

4.00.00 I.S. 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.

a) IS: 73 - Paving Bitumen

b) IS: 702 - Industrial Bitumen

c) IS: 1203 - Methods of testing tar and bitumen

d) IS: 1322 - Bitumen felts for waterproofing and damp proofing.

e) IS: 1346 - Code of practice for waterproofing of roofs with bitumen felts.

f) IS: 1609 - Damp-proofing Treatment using Bitumen Felts – Code of Practice

g) IS: 3067 - Code of practice for General design details and preparatory work for Damp-proofing and water-proofing of buildings

h) IS: 3384 - Bitumen primer for use in waterproofing and damp proofing.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be for complete work, including the cost of all materials and labour, as detailed in the specification unless any portion is specifically excluded in the "Schedule of Items".

No extra shall be paid for finishing around opening, sleeves, pipes, ducts, inserts, etc.

No separate payments shall be made for cleaning of surface, treating of cracks and surface preparation.

5.02.00 Measurement

The finished work shall be measured in Sqm of actual surface area for the purpose of payment.

No deduction shall be made and no extra shall be paid for openings upto 0.4 sqm.

VOLUME: II B

SECTION - D

SUB-SECTION – D5

METAL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC.

SPECIFICATION NO. PE-TS-999-600-C005

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	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	8
4.00.00	INFORMATION TO BE SUBMITTED	9
5.00.00	I.S. CODES	10
6.00.00	RATES AND MEASUREMENTS	10

ATTACHMENT

ANNEXURE – A	SCHEDULE OF FIXTURES	12

METAL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC.

1.00.00 SCOPE

This section covers supplying and/or erecting and installing of all metal doors, windows, ventilators, louvers, glazed partitions, etc. The scope of work shall also include the assembly and erection of all doors, windows, louvers, glazed partitions, etc. Supplying and/or fixing of all door and window accessories and hardware are also included in the scope.

2.00.00 INSTALLATION

2.01.00 Materials

Steel sections used for fabrication of doors, windows etc. shall be standard rolled steel sections specified in IS: 1038 and IS: 1361 or as specified.

Steel sheets for frames, shutters, louver blades etc. shall be of gauge mentioned in drawings and schedules.

Aluminium sections for fabricating doors, windows, partitions etc. shall be extruded sections conforming to IS:733 or IS:1285 or as manufactured by Indian Aluminium Company Limited or approved equivalent. Aluminium door, windows and ventilator shall be fabricated as per IS:1948 and IS:1949. The alloy used shall conform to IS Designation HE 9-WP of IS: 733.

Hardware and fixtures shall be as specified and the best quality from approved manufacturers shall only be used. The tenderer shall specifically state the particular manufacturer's materials he proposes to use. Improper alignment or faulty operation due to inadequate strength of hardware or fixture shall entirely be the Contractor's responsibility.

All hardware and fixtures shall be able to withstand repeated use. Door closures shall conform to IS: 3564 and shall be suitable for doors weighing 61-80 Kg. unless otherwise stated. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or shall be replaced free of charge. Concealed door closers shall be either floor mounted or transom mounted, suitable for installation with metal doors. It shall conform to the performance Requirements and endurance test stated in IS: 3564 - Appendix-A. The Contractor shall submit samples of each type of hardware to the Engineer. The approved samples shall be retained by the Engineer for comparison of bulk supply. The samples shall be returned to the Contractor towards end for incorporation in the job. The mastic for caulking shall be of best quality from a manufacturer approved by, the Engineer. In general, mastic for fixing of metals frames shall be as per IS: 1081 or as approved by the Engineer.

2.02.00 Fabrication

2.02.01 Steel Doors, Windows, Ventilators, louvers etc.

a) Door Frames

Frames shall be fabricated from 16 gage(G) sheets. They shall, be mortised, reinforced, drilled, and tapped for hinge lock and bolt strikes. Where necessary, frames shall be reinforced for door closers. Welded construction with mitered Corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose "T" masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be installed. Frames shall be brought to site with floor ties/weather bars installed in, place.

b) Double Plate Flush Door Shutters

Door shutters shall be 45 mm thick, completely flush design and shall comprise of the outer sheets or 18 G steel sheets, rigidly connected and reinforced inside with continuous vertical 20 G stiffeners, spot welded in position at not more than 150 mm on centres.

Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally as shown on drawing by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and heads, shall have proper level on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting-stile edges bevelled or rebated. Where shown on drawing, or called for in the schedule of items, the doors shall be sound deadened by filling the inside voids with mineral wool or other suitable approved materials.

Doors shall be mortised, reinforced, drilled, and tapped in shop for hinges, locks, and bolts. They shall also be reinforced for closers, push-plates, and other surface hardwares where necessary. Any drilling and tapping required for surface hardware shall be done at site. Where shown drawing, provision shall be made for fixing glazing, vision panels, louvers etc. glazing mouldings shall be of 18 G steel or extruded aluminium sections and suitable for fixing 6 mm. glass. Louvers blades shall be V or Z shaped and made out of 16 G sheets.

c) Single Sheet Door Shutters

Single sheet doors shall be made from best quality 18 G mild steel sheets, and shall present a flush surface on the outside. The inside shall be stiffened with semi tubular edge and central stiffening rail, which shall convey the lock and other fixture. The frames shall be made from best quality, 16 G mild steel sheets.

Wherever required, provisions for fixing glass panes, louvers etc. shall be made.

The manufacturing shall be done as specified in 2.02.01 (b) “Double Plate Flush Door Shutters.”

d) Sliding Door

Sliding doors shall be either double plate or single plate Construction made out of 18 gauge steel sheets with adequate stiffeners. The contractor shall specify the weight of the door in his shop and submit the manufacturer's catalogue of the sliding gear he proposes to use. Where called for the Contractor shall make provision for openings to the door for monorail beams. Doors shall close positively to exclude rainwater from seeping in. When called for, sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

e) Door Threshold

Door threshold shall be provided. Doors without threshold shall have bottom tie of approved type.

f) Steel Windows, Sashes, and Ventilators etc.

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, and pivot arrangements for ventilators, etc. or as called for. All welds shall be dressed flush on all exposed and contact surfaces. Where composite unit openings are required the individual window units shall be joined together with requisite transoms and mullions. All windows shall be outside glazed, fixed with putty or metal glazing beads as specified. Where aluminium glazing beads are specified, they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Indal Section No. 2209) unless otherwise shown on drawings. Aluminium beads shall be given one coat of zinc chromate primer before fixing to windows.

2.02.02 Aluminium Door, Windows, and Frames

Extruded sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors frames, mullions, transom etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum 15 micron thickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent Coating shall be applied to the sections before shipment from the factory.

All work shall be fitted and shop assembled to a first class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as will produce an uniform colour throughout the work. Work on the above, other than described, shall be carefully fitted and assembled with neat joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and on edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. Glazing beads shall be snap fit type without visible screws and shall be of sizes to accommodate 6 mm thick glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

2.03.00 Shop Coat or Paint

The shop Paint for steel doors, windows etc. shall be best lead or zinc chromate primer paint from, approved manufacturer. All surfaces shall be thoroughly cleaned of rust, grease, loose mill scales etc. and given one coat of shop paint. Portions like mullions, transoms etc. that will be inaccessible after assembly of units shall be given an extra coat of paint before assembly.

Where called for, all steel doors, windows, etc. shall be hot dip galvanized to give a coating weight of 1½ - 2 oz. per sqft. One coat zinc chromate primer coat shall then be applied as shop paint.

Portions of aluminium frame, which come in contact with masonry construction shall be (before shipment from workshop) protected with a heavy coat of alkali resistant paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer.

2.04.00 Handling & Storage of Fabricated Material

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.

When taking delivery of items supplied by Owner, the Contractor shall satisfy

himself that the items supplied are up to the specified standard. Any defect detected shall promptly be brought to the notice of the Engineer.

All metal doors, windows etc. shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust, mortar etc.

2.05.00 Assembly & Erection at Site

In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvers, etc. including transoms and mullions for composite units in respective places, keening proper “Lines and levels”, and in approved workmanlike manner, to give trouble free and leak-proof installations. Installation shall be done according to instructions of the manufacturer, and/or as approved by the Engineer. If required by the Engineer, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take all precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor and made good again as per original, after installation, without any extra charge.

After installation of steel doors, windows, etc. all abrasions to shop-coat of paint shall be retouched and made good the same quality of paint used in shop coat.

All coupling mullions, transoms, frames, etc. in contact with adjacent steel and other members, shall be well bedded in mastic. The Contractor shall bring to the site the cement in original sealed containers of manufacturer and shall apply it as per the instruction. For all frames supplied by either the owner or the Contractor, mastic shall be supplied by the Contractor and caulking done properly as per drawings, specifications and as per instructions of the Engineer.

Door shutters, partitions hardware fixtures etc. shall be fixed only after major equipments have been installed in rooms.

Wherever required, nylon cords of approved quality shall be supplied along with pivoted sashes and shall be of adequate length to terminate one metres from the floor. Loose ends of cords shall end in metal or plastic pull as approved by the Engineer.

2.06.0 Fire proof Door

Fire proof doors shall be provided at all fire exit points as specified and also to restrict the spread of fire within buildings whether from internal fire or from external fire. The construction details of door shall conform to the

requirements stipulated in IS:3614(Part-1). Doors shall comply with the testing requirement mentioned in IS:3614 (Part-2). The doors shall be approved by Tariff Advisory Committee and shall have minimum 2 hrs. fire rating.

Metal covered (on both sides) Doors having insulating core filled up with mineral wool shall be used at all fire exit points and shall open out side.

All necessary accessories and hardware shall also be supplied along with doors. Fire proof door shall be provided with zinc silicate primer (minimum DFT 75 micron) after blast cleaning the surface to near white metal surface and shall be finished painted with epoxy based painting.

3.00.00 ACCEPTANCE CRITERIA

3.01.00 For fabricated Items

a) Overall dimensions shall be within ±1.5 mm of the size shown on drawings.

b) Mullions, transoms etc. shall be in one length and permissible deviations from straightness shall be limited to ±1.5 mm from the axis of the member.

c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm for double leaf doors; the gap at the meeting stiles shall not be more than 1.5 mm.

d) Door leaves shall be undercut where shown on drawings.

e) Doors, windows, frames, etc. shall be on a true planes, free from warp or buckle.

f) All welds shall be dressed flush on exposed and contact surfaces.

g) Correctness of location and smoothness of operations of all shop installed hardware and fixtures

h) Provision for hardware and fixtures to be installed at site.

i) Glazing beads shall be cut with mitered corners.

j) Glazing clips, fixing devices etc. shall be supplied in adequate numbers.

k) Shop coats shall be properly applied.

l) Exposed aluminum surfaces shall be free from scratches, stains, and discoloration. Anodized surfaces shall present a uniform and pleasing look.

3.02.00 For installed Items

a) Installations shall be at correct location, elevation and in general, on a true vertical plane.

b) Fixing details shall be strictly as shown on drawings.

c) Assembly of composite units shall be strictly, as per drawings with mastic caulking of transoms and mullions, gaskets, weather strips etc. complete.

d) All frames on external walls shall be mastic caulked to prevent leakage through joint between frames and masonry.

e) All openable section shall operate smoothly without jamming.

f) Locks, fasteners etc. shall be engage positively. Key shall, be non-interchangeable.

g) Cutting to concrete or masonry shall be made good and all abrasions to shop paint shall be touched up with paint of same quality as shop paint.

h) Aluminium doors, windows, etc. shall be free from scratches stain or discoloration.

4.00.00 INFORMATION TO BE SUBMITTED

4.01.00 With Tender

a) Names of manufacturers for Doors, windows etc.

b) Manufacturer's catalogue for all hardware and fixtures proposed to be used.

4.02.00 After Award

a) Before starting fabrication of all metal doors, windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

b) He shall submit a programme of work to be done for the approval of the Engineer.

c) Before bulk supply, he shall submit for the approval of the Engineer samples of all bought out items and samples of each type of fabricated items. The samples shall by retained by the Engineer for comparison of bulk supply and returned to the Contractor towards the end for final incorporation in the job.

5.00.00 IS CODES

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.

Specification for Wrought Aluminium and Aluminium Alloy bars, rods and sections (for general engineering purpose)	-	IS: 733
Specification for Wrought Aluminium and Aluminium Alloy, extruded round tube, hollow section (for general engineering purpose)	-	IS: 1285
Steel doors, windows, and ventilators	-	IS: 1038
Steel windows for industrial, building	-	IS: 1361
Aluminium doors windows, and ventilators	-	IS: 1948
Aluminium windows for industrial buildings	-	IS: 1949
Steel doorframes	-	IS: 4351
Code of practice for fixing and glazing of Metal (steel and aluminium) doors, windows and Ventilators.	-	IS: 1081
Specification for Fire-check Doors – Part 1: Plate, Metal covered and Rolling type	-	IS: 3614
Hot Rolled Steel Sections for Doors, Windows and Ventilators – Specification	-	IS: 7452

6.00.00 RATES AND MEASUREMENT

6.01.00 Rates

Rates shall be applicable of all elevation. Rates shall include preparation of working drawings (if required), supply of material, fixtures, gaskets, erection of unit, caulking and jamming of frames, including cutting/drilling/welding, grouting, grinding, making good of the structure for installing the unit etc. complete as per “Schedule of Items”.

Rates shall also include cost of surface preparation, application of primer, enamel painting or anodizing as applicable.

Rate for fire proof door is inclusive of providing insulation core, primer, shop painting (epoxy based), all hardware as specified in Schedule of items.

6.02.00 Measurement

Supply and installation of doors, windows, and ventilators shall be measured in Sqm or Kg as per BOQ item. If measured in sqm, it shall be for net outer to outer (excluding frame) area of doors, windows, and ventilators of each type used as described in "Schedule of Items". Frame for steel or aluminium shall be measured in Kgs. Wooden frames shall be measured in Cum. Measurement for aluminium partition frames shall be in Kg. Panelling and glazing shall be paid separately if not covered in BOQ item description.

Measurement for fire proof door shall be in SqM in net area outer to outer of the door.

ANNEXURE-A

SCHEDULE OF FIXTURES

A. TIMBER DOORS

1. For single leaf panel/flush doors

   i) 100 mm brass butt hinges with screws - 3 Nos.

   ii) 150 mm brass tower bolts with screws - 1 No.

   iii) 100 mm x 225 mm clear plastic push Plate with counter sunk brass screws - 1 No.

   iv) 30 mm brass ring pull handle with Plates and screws - 1 No.

   v) 150 mm brass coat hook with screws - 1 No.

   vi) Heavy duty, cylinder looks on active leaf - for flush door. For door-closure, see "Door Schedule".

B. ALUMINIUM DOORS

1. For double leaf door

   i) Concealed hanging arrangement for door leaves.

   ii) Concealed two points bolt encasing simultaneously at head and threshold on inactive leaf, operable from inside.

   iii) Heavy duty, cylinder look on active leaf.

   iv) Pull handle of approved design on both leaves.

   v) Doors stops for both leaves.

   vi) Overhead door closure for both leaves.

ANNEXURE-A

C. STEEL DOORS AND WINDOWS

1. Doors

a) Double leaf doors

i) 100 mm butt hinges - 3 Nos. on each leaf.

ii) 300 mm aluminum tower bolt - 2 Nos. (top and bottom) On inside of inactive Leaf. 1. No. (Top only) On inside active leaf.

iii) 200 mm anodized aluminum pull handle - 1 No. of each leaf.

iv) Door stop of approved design - 1 No. of each leaf.

NOTE: For locks, door closure and threshold, see "Door Schedule".

b) Single leaf doors

i) 100 mm butt hinges - 3 Nos.

ii) 300 mm aluminum tower bolt - 2 Nos. top & bottom of Inside face

iii) 200mm anodised aluminum Pull handle - 1 No.

iv) Door stop of approved design - 1 No.

NOTE: For locks, door closures and threshold, see "Door Schedule".

2. Windows, Ventilators, etc.

a) Side Hung Windows

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) 12" peg stays - 1 No. per leaf

iii) 2 point handles - 1 No. per leaf

b) Top Hung Ventilators (Projecting Out)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Adjustable sliding fabrication assembles - 2 Nos. per leaf.

iii) 2 point handles - 1 No. per leaf.

c) Bottom Hung Ventilators (Projecting in)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Concealed side arms for opening adjustment. - 2 Nos. per leaf.

iii) Spring Catch - 1 No. per leaf.

ANNEXURE-A

D. ALUMINIUM WINDOW, VENTILATORS, ETC.
(As per IS-1948 latest editions)

a) Side Hung Windows

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) 300 mm peg stays - 1 No per leaf

iii) 2 point handles - 1 No per leaf

b) Top Hung Ventilators (Projecting out)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Adjustable sliding fabrication assembles - 2 Nos. per leaf

iii) 2 Point handles - 1 No. per leaf

c) Bottom Hung Ventilation & (Projecting In)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Concealed side arms for opening adjustment - 2 Nos. per leaf

iii) Spring Catch - 1 No. per leaf

VOLUME: II B

SECTION - D

SUB-SECTION – D6

GLASS AND GLAZING

SPECIFICATION NO. PE-TS-999-600-C006

Maharatna Company

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	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	4
4.00.00	I.S. CODES	4
5.00.00	RATES	5

GLASS AND GLAZING

1.00.00 SCOPE

This section covers supplying and fixing of all glass and glazing including all clips, putty, mastic cement etc. wherever required as per specifications.

2.00.00 INSTALLATION

2.01.00 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, from approved manufacturer like Hindustan Pilkinton or equivalent, having uniform refractive index and free from flaws, specks, and bubbles. The glass shall be brought to site in the original packing from the manufacturer and cut to size at site.

Materials

a) Glare reducing or beat absorbing glass shall be "Calorex" of Hindustan Pilkinton or approved equivalent and special care shall be taken to grind smooth and round off the edges before fixing.

b) Clear glass shall be flat draw sheet glass and shall be at least 4 mm thick. Sheet glass for doors shall be minimum 5.5 mm thick.

c) Wired glass shall be thick- rolled glass with centrally embedded 42g wire mesh of Georgian type. This may be of clear or coloured glass, as required.

d) Obscure glasses shall have a cast surface in one side.

e) Coloured and figured glass shall be as per approved sample.

f) In general, the putty shall conform to IS: 400 and be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing.

g) Neoprene gaskets with snap-fit glazing beads shall be fixed as per manufacturer's instructions and shall sit snugly against glass to give a leak proof installation.

2.03.00 Glazing, Setting, and Finish

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 I.S. Codes, four glazing chips shall be provided per glass pane, except for large panes were six or more clips shall be used as per engineer's instructions. All holes that may be necessary for holding the clips glazing heads and all other attachments shall be drilled by, the Contractor.

Glass panes shall be set without springing, and shall be bedded in putty and back puttied, except where mouldings or gasket are specified, putty, mastic cement etc. shall be smoothly finished to the even line and figured glass shall be set with smooth side out.

Where owner will supply glass, the Contractor shall cut it to size and fix them in the same as specified above.

The Contractor shall supply necessary glazing clips, putty, mastic cement etc.

After completion of glazing, the Contractor shall remove all dirt stains, excess putty etc. clean glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at the contractor's own cost.

3.00.00 ACCEPTANCE CRITERIA

a) All installation shall be free from cracked, broken, or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked, or underground 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.

4.00.00 I.S. CODES

Following are some of the important I.S.Codes relevant to this Section:

IS: 3548 - Code of practice for glazing in building.

IS: 1081 - Code of practice' for fixing and glazing metal doors, windows ventilators.

5.00.00 RATES

Rates of glass and glazing if not included in respective items for supply and installation of window, ventilator, and partitions shall be paid separately as per BOQ items provided. No separate payment shall be made for glazing clips, mastic cement, putty, screws; rails, etc. nor for drilling holes in frames for inserting glazing clips.

VOLUME: II B

SECTION - D

SUB-SECTION – D7

ROLLING STEEL SHUTTERS AND GRILLS

SPECIFICATION NO. PE-TS-999-600-C007

Maharatna Company

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	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA & GUARANTEE	5
4.00.00	I.S. CODES	5
5.00.00	RATES AND MEASUREMENTS	5

ROLLING STEEL SHUTTERS AND GRILLS

1.00.00 SCOPE

This Section covers the design and supply of materials, fabrication, delivery and erection of Rolling Shutters/Grills with motor drive and/or manual operation including all accessories as hereinafter specified.

2.00.00 INSTALLATION

2.01.00 Components

a) Slats for rolling shutters shall be made from tested bright cold rolled, annealed M.S. strips, not less than 0.9 mm thick for shutters upto 4.5 M wide and not less than 1.25 mm thick for shutters having width more than 4.5 M, wide and above, machine rolled at 75 mm rolling centers, 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 6mm rods at 35 mm on centers running horizontally flexible connected with vertical links spaced not more than 200 centers. Alternatively, rolling grills shall be made from perforated slats of approved design reinforced with 6mm dia rods.

c) End locks shall be heavy type M.C.I./C.I. and shall be provided at each end of alternate slats unless specified otherwise.

d) Bottom bars shall be finished with two angles not less than 6 mm thick for external shutters. When shown on drawings, a flexible weather strip shall be applied to make tight contact with the floor.

e) Guides shall be of such depth as to retain the shutter under a wind pressure of 100 Kg/Sq.m.

f) Shafts shall be of steel pipe of sufficient size to carry the tensional load with a maximum deflection of 1/360th 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, suitable reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as prescribed by the Engineer.

i) Power unit shall be suitable for 3 phase, 50 cycles, 400-volt A.C. power supply and be either 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 second. 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 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 galvanized and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength grey cast iron, machine moulded from machine out patterns.

2.02.00 Manually Operated Shutters/Grills

Manually operated shutters shall be easily operable by one person. The speed of operation shall be about 1.3 metres per second. In general, manually operated shutters shall be push pull type for opening up to 9 Sq. metre in area. Larger shutters shall, be either chain and gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as desired by the Engineer.

2.03.00 Power operated Shutters/Grills

These shall be operable from a push button station conveniently located beside the door. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for, externally mounted shutters shall be operated by control mechanism located inside the building.

2.04.00 Shop Coat

Shutters shall be painted with one coat of red lead or zinc chromate primer. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat.

2.05.00 Erection

Door shall be installed by the manufacturer or his authorized representative and all work shall be as per manufacturer's instructions. Any drilling or cutting to concrete, masonry etc. shall be made good after erection of shutters and all abrasion to shop coat shall be touched up. All electrical work shall be

in strict accordance with the latest Indian Electricity Rules.

3.00.00 ACCEPTANCE CRITERIA AND GUARANTEE

3.01.00 Shop Inspection

After completing the manufacture of the different components of the rolling shutter, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

3.02.00 Field Inspection

After installing the shutters, the Contractor shall test the performance of the shutter in the presence of the Engineer. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault free performance.

3.03.00 Guarantee

The Contractor shall give one year's guarantee for the successful operation of the shutters. This shall be supported by a separate and unilateral guarantee from the manufacturer of the shutters.

4.00.00 I.S. CODE

IS: 6248 - Metal rolling shutters and rolling grills.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates for rolling shutters and grill shall include the cost of the locks, guide channels, cost of drive as specified. In case of electrically operated rolling shutters, the rate shall also include the mounting of controls, wire and wiring from the nearest junction box, conduit and other electrical connections and cost of electric motor.

5.02.00 Measurement

Supply and installation of rolling shutter and grill shall be measured in Sqm in net outer to outer (including frame) area of each type used as described in “Schedule of Items”.

VOLUME: II B

SECTION - D

SUB-SECTION – D8

MISCELLANEOUS METAL

SPECIFICATION NO. PE-TS-999-600-C008

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	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	7
4.00.00	IS CODES	8
5.00.00	RATES AND MEASUREMENTS	8

MISCELLANEOUS METAL

1.00.00 SCOPE

This section covers supply, fabrication and erection of miscellaneous metal items of light nature in gates, balcony and stair hand rails, structural works, ladders, hangers, masonry anchors, anchor bolts, fasteners, chain link fencing, barbed wire fencing etc. as specified or shown on drawing or as instructed by the Engineer. The above items shall be of fabricated or cast of mild steel, aluminium, brass, cast iron, M.S.& galvanized M.S. sheets, aluminium sheets, expanded metal, wire mesh as shown on drawings or specified.

2.00.00 INSTALLATION

2.01.00 Fabrication/casting

2.01.01 General

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural or foundary shop.

2.01.02 Shop Connections

a) All shop connections shall be riveted or welded except when noted otherwise on drawings.

b) Welding of steel shall be done in accordance with IS: 816.

c) Welding of aluminium shall be done accordance with IS: 2812, “Arc welding of Aluminium and Alloys.” Special care shall be taken to grind smooth all welded surface that shall remain exposed to view. Welds shall be electrically continuous if so required by the Engineer.

2.01.03 Shop Coat

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill seals, rust and foreign matter. Except where encased in concrete, all steelwork shall be given one coat of approved metal protective paint, applied be brush thoroughly and evenly, well worked into joints and other open spaces. All paint shall be applied to dry surfaces. When specified steel work shall be galvanised or painted with a coat of zinc chromate primer. Aluminium surfaces, which shall come in contact with masonry, shall be given one coat of bituminous paint.

2.02.00 Erection

2.02.01 Bracing

The Contractor shall provide all necessary temporary guys and braces to ensure alignment and stability of the members and to take care of all loads to which the structure may be subjected, including erection of equipment and operation of the same.

2.02.02 Temporary Bolting-Up

As erection proceeds the Contractor shall plum up and level all members and shall securely bolt up to take care of all dead load, wind load and erection stresses. Wherever erection equipment or other loads are carried by members during erection, proper provision shall be made to take care of the stresses resulting from the same.

2.02.03 Turned Bolt

For field connections where bolting is specified, holes for the turned bolts may be reamed in the field, if required. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled.

2.02.04 Welding

Where specified on drawings, welding shall be done in accordance with IS: 816 for steel and IS: 2812 for Aluminium & Alloys.

2.02.05 Cutting and Fitting

No cutting of sections, flanges, webs of angles shall be done without the approval of the Engineer. Where indicated on the drawings holes, cuttings, etc. shall be provided as required for installation, to the work by the other Contractors. No additional holes or cuttings, than those shown on drawings, shall be made without the approval of the Engineer.

2.02.06 Drifting

Correction minor misfits and a reasonable amount of reading and cutting of excess stock from rivets may be permitted. For this, light drifting may be allowed to draw holes together. Twist drills shall be used to enlarge as necessary to make connections, reaming that weakness the members or make it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins or a moderate amount or reaming and slight

chipping and cutting shall immediately be called to the attention of the Engineer-and approval of the method of correction obtained. The use of cutting torches to enlarge or alter rivet holes shall not be permitted.

2.02.07 Spot Painting

All field rivets and bolts and also any serious abrasion to shop paint shall be spot painted with the same materials and used for the shop paint or equivalent.

2.02.08 Good

All cutting to concrete or masonry shall be made good to the satisfaction of the Engineer.

2.02.09 Grouting

All bearing plates, loose, lintels and beams, etc. shall be set to proper grade and level by the Contractor and the Engineer's approval obtained before proceeding with the grouting. Grouting shall be done in 1:1½:3 concrete with 6 mm down stone chips or as specified in schedule of items.

2.02.10 Anchor Fasteners

The anchor fasteners shall be of two type viz. light duty for carrying tensile load upto 0.5MT per fasteners and heavy duty for carrying tensile load of 0.5MT to 5.0MT per fasteners. These anchor fasteners shall be fixed into concrete. The Contractor shall submit the Manufacture's literature showing the average pull out and average shear value for anchor of various sizes. Anchors shall be fixed in position strictly as per the manufacturers instructions and as approved by the Engineer.

Heavy Duty Anchor Fasteners

The safe tensile load carrying capacity of the anchors shall be arrived by providing the minimum factor of capacity of 2.5 for the characteristic load of the anchor. Minimum size of anchor shall be M8 (8mm). All anchors shall be from the approved manufacturers like HILTI or equivalent.

a) Anchor fasteners shall be supplied and fixed in position by the contractor. Anchor fasteners can be of mechanical bonding or chemical bonding.
b) Capacity of the anchor shall be established after considering the effect of concrete grade, embedment depth, concrete thickness, anchor spacing and edge distance from the concrete edge.
c) The selection for the particular type of bonding for the anchors shall be made after considering the concrete grade, available embedment depth, load to be transferred, space available for installing anchors.
d) The mechanical bonding anchor are torque controlled anchors made from carbon steel of grade 8.8 as per IS:1367 part 3. Anchors in bolt as well as

nut version are acceptable. The bolt version anchors consists of bolt washer, sleeves, plastic section, expansion sleeves and a cone. Nuts version anchor consists of nuts, threaded rod, washer, sleeves, plastic section, expansion sleeves and a cone. All steel component of anchor shall be electro galvanised to minimum 5 micron coating thickness. The plastic section shall be of polyacetal Derlin 100 or equivalent.

e) Chemical bonding anchor shall consist of foil capsule and threaded rod. The foil capsule shall contain the resin and hardener. The threaded rod shall have chiselled tip. The behaviour of anchors under fire shall conform the heating curves as per ISO:834. Anchors of size M8 to M24 shall conform to grade 5.8 and anchors of size M27 to M39 shall conform to grade 8.8 as per IS:1367 part 3. All steel components of the anchors shall be electro-galvanised to minimum 5 micron thickness.

Light Duty Anchors

This anchor shall comprise of stud, nut, washers, expansion sleeve. The one end of the stud shall have thread and the other end shall have cold formed conical head. All steel components of the anchors shall be electro-galvanised to minimum 5 micron thickness. The expansion sleeve shall preferably be of stainless steel of SS316. The anchors shall conform to minimum grade 5.8 as per IS:1367 part 3.

2.02.11 Pipe Joints

MS pipes or GI pipes shall be joined by threaded sockets or by welding. Cast iron pipes shall be socket and spigot joined and caulked with hemp and molten head.

2.03.0 FENCING

2.03.01 Chain Link Fencing

The material requirement shall conform to IS: 2721 latest edition. The chain link fencing shall be woven from 3.15mm dia. wire with mesh size of 50mm. The mesh wire shall not vary from specified dia. by more then $\pm$0.05mm. all steel wire shall be hot dipped galvanised wire. The dia shall be measured over the galvanised coating. The line wire shall be 4.0mm dia. mild steel. The stirrup wire for securing the line wire to the intermediate post (RCC/structural steel) shall be 2.5 mm diameter mild steel. The tying wire for securing the chain link fencing to the line wire shall be 1.6mm diameter mild steel. Hair pin chain staples for fastening down the bottom of galvanised chain line fencing to the concrete sill shall be 3.15mm wire. The ends shall be bent outwards for securing anchorage.

Cleat for eye bolts shall be of uniform size and shall consist of mild steel angle of 75 x 50 x 8 mm. The eye bolts strainer shall consist of bolt with welded eye

sufficiently threaded and fitted with a nut and washer. Two-way eye bolt strainer shall have suitable ring nuts fitted after the wires have been strained on one side. Stretcher bar shall consist of mild steel flats 25 x 4.75 mm. They shall be secured to the cleats by steel bolts.

The chain link fencing shall be strained between each pair of straining posts and secured to each straining posts by means of a stretcher bar. One of top line wire shall be threaded through appropriate adjacent row of mesh, care being taken that no meshes in the row are bypassed by the line wire except where deviation is necessary at the straining posts. The second top line wire shall be strained in front of the fencing. The fencing shall be attached to the top and bottom line wire by wire ties spaced at 150mm apart and to the other middle line wire by wire ties spaced at 450mm apart.

The bottom of fencing shall be treated as follows:
Continuous concrete sill 125mm wide x 225mm high for full length between posts shall be cast with the top 25mm above GL and 25mm below the chain link fencing. Hair pin staples shall be threaded through the bottom row of mesh at 750mm c/c and set in the sill to a depth of 150mm.

2.03.02 Barbed Wire Fencing

The barbed wire shall be conform to IS:278 latest edition. The barded wire shall be galvanised and galvanising shall conform to the requirement laid down for 'light-coated wire' of IS:4826 and it shall be smooth and relatively free of lumps etc. Wire with excessive roughness blisters, salammoniac spots shall be rejected. The barbed wire shall be made from two line wire and two point wire of 2.5 mm thickness each. The barbs shall have four point and shall be formed by twisting two point wires, each two turns, tightly around both or one line wire (Type A - around both line wire, Type B - around one line wire) making altogether four complete turns. The barbs shall be so finished that four points are set and located or locked as far as possible at right angle to each other. The barbs shall have a length of not less then 13mm and not more than 18mm. The distance between two barbs shall be 75$\pm$12mm.

Straining posts shall be provided at all ends and corners of fences or at changes in direction or acute variation in level and at intervals not exceeding 66 M on straight lengths of fence. Intermediate posts shall be spaced at regular intervals not exceeding 3.0m. Struts shall be fitted to all straining posts behind the chain link fabric in the direction of line of fence. There shall be four evenly spaced row of line wire in all. The top line wire shall be doubled, making five line wire in all. The bottom wire shall be closed to the ground. Each line wire shall be strained tightly by means of eyebolts strainers or winders at each straining points. Each line wire shall be secured to each intermediate post by a wire stirrup passed through a hold in the post and secured to the line wire by three complete turns on each sides of the post. The barbed wire shall be fitted with one dropper at the centre of each bay, secured

to the wire so that they could not be bunched together. Droppers for barbed wire shall be of mild steel of not less then 25 x 4.75 mm thick with 38 x 4.85 mm half round staples for fastening the barbed wire to them. Bracing for the rows of barbed wire shall be approved by the Engineer.

3.00.00 ACCEPTANCE CRITERIA

a) All items shall be correct shape, size, weight etc. shown on drawings and schedule of items.

b) For installed items, the tolerances shall be as follows

i) Permissible deviation from, straightness – 1 in 1000.

ii) Seats, stiffener connections etc. shall be as per approved drawings and shall not interfere with architectural clearances.

c) All castings shall be free from blowholes, cracks, and other blemishes.

d) All MS wire fencing shall be in true vertical plain, and shall not bulge.

4.00.00 IS CODES

IS:278	Specification for Galvanised Steel Barbed wire for fencing.
IS:816	Code of practice for use of Metal Arc welding for general construction in mild steel.
IS:1367	Industrial Fasteners – Threaded steel fasteners - Technical supply condition.
IS:2721	Specification for Galvanised Steel Chain Link fence fabric.
IS:2812	Arc welding of Aluminum and Alloy

5.00.00 RATES AND MEASURMENTS

5.01.0 Rates

Rates shall include supply, fabrication and installation for misc. metals works as required for completion of works like gates, fencing, handrails, ladders, hangers, anchors etc., unless otherwise specified in Schedule of Items.
Rate for fencing shall also include excavation, concreting and supply, erection & fabrication of post (post made of either structural steel or reinforced cement concrete), unless any specific item is excluded.

5.02.0 Measurements

Measurement for MS gates shall be in MT.

Measurement for galvanised MS wire fencing shall be in Sqm.

Measurement for Anchors shall be in nos. for the type as specified in schedule of items.

Measurement of other misc. metals shall be done in MT unless otherwise specified in schedule of items.

VOLUME: II B

SECTION - D

SUB-SECTION – D9

MASONRY AND ALLIED WORKS

SPECIFICATION NO. PE-TS-999-600-C009

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	PAGE NO.
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5.00.00	RATES AND MEASUREMENTS	11

MASONRY AND ALLIED WORKS

1.00.00 SCOPE

This section covers furnishing, installation including handling, transporting, batching, mixing, laying scaffolding, centering, shuttering, finishing, curing, protection, maintenance and repair of common building materials till handing over of masonry and allied works for use in structures and locations covered under the scope of this package.

2.00.00 MATERIALS

a) Brick

Bricks for general masonry work shall be of class designation 7.5 of nominal dimensions as per standard specification under IS: 1077, well burnt, of uniform size, shape and colour, free from cracks, flaws or modules of free lime and emit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, lumps holes etc. Water absorption after 24 hours immersion shall not exceed 20% by weight for bricks. Dimensional tolerance shall not exceed 8% of the size shown in drawings for bricks. All bricks shall have rectangular faces and sharp straight edges. The bricks shall show no efflorescence after soaking in water and drying in shade.

Each brick shall have the manufacturer's identification marks clearly marked on the frog. Representative samples shall be submitted and approved samples shall be retained by the Engineer for further comparisons and reference. Any brick not found up to the specification shall be removed immediately from site at the Contractor's own cost.

Bricks shall not be dumped at site. They shall be stacked in regular tiers, even as they are unloaded; to minimize breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately.

b) Stone

All stones shall be obtained from approved quarries, hard, tough, durable compact grained, uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean, and sharp and shall show uniformity of texture, without

loose grains and free from any dull, chalky, or earthly appearance. Stone showing mottled colours shall not be used for face work. A stone shall not absorb more than 5 per cent of its weight of water after 24 hours immersion. The type of stone shall be as specified on drawings and/or instructed by the Engineer. Samples shall be submitted by the Contractor and approved samples shall be retained by the Engineer for comparison of bulk supply.

c) Cement

Cement used shall be Ordinarily Portland Cement or Portland Slag Cement or Portland Pozzolana Cement conforming to IS Codes and shall be fresh when delivered. In special cases, Rapid Hardening Portland Cement, Low Heat Cement etc. may be permitted or directed to be used by the Engineer. The Contractor shall submit the manufacturer's certificate for each consignment of cement procured to the Engineer. If at any time, the Engineer feels that the cement being used by the Contractor is not up to specification, he may stop the work and send the samples of the cement to a testing laboratory for standard tests and all expenses incurred thus shall be borne by the Contractor. The Contractor shall also have no claim for this type of suspension of work.

The cement shall be stored above the ground level in perfectly dry and watertight sheds. The bags shall be stacked in a manner so as to facilitate removal or first in first out basis. Any material considered defective by the Engineer shall not be used by the Contractor and shall be removed from the site immediately.

d) Coarse Aggregate

Coarse aggregates shall be as per IS: 383 latest editions, consisting of hard, strong and durable pieces of crushed stone and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles etc. and any other material liable to affect the strength, durability or appearance of concrete.

Aggregates other than crushed stone conforming to the provisions of specification may be used if permitted by the Engineer.

Washing of aggregates by approved means shall be carried out, if desired by the Engineer.

Grading of coarse aggregates shall generally conform to IS: 383 and shall be such as to produce a dense concrete or the specified proportions and strength and of consistence that will work readily into position without

segregation.

Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass, or any other injurious substances at any stage.
Aggregate of different size shall be kept in separate stacks. If so desired by the Engineer aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

e) Sand

Sand shall be hard, durable, clean, and free from adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of mortar, plaster or concrete or to cause corrosion to any metal in contact with such mortar, plaster or concrete. All sand shall be properly graded and shall be as per relevant IS Code. Sand for concrete shall conform to IS: 383.

f) Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc.

g) Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings, which may impair proper bond. Structural steel shall conform to IS: 2062. Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement shall conform to IS: 432. Cold twisted steel bars shall conform to IS: 1786. Hand drawn steel wire fabric shall conform to IS: 1566. Hexagonal wire netting shall conform to IS: 3150. All steel bars including and above 10 mm diameter shall be of tested quality. All wire netting shall be galvanized.

Reinforcement bars shall be stored off the ground and under cover if so desired by the Engineer. If necessary, a coat of cement wash shall be given to the bars to guard against rusting.

3.00.00 INSTALLATION

3:01.00 Soling

3.01.01 Brick Soling

The ground shall be dressed, consolidated by ramming, or by light rolling and a 12 mm thick cushion of sand laid. On the sand cushion the bricks shall be laid with fine joints and placed firmly in position by hammering with wooden mallet. The surface shall be free from undulations. The 'frog' side shall be on the underside. The joints shall be broken the in all direction and bricks cut as required. The pattern of laying and number of layers shall be as per Schedule of item. Orientation shall be as desired by the Engineer. After laying of each layer of bricks sand shall be spread over and worked into the joints to pack the bricks tight.

3.01.02 Stone Soling

The stones for soling shall be selected on the basis of thickness of soling specified in the Schedule of Items. The larger stones shall be laid and the gaps filled by smaller stones. The interstices shall then be firmly packed with sand by flooding with water.

3.02.00 Brick-on-Edge

Excavation shall be done close to the brick dimensions and in perfect alignment. Bricks shall be firmly placed by hammering with wooden mallets and sides and joints packed firmly with earth so that the edging is not disturbed easily. Alignment and level shall be acceptable to the Engineer.

3.03.00 Masonry

3.03.01 General

All masonry work shall be true to lines and levels as shown on drawings. All masonry shall be tightly built against structural members and bonded with dowels, inserts etc. as shown on drawings.

3.03.02 Cement Mortar

Cement mortar shall be prepared with materials specified in clause 2.00.00. Sand for masonry mortar shall conform to IS: 2116. Cement and sand in the specified proportion shall be mixed dry thoroughly and minimum water added to attain required workability.

Surplus mortar droppings from masonry, if received on surface free from dirt may be mixed with fresh mortar if permitted by the Engineer who may direct addition of additional cement without any extra payment. No mortar, which has stood for more than half an hour, shall be used.

3.03.03 Brick Masonry

Bricks shall be soaked by submergence in clean water for at least two hours in approved vats before use. Bricks shall be laid in English bond unless specified otherwise. Broken bricks shall not be used. Cut bricks shall be used if necessary to complete bond or as closers. Bricks shall be laid with frogs upwards over full mortar beds. Bricks shall be pressed into mortar and tapped into final position so as to embed fully in mortar. Inside faces shall be buttered with mortar before the next bricks is placed and pressed against it. Thus all joints between bricks shall be fully filled with mortar.

Mortar joints shall be kept uniformly 10 mm thick. All joints on face shall be raked to minimum 10 mm depth using raking tool while the mortar is still green to provide bond for plaster or pointing.

Where plaster or pointing is not provided, the joints shall be struck flush and finished immediately. Brickworks two bricks thick or more shall have both faces in true plane. Brickwork of lesser thickness shall have one selected face in true plane.

3.03.04 Exposed Brickwork

Brickwork in superstructures, which is not covered by plaster, shall be as shown on drawing and executed by specially skilled mason. Courses shall be truly horizontal and vertical joints truly vertical. Wooden straight edges with brick course graduations and position of window sills and lintels shall be used to control uniformity of brick courses. Masons must check workmanship frequently with plumb, spirit level, rule, and string. All brickwork shall be cleaned at the end of days work. If face bricks are specified, the brickwork shall be in composite bricks, with face bricks on the exposed face and balance in routine bricks, but maintaining the bond fully. Where face bricks are not specified, bricks for the exposed face shall be specially selected from routine bricks. All exposed brickwork on completion of work shall be rubbed down, washed clean, and pointed as specified. Where face bricks are used carborandum stone shall be used for rubbing down.

3.03.05 Reinforced Brickworks

Reinforcements shall be as specified. All reinforcements shall be thoroughly cleaned and fully embedded in mortar. Where M.S. bars are used as reinforcement, these shall be lapped with dowels if left in R.C. columns or welded to steel stanchions.

3.03.06 Stone Masonry

Stones shall be thoroughly soaked before laying. Stones shall be laid on their natural quarry beds. Individual stones shall be fitted with mallet and properly wedged to reduce thickness of mortar joints. Thickness of joint shall be not less than 8 mm and not greater than 25 mm. At least two stones shall run the full width of the wall for every square meter of surface area.

3.03.07 Exposed Stone work

Stonework, which is to be kept exposed, shall be as shown on approved drawing. It shall be executed by specially skilled mason. Stones used for exposed face shall be specially selected. All exposed stone faces shall be kept clean and free from mortar and pointed up neatly as the work proceeds in a manner called for in the drawings or instructions. A sample wall, 10 Sq.M. area shall be built and approved by the Engineer and all works shall match with this sample.

3.03.08 Composite Masonry

Where stonework facing with brick masonry backing is specified the bond between them shall be achieved by bond stones of dimensions and frequency as desired by the Engineer.

3.03.09 Expansion & Separation Joints

Location of joints shall strictly be as shown on drawings or as instructed by the Engineer. Expansion joints shall be as shown on drawings and specified. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall meet the approval of the Engineer.

Separation joints shall be with standard waterproof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Engineer.

3.03.10 Mouldings, Cornices, Drip Course

These shall be made as shown in drawings. Bricks or stone shall be cut and dressed as required. If no subsequent finish is envisaged, these shall be rubbed to correct profile with Carborundum stone.

3.03.11 Curing

Masonry shall be cured by keeping it wet for seven days from the date of laying. In dry weather at the end of days work top surface of masonry shall be kept wet by ponding.

3.03.12 Embedding of fixtures

All fixtures shall generally be embedded in mortar and masonry units shall be cut as required.

3.03.13 Encasing of Structural Steel

This shall be done by building masonry work round flanges, webs etc., and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh when shown on drawings or instructed by the Engineer. The minimum lap in chicken wire mesh shall be 50 mm.

3.04.00 Damp Proof Course (DPC)

Unless otherwise specified Damp-proof course shall be 40 mm thick 'artificial stone' in proportion 1:1½:3 cement sand stone-chips (10 mm down) with admixture of a waterproofing compound as approved by the Engineer. The percentage of admixture shall be as per manufacturer's specifications but not less than 2% by weight of cement. The top surface shall be double chequered and cured by ponding for seven days.

3.05.00 Damp Proof Membrane

Damp proof treatment using fibre or hessian base bitumen felt shall be 6, 8 or 10 course treatment as specified in IS: 1609. The number of courses shall be as shown as drawings or as specified. Sequence of work shall be as directed by the Engineer. Extreme care shall be taken to prevent damage to felt during and after laying. The Contractor shall be obliged, at his own expense, to rectify any leakage appearing within 5 years of installation by removing and renewing the coats at the point of leakage.

Where shown on drawing, damp proof membrane with one layer bitumen paper or one layer alkathene sheet shall be laid with minimum 150 mm lap under slabs on grade.

3.05.00 Plinth Protection

Plinth of buildings shall be protected with brick-on-edge paving of minimum 750mm width unless otherwise shown on the drawings. The treatment shall

consist of laying bricks in cement mortar 1:6 (1 cement: 6 sand) over a 75mm thick bed of dry graded brick aggregate, 40mm nominal size, grouted with sand. The top shall be finished with 1:2 cement mortar pointing (1 cement: 2 sand). Plinth protection shall be laid with a minimum outward slope of 1 in 50. The brick aggregate shall be well graded, broken from well burnt or slightly overbumt and dense brickbats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dirt or any other foreign matter.

The ground shall first be prepared to the required slope around the building. The high portions of the ground should be cut down; hollows and depressions filled up to the required level from the excavated earth and rammed so as to give uniform outward slope. The bed shall be watered and rammed with heavy iron square rammers. Surplus earth, if any, shall be disposed off beyond a lead of 50m or as directed by the Engineer.

Over this, 75mm thick bed of aggregate of 40mm nominal size, shall be laid with a minimum outward slope of 1 in 50. Aggregates shall be carefully laid and packed, bigger sized being placed at the bottom. The brick aggregates shall be consolidated dry with heavy iron rammers.

The aggregates shall then be grouted evenly with sand at the rate of 0.6 cubic metre per square metre area, adequately watered to ensure filling of voids by sand and again rammed with heavy iron rammers. The finished surface shall give uniform appearance. After the subgrade has been compacted thoroughly, brick flooring with bricks of specified strength in cement mortar 1:6 (1 cement: 6 sand) shall be laid.

The bricks shall be laid on edge in Diagonal/Herring Bone Bond or other paftem as specified or as directed by the Engineer. Bricks shall be laid on 12mm thick mortar bed and each brick shall be properly bedded and set home by gentle tapping with handle of trowel or wooden mallet. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. On completion of the portion of flooring, the vertical joints shall be fully filled from the top with mortar. The surface shall present a true plain surface with the required slope.

The pointing shall be done in cement mortar 1:2 (1 cement: 2 sand). The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the bricks so as give a smooth appearance. The edges shall be neatly trimmed with a trowel and a straight edge. The mortar shall not spread over surface of the masonry.

Brick flooring & pointing shall be kept wet for a minimum period of seven days. These shall be protected from rain by suitable covering when the mortar is green.

4.00.00 I.S. CODES

Some of the important relevant codes for this section are:

IS: 1127: Recommendations for dimensions and workmanship of natural building stones for masonry work.

IS: 1597: Code of Practice for Construction of stone Masonry.

IS: 1609: Code of Practice for laying Damp proof treatment using bitumen felts.

IS: 2212: Code of Practice for Brickwork.

IS: 2250: Code of Practice for preparation and use of masonry Mortar.

IS: 5134: Bitumen Impregnated Paper & Board.

5.00.00 RATES AND MEASUREMENTS

5.01.00 Rates

Unit rate for masonry work shall include the following:

a) Raking out joints for plastering or pointing or finishing the joint flush as the work proceeds.

b) Preparing top sand sides of existing wall for joining old with new work.

c) Providing, dismantling and removing the scaffolding.

Unit rate for DPC shall be inclusive of formwork and bitumen painting.

5.02.00 Measurement

Brickwork in wall of half brick thickness shall be measured separately in Sqm stating the wall thickness and more than half brick thickness shall be measured by volume. Plaster thickness shall not be considered for computation of volume.

Masonry work in sub structure and super structure shall be measured separately, unless otherwise specified in the Schedule of items.

No deductions shall be made and no extra payment shall be made for following:

a) Opening upto 0.1 Sqm each in area. In calculating the area of the opening lintels or sills shall be included along with the size of the opening.

b) Drainage holes and recesses for cement blocks to embed holdfasts for doors, windows etc.

c) Pipe and fixtures upto 300mm dia. and nothing extra shall be paid for the mortar used for fixing.

d) Ends of dissimilar materials (i.e. joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc); up to 0.1 sqm in section;

e) Chases of section not exceeding 50 cm in girth;

f) Iron fixtures, such as wall ties and hold fasts for doors and windows;

g) Cement concrete blocks as fcr hold fasts and holding down bolts;

h) Wall plates, bed plaros, and bearing of slabs, CHAJJAS and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;

Reinforcement in masonry work shall be paid separately under respective items.

Damp proof course shall be measured in Sqm. No deduction shall be made and no extra shall be paid for opening upto 0.1 Sqm in area.

Plinth protection shall be measured under respective item of works executed required for completion of the work as specified.

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SECTION - D

SUB-SECTION – D10

FINISH TO MASONRY AND CONCRETE

SPECIFICATION NO. PE-TS-999-600-C010

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
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3.00.00	ACCEPTANCE CRITERIA	8
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FINISH TO MASONRY AND CONCRETE

1.00.00 SCOPE

This Section covers finishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of finishing items for masonry and concrete. This shall also include the work to be done to make the surface suitable for receiving the finishing treatment.

Before commencing finishing items the Contractor shall obtain the approval of the Engineer regarding the scheduling of work to minimize damage by other trades. He shall also undertake normal precaution to prevent damage or disfiguration to work of other trades or other installation.

2.00.01 INSTALLATION

2.01.00 Preparation of Surface

All joints in masonry walls 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. Walls shall be rushed down with stiff wire brush to remove all loose dust from joints and thoroughly, washed with water. All laitance shall be removed from concrete to be plastered.

For all types of flooring, skirting and dado work, the base cement concrete slab or masonry surface shall be roughened by chipping and cleaned of all dirt, grease or loose particles by hard brush and water. The surface shall be thoroughly moist to prevent absorption of water from the base course. Any excess of water shall be mopped up.

At any point, the level of base shall be lower than the theoretical finished floor level by the thickness of floor finish. Any chipping or filling to be done to bring the base in the required level shall be brought to the notice of the Engineer and his approval shall be taken regarding the method and extent of rectification work required.

Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as to the acceptability of the base.

2.02.00 PLASTERING

2.02.01 Mortar

Mortar for plastering shall be as specified.
For sand cement plaster, sand and cement in the specified proportion shall be mixed dry, on a watertight platform and minimum water added to achieve

working consistency. The sand for plaster shall conform to IS: 1542.

No plaster, which has stood for more than half an hour, shall be used; plaster that shows tendency to become dry before this time shall have water added to it.

2.02.02 Application of Plaster

Plaster, when more than 12 mm thick, shall be applied in two coats a base coat followed by the finishing coat. Thickness of the base coat shall be sufficient to fill up all unevenness in the surface; no single coat, however, shall exceed 12 mm in thickness. 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 undercoat 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 150 mm square or wooden screed 75 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 the Owner, make up any irregularity in the brickwork with plaster.

All vertical edges of brick pillars, doorjambs etc. shall be chamfered or rounded off as directed by the Engineer. All drips, grooves, mouldings and cornices as shown on drawing or instructed by the Engineer shall be done with special care to maintain true lines, levels and profiles. After the plastering work is completed, all debris shall be removed and the area left clean. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

2.02.03 Finish

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, color and finish.

a) Standard Finish

Wherever punning is 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.

b) 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.

c) Coloured Plaster Finish

This shall be done in the same way as specified in Clause 2.02.02 but using Coloured cement in place of ordinary cement. When coloured plastering is specified in more than one coat, the topcoat only shall be made with coloured cement.

Coloured cement shall be either ready mixed material or may be obtained by mixing pigments and cement at site, as approved by the Engineer. The pigments to be mixed with cement shall conform to Appendix-A of IS: 2114 latest editions.

Samples of colouring material shall be submitted to the engineer for approval and material procured, shall conform in all respects to the approved samples, which shall remain with the Engineer. All coloured cement and/or pigments shall be stored in an approved manner in order to prevent deteriorations.

d) Pebble-dash Finish

Mortar of required thickness consisting of 1 part cement and 4 parts sand by volume shall be applied in the usual manner as described under plastering Clause 2.02.02. While the mortar is still plastic small pebbles or crushed stone of size generally from 10mm to 20mm as approved by the Engineer shall be thrown on the plastered surface. The aggregate shall be lightly tapped into the mortar with a wood float or the flat end of oil a trowel, in order to ensure satisfactory bond between the dashing and the mortar.

e) Rough-cast Finish

A wet plastic mix of 3 parts coloured cement 6 parts sand and 4 parts aggregate by volume (gravel or crushed stone of size from 6 mm to 12 as approved by the Engineer) shall be thrown on to the wall by means of a plaster's trowel and left in the rough condition.

f) Scraped Finish

Ordinary plaster as described under Clause 2.02.02 after being leveled and allowed to stiffen for a few hours, shall be scraped with a steel straight edge to remove the surface skin. The pattern shall be as approved by the

Engineer.

g) Textured Finish

Mortar consisting of 1 part cement and 3 parts sand by volume shall be applied in a manner as specified under "Plastering" Clause 2.2.2 Ornamental treatments in the form of horizontal or vertical rib texture fan texture etc. shall be applied by means of suitable tools to the freshly applied plastered surface, as approved by the Engineer.

h) Sand Faced Plaster

The plaster shall be applied in 2 coats. The first coat or the scratch coat should be approximately 14mm and shall be continuously carried out without break to the full length of wall or natural breaking points such as doors, windows, etc. The scratch coat shall be dashed on the prepared surface with heavy pressure, brought to true and even surface and then lightly roughened by cross scratch lines, to provide bond for the finishing coat. The mortar proportion for this scratch coat shall be as specified in the respective item or work. The scratch coat shall be cured for at least 7 days & then allowed to dry. The second coat shall be 6mm thick and it shall not be applied until at least 10 days have elapsed after the application of scratch coat. Before application of the second coat, the scratch coat shall be evenly damped. This coat shall be applied from top to bottom in one operation & without joints; finish shall be straight, true, & even. The mortar of this coat shall be as specified under the respective item of work. White sand for finish shall be used for the second coat & for finishing work. Sand for finish shall be of even coarse size & shall be dashed on the surface & sponged.

2.02.04 Curing

All plastered surfaces after laying shall be watered, 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 commence, as soon as the plaster has hardened sufficiently and 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.

2.03.00 Pointing to masonry

All Joints of brickwork shall be raked out to a depth of 10 mm with a hooked tool made for the purpose while the mortar is still green. The brickwork shall then be brushed down with a stiff wire brush, so as to remove all loose dust from the joints and thoroughly washed with water. Mortar consisting of 1 part cement and 3 parts clean, sharp, well graded sand by volume shall be pressed carefully into the joints and finishes with suitably tools to shape as shown on

the drawings. Any surplus mortar shall be scalped off the wall face leaving the surface clean.

The pointed surface shall be kept wet for at least three days for curing.

2.04.00 Plaster with Metal Lath

The supports, hangers, brackets, cleats etc. shall be as shown on drawings and/or as approved by the Engineer. These shall have a coat of prime paint before and another coat of approved paint after erection.

The metal lath shall be expanded metal, with 12 mm x 38 mm mesh, 16 thick and 3 mm wide strands. Side laps shall be minimum 12 mm and end laps 25 mm minimum. The plastering shall be minimum 20 mm thick measured from the back of lath and applied in two-layers. The mortar for plastering shall consist of 1 part cement and 4 parts sand by volume mixed as specified in plastering, Clause 2.02.01. The application, finish etc. shall be as specified under relevant clause above. Where called for a 2 mm Plaster of Paris punting shall be applied over plaster as a finishing coat to give perfectly smooth and even finish.

2.05.00 Lime Punning

For plastered surfaces, where an even smooth surface is specified, lime punning with 5 parts of shell lime properly slaked, strained and aged, mixed with 1 part clean, washed, sieved, fine sand by volume shall be done. The thickness of lime punning shall be not less than 2 mm and more than 3 mm. The plastered surface shall be saturated with water before application of the lime punning. The punting shall be applied by skilled workman and given a smooth and ever finish free from undulations, cracks etc. and to the satisfaction of the Engineer.

2.06.00 Plaster of Paris Punning

Plastered surfaces, where specified shall be finished with Plaster-of-Paris punning. The material shall be from approved manufacturers and approved by the Engineer. The thickness of the punning shall be 2 mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation, cracks etc.

Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 Sq.M. areas and approval of the Engineer taken. The work shall then be taken in hand as per approved sample.

2.07.00 Stone Facing

Stone facing where specified shall be done as shown on design drawings and

approved shop drawings. The stone shall be as specified on drawings. Samples of stone shall be submitted to the Engineer for approval and then bulk purchase made. The Contractor shall submit three copies of shop drawings for the Engineer's approval before commencing the work.

The thickness of facing stone shall be not less than 25 mm unless otherwise specified on drawings.

The stone slabs shall be cut and finished to sizes as per pattern shown on drawings. They shall be fastened to wall with suitable non-corrodible anchorage as approved by the Engineer. Where mild steel clamps, stays etc. are used for anchorage, they shall be galvanized (weight of zinc coating shall. not be less than 700 gms per square meter of surface) to prevent rust stains developing on the finished surface. There shall be at least 12 mm gap between the stone and masonry, which shall be filled up and packed by a mortar of 1 part cement and 3 parts of sand by volume. After the mortar is set and cured for at least four days, the exposed surface shall be rubbed and polished as approved by the Engineer.

The completed surface shall be neat, or uniform texture and acceptable to the Engineer.

Where pointing is specified on drawings it shall be done by mortar as specified on drawings.

3.00.00 ACCEPTANCE CRITERIA

Finish to masonry and concrete shall fully comply with the Specifications, approved samples and instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as mentioned in the body of the specification or as shown on drawings.

4.00.00 I.S. CODE

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: 1661: Code practice for cement and cement-lime plaster finish on wall & ceilings.

IS: 4101: code of practice for external facings and veneers.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall also include providing, dismantling and removing of scaffolding, surface preparation, curing and all type of surface, shapes/ profiles and at all elevations.

5.02.00 Measurement

All plastering shall be measured net (on surface area on which it is applied) in Sqm. Plaster work shall be classified according to the type used and shall be measured separately. Plaster on ceiling and walls shall be measured separately. Soffits of stairs shall measured as plastering on ceiling.

No deduction shall be made for opening not exceeding 0.5 Sqm and for ends of beams, joints, etc. also no payment shall be made for reveals, jams, soffits, sills of these openings.

50% deduction shall be made for opening exceeding 0.5 Sqm but not exceeding 3.0 Sqm each and no addition shall be made for reveals, jams, soffits, sills etc.

In case of opening exceeding 3.0 Sqm each, deduction shall be made for opening but jams, soffits, and reveals shall be measured and paid for.

VOLUME: II B

SECTION - D

SUB-SECTION – D11

PAINTING, WHITEWASHING, POLISHING

SPECIFICATION NO. PE-TS-999-600-C011

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.
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PAINTING, WHITE WASHING, POLISHING, ETC.

1.00.00 SCOPE

This section covers painting, white washing, varnishing, polishing etc. of both interior and exterior surfaces of wood work, masonry, concrete plastering, plaster of paris, false ceiling, structural and other miscellaneous steel items, rain water down comer, floor and roof drains, soil, waste and service water pipes, and other ferrous and non-ferrous metal items.

Copper, bronze, chromium plate, Nickel, stainless steel and aluminium shall generally not be painted or finished except if otherwise specified.

Before commencing painting, the Contractor shall obtain the approval of the Engineer in writing regarding the schedule of work to minimize damage; disfiguration or staining to work of other trades or other installations.

2.00.00 INSTALLATION

2.00.01 Materials

Materials shall be highest grade products or well-known approved manufacture 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. All materials shall be subject to inspection, analysis and approved by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade is obtained from the same manufacturing batch. Each and every supply of primer, finish paint etc. shall be accompanied by manufacturer’s test certificate. All paint shall be subject to analysis from random samples taken at site from painters bucket, if so desired by the Engineer.

All prime coats shall be compatible to the material of the surface to be finished as well as to the finished coats to be applied.

All unspecified materials such as snellac, turpentine or linseed oil shall be of the highest quality available and shall conform to the latest IS standards. All such materials shall be made by reputable recognized manufacturers and shall be approved by the Engineer.

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.

a) White Wash/Colour Wash

Shall be done from pure shell lime or fat lime, or a mixture of both as instructed by the engineer, and shall conform to IS: 712 latest editions. Samples of lime shall be submitted to the Engineer for approval, and lime as per approved sample shall be brought to site in unslaked condition. After slaking, it shall be allowed to remain in a tank for two days and then stirred up with a pole, until it attains the consistency of thin cream. 100 grams of gum to 6 liters of white wash water and a little of indigo or synthetic ultramarine blue shall be added to the lime. Mineral colour not affected by lime shall be added to white wash to get the required tint/shade approved by the Engineer.

b) Dry distemper

Shall be made from suitable pigments, extenders, lime proof tinters, water-soluble binders etc. and share conform to IS: 427. The distemper shall be diluted with prescribed thinner in a manner recommended by the manufacture. Only sufficient quantity of distemper required for a day's work shall be prepared.

c) Oil Bound Washable Distemper

Shall be of oil emulsion type containing suitable preservatives and shall conform to IS: 428. The distemper shall be diluted with prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for a day's work shall be prepared.

d) Waterproof Cement Paint

Shall be made from best quality white cement and lime resistant colours with accelerators, waterproofing agents and fungicides. The paint shall conform to IS: 5410.

e) Acrylic Emulsion Paint

Shall be water-based acrylic copolymer emulsion with rutile titanium dioxide and other selected pigments and fungicide conforming to IS: 5411 (Part-1). 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 blistering. 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, blistering, or peeling.

f) 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 resist interior surfaces. White and pastel shades shall not yellowing and darkening with aging. The paint shall conform to IS: 2932 and IS: 2933.

g) Aluminium Paint

Shall be in two pack containers and shall resist weathering. The paint shall conform to IS: 2339.

h) Varnishing

Shall be best quality alkyd varnish suitable for brushing over the tint of paint or light natural wood and shall not darken or yellow with age.

i) French Polish

Shall be made from best quality shellac, denatured spirit and other suitable alcohol soluble ingredients and made by a well known approved manufacturer. The material shall conform to IS: 348.

French polish shall not be used on bare wood it shall only be used as finishing coat on wood after the woods pretreated with a liquid wood filler conforming to IS: 345 is applied and rubbed out.

j) Bitumen paint (black bituminous anti-corrosive paint)

Bitumen based anti-corrosive paint conforming to IS: 158 shall be used.

2.00.02 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, & stains. Paint 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.

2.01.00 Preparation of surface

Before starting the work the Contractor shall obtain the approval of the Engineer regarding the soundness & readiness of the surface to be painted on.

2.01.02 Wood

All surfaces shall be free from, dirt and loose or peeling paints. The surface shall be rubbed down smooth. All nails & screws shall be sunk below the surface and filled with putty after applying an under coat. Small knots that do not justify cutting and sap streaks shall be covered with minimum 2 coats of pure shellace coating applied thinly & extended 25 mm beyond the area. All large, loose, or resinous knots shall be removed and filled with sound wood. All work shall be done as per IS: 2338.

2.01.02 Masonry, Concrete, and Plastered Surface

Surface shall be free from 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 resurfaces area shall be treated with minimum one coat of cement primer, which should be continued to the surrounding area for a distance of minimum 100 mm.

Surface with **Mildew or Efflorescence** shall be treated as below:

All mildewed surfaces shall be treated with an approved fungicide such as ammoniacal wash consisting of 7g of copper carbonate dissolved in 80ml liquor ammonia and diluted to water, or 2.5 percent magnesium silicofluoride solution and allowed to dry thoroughly before paint is applied.

2.01.03 Metal

The surface preparation shall be done in accordance with IS:1477(Part-1) 'Code of practice for painting of ferrous metals in building' and as directed by Engineer. All metal surfaces shall be absolutely clean, dry, and free from rust, scales, weld slag, flux deposit, wax, grease, dried soap films, foreign matters like cement mortar etc and free from existing loose red oxide zinc chromate primer and should be removed by means of wire brushes, hand scrappers, sand paper, emery cloth, emery papers, or by mechanical power tools etc. or as directed by Engineer. For exposed chemical resistant paints, surfaces shall be blast cleaned to near white metal. All galvanized iron surfaces shall be pretreated with a compatible primer according to the manufacturer's direction. Any abrasion in shop coat shall be touched up with the same quality of paint as the original coat. The actual painting work should be commenced only after obtaining clearance from the Engineer regarding proper cleaning of the surface.

2.02.00 Application

2.02.01 General

The method of application shall be as recommended by the manufacturer. In case of selection of special shades and colour (not available in standard shades) the Contractor shall mix different shades and prepare test panels of minimum size 1 meter square as per instruction of the Engineer and obtain his approval prior of application of finishing paints.

Proper tools and implements shall be used. Scaffoldings used shall be independent of the surface to be painted to avoid shade differences of the freshly repaired anchor notes.

Painting shall be done by skilled labours in a workmanlike manner. All materials shall be evenly applied so as to free of sags, runs, crawls, or other defects. All coats shall be of proper consistency. In case of application by brush, no brush marks shall be visible. The brushes shall be clean and in good condition before application of paint.

All priming undercoat for painting shall be applied by brush only, and rollers spray equipments etc. shall not be used.

No work shall be done under conditions that are unsuitable production of good results. No painting shall be done when plastering is in progress or is drying. Application of paint, which seals the surfaces to moisture shall only be done after the moisture on and below the surface has dried out.

All coats shall be thoroughly dry before succeeding coat is applied. Coats of painting as specified are intended to cover surfaces perfectly. In case the surface is not covered property by applying the specified number of coats, further coats shall be applied by the Contractor when so desired by the Engineer.

All primers and undercoats shall be tinted to approximate the colour of the finishing coats. Finished coats shall be of exact colour and shade as per approved samples and all finish shall be uniform in colour and texture. All parts of mouldings and ornaments shall be left clean and true to finish.

Painting on ferrous metal surface shall, be done as per IS: 1477 (Part I & 2). The total dry thickness of film should not be less than 120 Micron.

2.02.02 White Washing

The surface where white washing is to be applied shall be cleared of all loose materials and dirt. All holes and irregularities of the surface shall be filled up with lime putty and shall be allowed to dry up before white washing.

One coat of whitewash shall consist of one stroke from top downwards, another from bottom upwards over the first stroke and another from left to right before the previous one dries up. Second coat shall be applied and in case the Engineer feels that one or more coats are required the Contractor shall do so without any extra cost to the Owner. No brush marks shall show on the finished surface.

2.02.03 Dry Distemper

New plastered surface shall be allowed to dry for at least two months. New lime or lime cement plastered surface shall be washed with a solution of 1 part Vinegar to 12 parts water or 1:50 sulphuric acid solution and for 24 hours after which the wall shall be thoroughly washed with clean water. For cement-plastered surface, the surface shall be washed with solution of 100 gms. of zinc sulphate to 1 litre of water and allowed to dry.

Dry distempering shall be done as per manufacturers instruction. In applying the distempers the brush, should first be applied horizontally and immediately crossed off perpendicularly. Brushing shall not be continued too long, otherwise brush marks may result.

2.02.04 Oil bound washable distemper

The distemper shall be applied after surface is primed with an alkali resistant primer, and followed by minimum two coats of oil bound washable distemper all as per manufacturer's instruction.

2.02.05 Waterproof Cement Paint

Surface to be coated with cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After 4 to 6 hours, the water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours) the second coat shall be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

2.02.06 Acrylic Emulsion Paint

Paint shall be applied after providing one coat of cement primer solvent of approved quality and primer shall be conform to IS: 109. 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 done strictly as per manufacturer's specification.

2.02.07 Synthetic Enamel Paint

Shall be applied on properly primered surface. Subsequential coat shall not be applied till the previous coat is dry. The previous shall be lightly sand papered for better adhesion of subsequent coats.

2.02.08 Aluminium Paint

The paint, supplied in two pack containers shall be mixed and applied strictly as per manufacturer's direction. When more than one coat of paint is required or indicated, the next coat shall only be applied after the previous coat become hard dry.

2.02.09 Clear Synthetic Varnish

The Varnish shall be applied on wood surface after (a) filling, (b) staining & (c) sealing operations are carried out. The application of a combination of filler and stain shall not be permitted.

For the finishing coats of varnish, the surface shall be allowed to dry and be rubbed down lightly, wiped off and allowed to dry. Careful attention to cleanliness is required for varnishing. All dust and dirt shall be removed from the surface as well as from the neighbourhood. Damp atmosphere and draughts shall be avoided, and exposure to extreme heat or cold & dampness shall not be allowed.

The varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with light strokes to avoid frothing. It shall be allowed to flow on white the next section is being laid on excess varnish shall then be scrapped off the brush and the first section be crossed, recrossed and then laid off lightly. The varnish once it has begun to set shall not be retouched. In case of any mistake in application, the varnish shall be removed and the work started afresh.

The varnish shall be minimum of two coats, with the first coat being a flatting varnish. This shall be allowed to dry hard and be flatted down, before applying the next coat. Sufficient time must be allowed between coats to get a hard dry surface before next coat is applied. All work shall be as per relevant IS Code.

2.02.10 French polish

All unevenness of the surface shall be rubbed down to smoothness with sand paper and the surface shall well dusted .The pores in the shall be filled up with a paste of whitening in water or methylated spirit with a suitable pigment like burnt siemme or umber.

After application of the filler paste, the French polish shall be applied with a pad of woollen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles so that the polish is sparingly but uniformly applied over the entire area to give an even surface. A trace of linseed oil may be used on the pad for case of application. The surface shall be allowed to dry before further coats are applied in the same manner. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit, and rubbed lightly and quickly with circular motions to leave the finished surface with a uniform texture and high gloss.

2.02.11 Chemical Resistant Paint

For chemical resistant paints, epoxy, chlorinated rubber, or vinyl butryl paint system shall be used. Manufacturer's recommendation shall be followed regarding the paint system, exposed to moderately to severe corrosive condition and subject to acid/alkali spillage & fumes, shall be followed.

2.03.00 Protection

Furniture and other movable objects, equipment, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationary 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 instructions of the Engineer.

2.04.00 Cleaning up

In addition to provisions in general conditions the Contractor shall, upon completion of painting etc. remove all marks and make good surfaces, where paint has been splashed or splattered, including all equipment, fixtures, glass, furniture, fittings etc. to the satisfaction of the Engineer.

3.00.00 ACCEPTANCE CRITERIA AND TESTING

a) All painted surfaces shall be uniform and pleasing in appearance.

b) All varnished surfaces shall be of uniform texture and high glossy finish.

c) The colour, texture etc. shall match exactly with those of approved samples.

d) All stains, splashes, and splatters of paints and varnishes shall be removed from surrounding surfaces.

Testing

a) As, each part of the work is under progress, i.e. preparation of surface, providing primer, providing different coats of finishing paints, it shall be passed by the Engineer. Variation from the drawings or specification or standard etc. shall not be accepted. The Contractor shall ascertain from the Engineer as to which parts will be inspected and passed from time to time. The Contractor shall provide all necessary arrangement for inspection of the painting work during its different working phase. The Contractor shall provide necessary scaffolding, approach for inspection of the above as per direction and satisfaction of the Engineer. All the necessary cost for scaffolding, approach, platform, lighting arrangement testing and inspection shall be borne by the Contractor. Such inspection and testing will not, however, exonerate the Contractor from his responsibilities for proper workmanship, material etc.

b) The Contractor shall carry out all sampling and necessary testing in accordance with the relevant Indian Standards and shall conduct such tests as called for by the Engineer. Where no specific testing procedure is mentioned in the relevant codes, the tests shall be carried out as per the prevalent accepted Engineering practice as per the direction of the Engineer. Tests shall be done in a laboratory, approved by the Engineer, and cost of testing shall be borne by the contractor.

c) Material/workmanship unsuitable for acceptance shall he removed and replaced by the Contractor. The work shall be redone as per Specification of the contract and direction of the Engineer without extra cost to owner.

4.00.00 I.S. CODE

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: 348	Specification for French polish
IS: 427	Specification for Distemper, dry colour as required.
IS: 428	Specification for Distemper oil emulsion, colour as required.
IS: 1477 (I & II)	Code of Practice for painting of ferrous metal in buildings.

IS: 2338 (I & II)	Code of Practice for finishing of wood and wood based materials.
IS: 2339	Specification for Aluminium, Paints for general purposes in dual containers.
IS: 2395	Code of Practice for painting concrete, masonry, and Plaster surface.
IS: 2932	Specification for enamel, exterior type-1.
IS: 5410	Specification for cement paint, colour as required.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be unit rates for complete items described in the "Schedule of Items".

Rate shall include cleaning, preparation of surface, supply and application of primer, painting and providing all protection and scaffolding required at site.

5.02.00 Measurements

Painting over the concrete/masonry/wooden surface shall be measured net (on the surface area on which it is applied) in Sqm.

No deduction shall be made for opening not exceeding 0.5 Sqm and ends of beams, joints, etc. also no payment shall be made for reveals, jams, soffits, sill of these openings.

50% deduction shall be made for opening exceeding 0.5 Sqm but not exceeding 3.0 Sqm each and no addition shall be made for reveals, jams, soffits, sills etc.

In case of opening exceeding 3.0 Sqm each, deduction shall be made for opening but jams, soffits, and reveals shall be measured and paid for.

Corrugated surfaces shall be measured flat and measured area shall be increased by 15%.

Painting of structural steel works shall be measured in M.T. of fabricated steel (as per section D-17 clause 6.02.00 i.e Mode of measurement of technical specification for fabrication of structural steel works) unless specified otherwise.

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SECTION - D

SUB-SECTION – D12

FLOOR FINISH AND ALLIED WORKS

SPECIFICATION NO. PE-TS-999-600-C012

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Maharatna Company

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.
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FLOOR FINISH AND ALLIED WORKS

1.00.0 SCOPE

This section covers furnishing, installation, finishing, curing, testing, protection, maintenance till handing over various types of floor finishes, and allied items of work as listed below

a) In Situ Finishes

i) Integral finish to concrete base

ii) Terrazzo finish

iii) Granolithic finishes

iv) Patent Stone

v) Metallic Hardener like “Ironte”/Hardonate Finish

vi) Mastic Asphalt finishes

vii) Chemical Resistant finish

b) Tiled Finishes

i) Terrazzo tile

ii) Chequered tile

iii) Glazed tile

iv) Tesse rae (Mosaic etc.)

v) Chemical Resistant

vi) Rubber, Vinyl etc.

vii) Stone Slab including Kota Stone.

1.01.00 Base

The base to receive the finish is covered under other relevant specifications.

1.01.01 Sequence

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer in view the activities of other agencies working in that area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damages whatsoever till handing over.

2.00.00 INSTALLATION

2.00.01 Special Materials

Basic materials are covered elsewhere under the Specification. In general, all such materials shall be as per relevant Codes where available. In all cases these materials shall be of the best quality available indigenously unless specified otherwise.

The materials for finishing items must be procured from well-reputed specialized manufacturers and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintain in the construction schedule.

2.00.02 Workmanship

Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Engineer's permission, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Engineer so desires the Contractor shall get the finishing items installed by the manufacturer.

2.00.03 Preparation of the Base Surface

The surface to be treated shall be thoroughly examined by the Contractor. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work.

For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking out joints and cleaning thoroughly all dirts, grease etc. with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification.

To prevent of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up.
The surface shall be bone dry where adhesives are used for fixing the finishes.

Prior to commencement of actual finishing work the approval of the Engineer shall be taken as per the acceptability of the surface.

2.01.00 In Situ Finishes

2.01.01 Integral Finish To Concrete Base

While the surface of the concrete laid as per specification for 'Cement Concrete' has been fully compacted and levelled but the concrete is still `green' thick slurry, made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark or undulations. This finish shall be as thin as possible by using 2.2 kg. of cement per Sq.M. of area.

The surface shall be kept in shade for 24 hours and then cured for at least 7 days continuously by flooding with water. The surface shall not be subjected to any load or abrasion till 21 days after lying.

As desired by the Engineer the surface, while still 'green' shall be indented by pressing strings, the marking shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

2.01.02 Terrazzo Finish in Situ

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

a) Thickness

Unless otherwise specified the total thickness of the 'finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall be not less than 10 mm. While the topping shall be of uniform thickness the underbed may very in thickness to provide necessary slopes.The vertical surface shall project out 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to acc ate the specified thickness. All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

b) Mix

i) Underbed
The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 parts cement, 1½ parts sand and 3 parts stone chips by volume. For vertical surfaces the mix shall consist of 1 part cement to

3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency.

ii) Topping

The mix for the topping shall be composed of cement, colour Pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour texture and pattern approved by the Engineer. The cement shall be white or gray or a mixture of the two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1½ parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and nonfading. It must be very finely ground. The marble powder shall be from White marble and shall be finer than IS Seive No.: 30. The size of marble chips shall be between 1 mm to 20 mm. Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

c) Laying

The underbed shall be laid in panels. The panels shall not be more than 5 Sq.M. in area of which no side shall be more than 2.5 M. long. For exposed locations the maximum area of a panel shall be 2.0 Sq.M. The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbeds plus topping.

After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat “green” but firm enough to receive the topping. A slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled f or horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be trowelled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in a even pattern of distribution.

d) Curing

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

e) Grinding and Polish

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no.80) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping it moist and then ground with fine grit blocks (no.: 120). It shall again be cleaned with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no.: 320) to get smooth surface without any pinhole. A suitable machine shall do the grinding. Where grinding machine can not be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no.:60), second rubbing with medium grade (no.: 80) and final rubbing and polishing with fine grade (no.: 120). The surface shall be cleaned with water, dried, and covered with soil free, clean sawdust if directed by the Engineer. The final polishing shall be postponed till before handing over if desired by the Engineer. Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. per. Sq.M., water sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped off and the surface to be left glossy, but not slippery.

2.01.03 Granolithic Finish

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

a) Thickness

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

b) Mix

The mix shall consist of 1 part cement: 1 part coarse sand 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well graded between 6 mm and 12 mm. Minimum quantity of water to get workability shall be added.

c) Laying of Monolithic Topping

The concrete base shall be laid as per specification "Cement Concrete" and levelled upto the required grade. The form shall remain sufficiently protruding to take the finish.

Within about 3 hours of laying the base while it is still fully -green- the topping shall be laid evenly to proper thickness and grade. If considered necessary the surface ' of the base shall roughened by wire brushing. Unless manual operation is permitted by the Engineer, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly secure full bond with concrete base.

The laitance brought to the surface during compression shall be removed carefully without disturbing the stone chips. The surface shall then the lightly trowelled to remove all, marks. When sufficiently set, hand trowelling shall be done to secure a smooth surface without disturbing the stone chips.

For large areas the laying shall be in panels of maximum 25 Sq.M. area. The panels shall be laid in chequered board pattern.

d) Laying of Topping Separately on Hardened Base

The base concrete shall be prepared as stated in clause 2.00.03 and a slurry of neat cement applied just prior to laying the granolithic concrete mix (1:1:2). The method of compaction etc. shall be same as for monolithic topping.

Curing

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface had hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pounding of water on the surface. The floor shall not be exposed to heavy traffic during this period.

f) Grinding

If grinding is specified, it shall start only after the finish has fully set. Clause 2.01.02 (e) shall be followed. However, the Engineer shall decide upon the ultimate polish required.

g) Finishing

Where specified, sodium, silicate or magnesium or zinc silico fluoride treatment shall be done. The number of coats to be applied shall be as per

approved drawings or as instructed. The concentration and method of application of the solutions shall be as specified in IS: 5491.

2.01.04 Patent Stone

It shall consist of an underbed and a topping laid on an already laid and matured concrete base.

a) Thickness

The patent stone finish shall have thickness as stipulated under clause 2.01.02 (a) except that the topping shall be 12 mm thick.

b) Mix

i) Underbed

The mix shall be as stipulated under clause 2.01.02 (b).

ii) Topping

The mix for the topping shall consist of 1 part cement and 2 part stone aggregate 6mm nominal size by volume.

c) Laying

The Patent Stone finish including the underbed shall be laid in alternate bays or in Chequered board pattern. No panel shall be cast in contact with another already laid till the contraction of the latter has already taken place.

The maximum area of each panel shall be 3 Sq.M. of which no side shall be more than 2 M. long.

A cement grout shall be applied and worked into the surface to receive the finish; the underbed then laid, compacted, and leveled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set but firm enough and rolled and pressed to get full bond. The topping shall be trowelled to a dense finish to the satisfaction of the Engineer. All trowel marks shall be mopped out with a soft cloth to give a clean smooth surface.

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing. If desired the finish shall be polished as directed by the Engineer.

2.01.05 Metallic Hardener Like 'Ironite'/ `Hardonate' Finish

This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is `green'.

a) Thickness

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth.

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 when desired by the engineer, actual samples shall be tested.

c) Mix

Proportion of the 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 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 2 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 specification 'Cement Concrete' and levelled upto required grade. The forms, if any, shall remain sufficiently projecting to make the finish. The surface shall be roughened by wire brash as soon as possible.

The finish shall be laid while the concrete underbed is still very `green' within about 3 hours of laying of the latter. The finish shall be of uniform thickness and even dense surface without trowel marks, pin holes etc. This topping layer shall be pressed firmly and worked vigoursly and quickly to secure full bond with the concrete base. Just when the initial set starts the surface shall be finished smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

2.01.06 Mastic Asphalt Finish

This is a one-layer treatment on concrete or brick base.

a) Thickness

The thickness shall be as specified in the drawing.

b) Materials

Bitumen shall be industrial Bitumen of the grade 90/15 and 75/15 conforming to IS: 702.

Mineral filler shall be dry stone dust passing through 75 micron IS Sieve.

Fine aggregate shall be crushed and graded natural limestone or other hard work.

Coarse aggregate shall be crushed siliceous stone or other approved aggregate 6 mm stone chips shall be used for finish upto 20 mm thick & 10 mm chips for thicker finish.

c) Composition

Bitumen mastic shall conform IS: 1195 and shall be either brought to site in blocks weighing about 25 Kg or prepared at site. If brought in blocks, these shall be remelted in mechanically agitated mastic cookers and coarse aggregate, preferably preheated fed in successive portions until the complete change is thoroughly, incorporated. At no stage during the remelting and mixing process, shall the temperature exceed 205°C.

d) Laying

The hot mastic shall be laid on dry base surface cleaned thoroughly by wire brushing and sweeping. The mastic shall be leveled and when cooled to some extent shall be finished with a wooden float with addition of small quantity of fine sand if required. No load shall be allowed till the finish has cooled to normal temperature.

The mastic shall be laid in suitable panels of about 1.5 Sq.M. in area each formed by formers. Succeeding panels shall be laid overlapping the finish panel so as to melt its edges and form a continuous finish without joint.

2.01.07 Chemical Resistant in Situ Finish

Chemical resistant in situ finish shall be as epoxy resin with suitable filler material over a primer. The minimum thickness shall be 6 mm. About its performance the Engineer shall have to be fully satisfied by test results and examination of similar treatment already in existence. The contractor shall get it done by a specialized Manufacturer and get guarantee of performance from the organization and pass it on to the Owner in addition to his own guarantee.

2.02.00 Tiled Finish

These shall include finish tiles, stone slabs, and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

2.02.01 Terrazzo Tile Finish

The finish will consist of manufacture terrazzo and an underbed.

a) Thickness

The total thickness including the underbed shall be minimum 40 mm for floors 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the tiled finish, to accommodate the specified thickness shall be done.

b) Tiles: Terrazzo

The tiles shall, unless specifically permitted in special cases be machine made under quality control in a shop. The tile shall be pressed hydraulically to a minimum of 140 Kg. per Sq.cm.

Each tile shall bear on its back permanent and legible trademark of the manufacturer. All angles of the tiles shall be right angles all arises sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance allowance length and breadth shall be ± 1 mm and the thickness ± 3 mm. Face of the tile shall be plane, free from pinholes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 10 mm.

The total thickness including the topping shall be as specified but not less than 20 mm in any case.

The backing shall be composed of 1 part ordinary gray cement and 3 parts of stone chips by weight mixed with water.

The topping shall be as specified under clause 2.01.02 (b).

The tile shall be cured at the shop for at last 14 days before delivery to the site. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be carefully stored to prevent staining by damp, rust, oil, and grease or other chemicals.

Tiles made in each batch shall be kept and used separately so that colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers for the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

c) Mix: Underbed

The underbed for floor and similar horizontal surfaces shall be 1 part lime putty: 1 part surkhi: 2 parts coarse sand by weight mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 12 mm thick and composed of 1 part cement and 3 parts coarse sand by weight.

d) Laying

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The surface shall be roughened for better bond. Before the underbed had time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and the tiles shall immediately be placed upon and firmly pressed by wooden mallet on to the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match the dimensions these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned

in advance and approval of the Engineer taken.

At the junction of horizontal surface with vertical surface the tiles on the former shall enter at least 12 mm under the latter.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall not be allowed.

If desired dividing strips as specified under Clause 2.01.02(c) may be used for dividing the work into suitable panels.

e) Grinding and Polishing

Procedure shall be same as Clause 2.01.02(e). Grinding shall not commence earlier than 14 days after laying of tiles.

2.02.02 Chequered Tile Finish

The finish shall consist of manufactured gray or coloured cement tiles or terrazzo tiles with chequered face and an underbed laid over concrete or brick surface.

a) Thickness

Thickness shall be same as in clause 2.02.01 (a).

b) Tiles: Chequered

The tiles shall have chequers not less than 2.5 cm. c/c and not more than 5 cm. c/c. Depth of grooves shall be not less than 5 mm. The grooves shall be uniform and straight.

The tiles shall conform to clause 2.02.01 (b) except that these may have the topping in terrazzo or plain gray cement or colour pigment added to cement.

c) Under-bed
As per clause 2.02.01 (c).

d) Laying
As per clause 2.02.01 (d).

e) Grinding and Polishing

As per clause 2.02.01 (e) except that the tiles shall be ground and polished by hand and after laying taking special care in polishing the grooves properly and uniformly.

2.02.03 Glazed Tiles Finish

This finish shall be composed of glazed earthenware tiles with an underbed laid over a concrete or masonry base.

a) Thickness

The total thickness shall be between 20mm and 25mm including the underbed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

b) Tiles: Glazed

The tiles shall be of earthenware, covered with glaze white or coloured, plain or with designs, of 150 mm x 150 mm nominal sizes and 5.5 mm to 6 mm on thick unless otherwise specified. The tolerance shall be ± 1.5 mm for length and breadth and ± 0.5 mm for thickness specials like internal and external angles; beads, covers, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt, unfading stable finish as desired by the Engineer. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense and homogeneous. The tiles shall be strong and free from flaws like cracks, craze, specks, crawlings, etc. and other imperfections. The edge and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar.

The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

c) Mix: Underbed

The mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

c) Laying
Same as clause 2.02.01 (d).

e) Finishing

The joints shall be cleaned and flush pointed with white cement and cured for 7 days by keeping it wet. The surface shall be cleaned with soap or

suitable detergent, washed fully, and wiped with soft cloth to prevent scratching before handing over.

2.02.04 Tesserae Finish (Mosaic etc.)

This finish consists of manufactured vitreous, glass, ceramic or similar hard small pieces set in an underbed over a concrete or masonry surface, already laid.

a) Thickness

The total thickness including the underbed shall be between 16 mm & 25 mm.

b) Tesserae Finish

These shall usually be 6 mm thick small piece of ceramic vitreous china, tinted glass, or similar hard wearing, strong, and durable material in desired shapes and sizes and patterns.

The supply shall come in the desired pattern in full or sections conveniently for handling, stuck to pieces of strong thick paper on the surface to be exposed. The gum used for this purpose must be water soluble and non-staining. The sections shall be properly marked to avoid mistakes and master drawing shall be available at the site for guidance.

c) Mix: Underbed
Same as clause 2.02.03 (c)

d) Laying

The specification for laying if given by the manufacturer of the item shall be followed provided it is approved by the Engineer. Otherwise clause 2.02.03 (d) shall generally be followed. However, instead of gray cement the slurry shall be made with white cement to fix the panels. The paper-mounted patterns in sections shall be carefully placed and pressed in position true to lines and levels. Earliest possible the paper shall be peeled off and surface examined and cleaned, joints flush pointed with white cement and cured for 7 days by keeping it wet.

2.02.05 Chemical Resistant Tiled Finish

This shall include all verities of special tiles used for specific chemical resistance function and an underbed over already laid concrete or masonry.

a) Tiles

The chemical resistant tiles shall be of the best indigenous Manufacture unless otherwise specified and shall be resistant to the chemical (both acid and alkali). The tiles shall have straight edges, uniform thickness, plain surface, uniform nonfading colour, and textures.

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/cm2. The surface shall be abrasion resistant and durable.

b) Laying

The mortar used for setting or for underbed these tiles shall be durable, strong and chemical resistant epoxy mortar. The grout, which shall be to the full depth of tile, shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Engineer.

2.02.06 Rubber, Vinyl, or Vinyl Asbestos Tiles Finish

This shall include various types of tiles manufactured from rubber, vinyl etc. set with an adhesive on concrete or masonry base. An underbed may be required to secure desirable surface and grade.

a) Thickness

The thickness of the tiles shall be as incorporated in drawing.

b) Tiles

Unless otherwise desired the tiles shall be squares of approved dimensions. The tolerance in dimensions shall be ± 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be nonfading and uniform in appearance, insoluble in water and resistant to alkalies, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer’s trademark, the thickness, sizes, batch number, and date of

manufacturer.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) Mix: Underbed

The underbed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty:1 part cement: 3 parts coarse sand mixed with just sufficient water to make it workable.

d) Laying

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air-conditioned space, the air-conditioning shall be completed before tiling is taken up.

The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

e) Finishing

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried, and polished with an approved type of polish just before handing over.

2.02.07 Stone Slab Finish: Marble, Stone, and Similar Fine Grained Stone including Kota stone

a) Thickness

The underbed shall be minimum 12 mm and average 20 mm thick. The slabs will be 20 mm thick.

b) Stone Slab

The stone slabs shall be made from selected stock, which is hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, and free from chipping and surface shall be plane. The slabs shall preferably be machine cut to the required dimensions. Tolerance of ± 5 mm in dimensions and ± 2 mm in thickness will be allowed. Unless specified the slabs shall be minimum 300 mm x 300 mm.

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the full depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

c) Mix: Underbed
Same as clause 2.02.01 (c).

d) Laying

The sides and top surface of the slabs shall be machine rubbed or table rubbed with coarse sand stone and washed before laying.

The underbed mortar shall be evenly spread and brought to proper level on the area under each slab. The slab shall be laid over the underbed, pressed, and tapped down with wooden mallet to the proper level. The slab shall then be lifted and the underbed corrected as necessary and allowed to stiffen a little. Next, thick cement slurry shall be spread over the surface. The edges of the slab shall be buttered with slurry of cement, gray / white / mixed with pigment matching the colour of the stone slabs. The slab shall be gently laid and tapped with wooden mallet to bed properly to a very fine joint and to the required level. All surplus cement slurry shall be removed and the surface mopped clean with wet soft cloth. The laid finish shall be cured for 7 days by keeping it wet.

e) Polishing, Finishing

Fine chiselling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified under clause 2.02.01 (e). However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for.

2.02.08 Stone Slab Finish: Sand Stone and Similar Coarse Grained Stone Finish

Generally clause 2.02.07 shall be followed except that the workmanship and finish shall not be fine as which are explained hereunder.

The slabs shall be rough chiselled or fine chiselled as specified. Tolerance may be allowed upto ± 6 mm for rough finish, but no sharp unevenness and shall be allowed. For fine chiselling the unevenness shall be limited to ± 2 mm. The sides shall be chisel dressed at least to half slab depth so that the maximum deviation from straight line shall be within 25 mm. Beyond this depth the edge may be slightly splayed.

The joint thickness shall be kept limited to 5 mm in case of rough finish and 3 mm in case of fine finish unless wider joints are specified. The joints shall be grouted with white or coloured cement. If fine joints in the flooring are specified, the edges of slabs shall be cut in such a way that it shall form a inverted 'Y'.

3.00.00 ACCEPTANCE CRITERIA

The finish shall be checked specially for:

a) Level, Slope, Plumb as the case may be

b) Pattern and Symmetry

c) Alignment of joints, dividing strip etc.

d) Colour, texture

e) Surface finish

f) Thickness of joints

g) Details at edges, junctions etc.

h) Performance

i) Precautions specified for durability

4.00.00 I.S. CODES

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: 777	:	Glazed earthenware tiles
IS: 1196	:	Code of practice for laying bitumen mastic flooring.
IS: 1197	:	Code of practice for laying of rubber floors
IS: 1237	:	Cement concrete flooring tiles
IS: 1443	:	Code of practice for laying and finishing of cement concrete flooring tiles.
IS: 2114	:	Code of practice for laying in situ terrazzo floor.
IS: 3461	:	PVC asbestos floor tiles
IS: 4860	:	Specification for acid resistant bricks
IS: 5518	:	Code of practice for laying of flexible PVC Sheet and tile flooring.
IS: 5491	:	Code of practice for laying in situ granolithic floor topping.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be for the complete work (including dividing strips, ironite, metals, tiles etc. if any) as per the schedule of items. Rates shall be applicable for application on horizontal and vertical surfaces at all elevations and for all types of work including stairs tread and riser, laying in desired pattern and panels, cost of specials (if any) rounding of corners, mouldings etc.

Rates shall be including provision of side shuttering (if required) for casting of floor in alternate panels and or without dividing strips.

5.02.00 Measurement

The finished surface shall be measured in Sqm for area unless otherwise specified. Deduction shall not be made for opening or embedded articles having area not exceeding 0.1 Sqm.

VOLUME: II B

SECTION - D

SUB-SECTION – D13

SHEET WORK IN ROOF AND SIDING

SPECIFICATION NO. PE-TS-999-600-C013

Maharatna Company

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	INSTALLATION	3
3.00.00	ACCEPTANCE CRITERIA	5
4.00.00	I.S. CODES	5
5.00.00	RATES AND MEASUREMENTS	6

SHEET WORK IN ROOF AND SIDING

1.00.00 SCOPE

This section covers supply, cutting & fabrication and erection of corrugated/plain asbestos, corrugated galvanized iron, aluminum, permanently colour coated troughed zinc-aluminium alloy coated M.S. sheet or other sheet for covering to roof and sides at various elevations as specified.

2.00.00 INSTALLATION

2.01.00 Storage of Materials

All materials shall be stored by the Contractor in proper way to prevent all damage.

2.02.00 Workmanship

The workmanship shall be according to best construction practice to give a watertight finish to the satisfaction of the Engineer. Fixing of gutters and down pipes shall be according to IS: 2527.

2.02.01 Asbestos Sheeting

Asbestos sheets of profiles as specified shall be fixed with minimum 150 mm end lap and side laps as per manufacturer's specification. Hook bolts or J-bolts shall be 8 mm dia. at 305 mm centres. Six (6) mm dia. galvanized iron seam bolt and nut with G.I. flat washers and bitumen washers shall be used for stiching ridge cappings, corner pieces, ventilators, north light curves etc.

2.02.02 C.G.I. Sheeting and Aluminium Sheeting

Side laps shall be 2 corrugations for roof and one corrugation for side sheeting. End laps shall be minimum 150 mm for roof and 100 mm for side sheeting. In ridges and hips where plain sheets are used, the end laps shall be minimum 100 mm. Holes in C.G.I. sheets shall preferably be made on the ground. The sheets should be placed on purlins/trestles and holes punched in the ridge of the corrugation from the outside inward for obtaining proper seating of limpet washers. Sheets shall be secured to sheet framing by 8 mm dia. galvanised iron hooks or J-bolts and maximum spacing of the bolts shall be 305 mm. The length of the hook or J-bolts shall be to suit the sections of the bearers. Sheets shall also be bolted at the ends at every third corrugation with 6 mm dia. galvanized iron seam bolts and G.I. flat washers and bituminous washers.

2.02.03 Fibre Glass Reinforced Plastic Sheeting

This shall be of thickness and profile as specified. Colour and light transmittance shall be as mentioned. Where used in conjunction with C.G.I. or asbestos sheeting, the end and side laps and fixing device shall be same as used for general sheeting. Where used in lieu of glass, the fixing shall be by means of timber or metal glazing beads. In all cases, the installation shall be completely watertight and able to withstand the designed wind-pressure.

2.02.04 PERMANENT COLOUR COATED (SANDWICHED INSULATED) METAL CLADDING SYSTEM

i. Troughed zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6mm minimum thickness (or high tensile steel sheet having minimum yield strength of 350 Mpa of 0.5mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm/sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF_2) of Dry Film Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns.

ii. Galvanised M.S. sheets of minimum 0.6mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 275 gm/sqm.

iii. The permanent colour coated sheet shall meet the general requirements of IS:14246 and shall conform to class 3 for the durability.

iv. Inner sheet shall be fixed directly to side runners and Z spacers made out of at least 2 mm thick galvanized steel sheet of grade 375 as per IS:277. Inner sheet shall be fixed at the rate not more than 1.50M centre to centre to hold the insulation and external sheeting. The fasteners shall be of high quality corrosion resistant grade of self tapping / self drilling type provided with suitable cap.

v. The insulation shall be of bonded mineral wool of minimum thickness 50mm conforming to IS:8183, having a density of 32 Kg/cu.m. for glass wool & 48 Kg/cu.m. for rock wool.

2.02.05 PERMANENT COLOUR COATED (NON-INSULATED) METAL CLADDING SYSTEM

i. Troughed zinc-aluminium alloy coated not less than 150 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet having

minimum yield strength of 350 Mpa of 0.5mm minimum thickness) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF_2 paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS:14246 and shall conform to class 3 for the durability.

ii. **FLASHING, CAPS, TRIM CLOSURES ETC.**

All flashings, trim closures caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding.

3.00.00 ACCEPTANCE CRITERIA

The installations shall present a neat appearance and shall be checked for water tightness. The following shall be checked:

a) Side and end laps

b) Absence of cracks, holes or damages in sheet

c) Spacing of bolts

d) Provision of double washers (G.I. and asbestos or bituminous washers)

e) Proper installation of flashing.

4.00.00 I.S. CODE

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: 3007	:	Code of practice for laying of asbestos cement sheets.
IS: 2527	:	Code of practice for fixing rainwater gutters and down pipes for roof drainage.
IS: 1626	:	Specification for asbestos cement building pipes, gutters and fittings.
IS: 277	:	Specification for galvanized steel sheets (plain and corrugated).

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall be unit rate for complete item described in "Schedule of Items" and shall include all wastage.

5.02.00 Measurement

Sheeting work in roof & sides shall be measured in Sq.M. for net area of the work done. Profiled sheeting shall be measured flat and not girthed. Opening less than 0.40 Sqm shall not be deducted. No extra shall be paid for extra labour in cutting and for wastage etc. No payment shall be made for laps, flashings, sealing, fasteners etc. in sheeting works.

VOLUME: II B

SECTION - D

SUB-SECTION – D14

SUSPENDED CEILING

SPECIFICATION NO. PE-TS-999-600-C014

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	INSTALLATION	3
3.00.00	SAMPLES	5
4.00.00	SHOP DRAWINGS	5
5.00.00	ACCEPTANCE CRITERIA	6
6.00.00	RATES AND MEASUREMENTS	6

SUSPENDED CEILING

1.00.00 SCOPE

This section covers supply and installation of suspended ceiling together with the suspension system as shown on drawing or specified in schedule of item with all materials, labour and equipments. The work shall also include providing of openings in the ceiling for lighting, air-conditioning diffusers etc. as shown on drawings or as instructed by the Engineer.

2.00.00 INSTALLATION

2.01.00 Suspension System

2.01.01 General

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural works, slabs and beams.

All members of the suspension system shall be of sufficient strength and rigidity to carry, the ceiling boards or sheets in a true and level plane without exceeding a deflection of 1/360th of their span. All joints in ceiling panels shall run straight and cross joint shall be at perfect right angles. Angle moulds where shown on drawings shall be securely fixed to walls. All drillings of structural concrete and installation of suitable anchoring device for installation including welding of the suspension system shall be included in the rate. All M.S. sections used for supports etc. shall be given one coat of synthetic enamel paint over a coat of red lead primer.

2.01.02 Metal Grid Suspension System

Aluminium grid ceiling system shall be “Bead lock” as manufactured by W A Beard shell and Co. Pvt. Ltd. or Ajit India Limited or approved equal. Steel grid ceiling system shall be 'Jolly Snap Grid' as manufactured by Jolly Board Limited or approved equal.

Steel tees as intermediate members and steel channels, as end pieces will be assembled in the form of grid. Size of tees and channels shall be as required.

The cross-tees shall intersect main tee runners in pattern shown on drawing and positively locked together with intersection members. All perimeter areas shall have tee runners fixed to vertical wall surfaces and end channels shall be fixed to runners leaving return air space between vertical wall and channels,

unless otherwise shown on drawings. Angle cleats or other suitable fixing device shall be fixed to the structural beams above for fixing of hangers. Main runners shall be hung by M.S. flats, angles, rods or 12G or heavier galvanized tie wire hangers at maximum 1.2 metre centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be as shown on drawings. Turnbuckles shall be provided in M.S. rods for adjustment in levels.

2.02.00 Ceiling Panels

2.02.01 Material

Ceiling panels shall be best quality material in thickness and properties called for in the "Schedule of items". The Contractor shall submit test certificates to the Engineer for approval before bulk supply. The ceiling panels may be of following type:

a) Plaster of Paris board (decorative)

b) Expanded polystyrene insulation board with plastic fascia.

c) Fibre Insulation board.

d) Bonded wooden particle board (Plain and decorative)

e) Glass fibre reinforced polystyrene sheets.

f) Flat asbestos sheets (with plastic fascia).

2.02.02 Installation of Ceiling Panels

Installation of Ceiling panels shall be strictly as per manufacturer's instruction.

For concealed grid system, tiles shall be fixed to the supporting grid in manner shown on drawing or as specified by the manufacturer. Where V joints in tiles are called for in drawings, these shall be in true lines. Where flush surface is required, the joints shall be filled with approved filler material and finished to give a neat uniform surface. Special care shall be taken to neatly finish the ceiling at junctions with walls, light fixtures, diffusers etc.

2.02.03 Aluminium Lineal Ceiling System

Aluminium lineal ceiling system shall be "Luxalon 84C " or approved equal and the installation shall be strictly as per manufacturer's instruction/ specification subject to approval of the Engineer.

Aluminium lineal ceiling shall comprise of plain panels, 84 mm wide and 12.5 mm deep with a 23.9 mm recessed flange, roll formed out of 0.5 mm thick aluminium alloy panels stove enamelled on both sides, fixed on roll-formed carriers made of enamelled 0.95 mm thick aluminium, 32 mm wide and 39 mm deep with prongs to hold panels in the module of 100mm, at maximum spacing 1.2 M centre to centre. The carriers shall be suspended from roof by 4 mm dia galvanised steel wire hangers with special height adjustment clips made out of spring steel at maximum spacing of 1.2 M c/c. Hangers shall be fixed to roof by 'J' hooks and nylon inserts. 25 mm thick resin bonded mineral wool (spintex 300 or equivalent) insulation bound in polythene shall be laid on top of panels. Lineal ceiling shall be fixed in pattern as per detailed drawings.

3.00.00 SAMPLES

Samples of Ceiling panels and metal suspension system components as noted below shall be submitted for Engineer's approval:

Panels : 3 samples approximately 300 mm square/long each

Suspension System : 3 samples of short length : each of main and secondary system

4.00.00 SHOP DRAWINGS

Shop drawings shall be submitted for approval as required and approval shall be obtained prior to delivery of suspended ceiling components. Shop drawings shall be co-coordinated with all related work and shall show the following information:

a) A reflected ceiling plan of areas indicated to receive the ceiling showing electrical and mechanical features.

b) Typical Intermediate framing for support where required.

c) Hanger fastening details.

d) Panels - unit support at ceiling penetrations.

e) Details of splicing method for main and cross runners.

f) A table indicating load bearing capacity of main and cross runner

g) A note stating that the suspension system member furnished will not deflect more than 1/360 of the span under the indicated loading.

5.00.00 ACCEPTANCE CRITERIA

Finished ceiling shall be at the correct plane and present a pleasing and uniform appearance, free from, sags, warps, disfigured, or damaged board. Cutouts for light fixtures, diffusers etc. shall be of exact dimensions and in exact locations.

6.00.00 RATES AND MEASUREMENT

6.01.00 Rates

Rates shall be for the complete item called for in the "Schedule of Items". No extra payment will be made for alignment and adjustment of lighting fixtures, air-conditioning diffusers, access panels etc. The rate shall include all cutting and wastage from standard size sheets, runners/carries etc.

6.02.00 Measurement

Actual area of work shall be measured in Sqm correct to second place of decimal. However, no deduction will be made for opening upto 0.25 Sqm. each in area.

VOLUME: II B

SECTION - D

SUB-SECTION – D15

WATER SUPPLY, DRAINAGE AND SANITATION

SPECIFICATION NO. PE-TS-999-600-C015

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	MATERIAL	3
3.00.00	INSTALLATION	6
4.00.00	TESTING AND ACCEPTANCE CRITERIA	17
5.00.00	I.S. CODES	20
6.00.00	RATE AND MEASUREMENT	21

WATER SUPPLY, DRAINAGE AND SANITATION

1.00.00 SCOPE

This section covers supply of all materials labour and incidentals required for supply, laying and installation of under/over ground pipes for water supply, drainage and sanitation with all fittings, fixtures and jointing, construction of ancillary works like manholes, drop connections, gully chambers, septic tank, soak pits, surface drain etc.

The supply and installation of water supply/sanitation fixtures and accessories like water closets, urinals, wash basins, sinks, mirrors, shelves, towel rail, soap container etc. with all fittings, fixtures, water supply/sanitation pipes and water storage tanks etc.

2.00.00 MATERIAL

All materials, fittings, fixtures, and appliances shall be of the best quality conforming to relevant Indian Standard and shall be procured from approved manufacturers. Unless specifically allowed by the Engineer, the Contractor shall submit samples of fittings and fixtures, which will be retained by him for comparison when bulk supplies are received at the site. Ultimate choice of type, model, and manufacturer lies completely with the Engineer.

It shall be the responsibility of the Contractor to procure the materials selected by the Engineer. Hence orders are to be placed with the manufacturers in time, so that the materials are available at the site well ahead of their requirement.

The materials brought to the site, shall be stored in a separate secured enclosure away from the building materials. Pipe threads, sockets, and similar items shall be specially protected till final installation. Brass and other expansive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and items found damaged shall not be retained at the site.

2.01.01 Pipes and Pipe Fittings

For water supply, galvanised mild steel pipe of medium grade confirming to IS: 1239 shall be used. The galvanising shall not be less than 400gm/sqm of pipe surface area. Galvanising shall be smooth and shall be subjected to testing as per IS: 2633 for uniformity of coating. The zinc coating shall be free from defects.

For Roof drainage and building sanitation works following type of pipe are coved in this Section:

a) Cast Iron pipe

b) Steel pipe (lined, coated with bituminous composition, out coated with cement concrete or mortar or galvanized)

c) Concrete pipe

d) Asbestos cement pipe

e) PVC pipe

f) Stoneware pipe

g) Vitrified pipe

h) Lead pipe (not to be used for portable water)

2.02.01 Fixtures

All material, fittings, fixtures, appliances, accessories shall be of approved quality and shall be procured from reputed brands like Hindustan/Pasriware/ Cera or equivalent or as approved by Engineer. The bidder shall procure the fixtures from the above named reputed manufacturers and shall mention in his bid the type & make of the fixtures he intends to use.

All items brought to the site must bear the manufacturer's identification mark. Procurements shall be made well in advance and should get inspected & approved immediately by the Engineer. All fixtures shall be adequately protected, covered, and plugged till handing over.

All fittings, gratings, fasteners, unless specified otherwise, shall be chromium plated. The chromium plating shall be of grade-2 (10micron thickness) confirming to IS: 4827. Powder coating shall be of approved colour and shall have minimum thickness (DFT) of 20micron. Stainless steel accessories shall be of grade SS-304 and from reputed manufacturer (like Salem Steel) and shall be polished bright finish.

Unless specified in the contract the fixtures shall be as specified hereinafter.

Water closet

a) **European type**

It shall consist of European type glazed vitreous china basin (confirming to IS: 2556, part-II), with siphon open front solid plastic seat and plastic cover, low level glazed stoneware flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium

plated. Colour of basin, cistern, seat and cover shall be as approved by the Engineer.

b) **Squatting type**

It shall consist of Orissa pattern glazed vitreous china squatting pan with integral foot rests (confirming to IS:2556, part-III) and high level cast iron flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. The flushing cistern shall be painted as specified by the Engineer.

Urinals

It shall consist of wall type glazed vitreous china urinals (conforming to IS:2556), cast iron automatic flushing cistern complete with supply connections, flush pipe, lead pipes, gratings, traps and all other necessary fittings. Frequency of automatic flushing shall be approximately once every five minutes. For every four urinals (maximum) located together may be served by one cistern of adequately capacity. All fittings shall be chromium plated.

Wash Basin

It shall be made of glazed vitreous china conforming to IS:2556, part-IV. The basin shall be flat back, wall hung by painted cast-iron brackets and complete with hot and cold CP brass faucets with nylon washers, PVC connection pipe with CP brass nuts, CP brass chain with rubber plug, 32mm dia. Chromium plated brass waste of standard pattern, 32mm dia. CP brass trap union complete with necessary fittings.

Sink

It shall be made of glazed vitreous china conforming to IS:2556, part-V. It shall be wall hung by painted cast iron brackets and complete with one CP brass faucet with nylon washers, PVC connection pipe with CP brass nuts, CP brass chain with rubber plug, 40mm dia. chromium plated brass waste of standard pattern, 40mm dia. CP brass trap union complete with necessary fittings.

Bathroom mirror

It shall be made of the best quality 6 mm thick glass and produced by a reputed mirror manufacturer. It shall be wall mounted with adjustable revolving brackets. The brackets, screws, and other fittings shall be chromium plated.

Glass shelves

Class shelves shall consist of 6 mm thick clear glass with guardrails and shall be wall mounted with brackets. All brackets, guardrails, and screws shall be chromium plated.

Towel rail

Towel rails shall be 20 mm dia chromium plated MS pipes wall mounted with steel brackets. The brackets, screws etc. shall also be chromium plated.

Soap holder

It shall be made of chromium plated strong members. The holders shall be wall mounted with chromium-plated screws.

Liquid Soap Dispenser

It shall be round and easily revolving with removable threaded nozzle. The body, bracket for wall mounting and screws shall be chromium plated.

Toilet roll bolder

It shall be made of glazed vitreous china with suitable cover cum cutter. Wall mounting screw shall be chromium plated.

Valve, cocks, Taps

All valves, stop cocks, taps etc. shall conform to relevant Indian standard specification and shall be of best quality from approved manufacturers. These shall be suitable for normal working pressures. Nominal size and material shall be as required / specified.

2.03.00 Water Storage Tank

Water storage tank shall be PVC of approved brand and make (Syntex or equivalent). Reservoirs made of concrete masonry or fabricated steel shall be covered by respective work specifications.

3.00.00 INSTALLATION

3.01.00 General

Basic layouts may be available in the drawings provided, the details might have to be supplemented by the Contractor and get the approval of the Engineer before installation. Special attention shall be given to economise the layout. Symmetry of layout is very important. Fittings meant for operation

shall be located and oriented to allow easy reach and operation. Maintenance, repairs, and replacements of pipes, fittings, and fixtures must be conveniently possible. All pipe lines, locations of fittings and fixtures, etc. shall be as per drawings or as directed by the Engineer. Correctness of lines, plumb, orientation, symmetry, and levels shall be strictly ensured. All items shall be fully secured against movement in any direction and so located as to allow easy maintenance.

All pipelines, fittings, and fixtures shall be installed leak proof. When the works under scope of this specification linked up with works executed by others, the connections shall be such as to prevent any splashing or spilling or emission of foul odour and gases.

3.02.00 Portable water supply Pipe Lines

3.02.01 Laying

In addition to fulfilling the functional requirements all pipelines shall be laid true to line, plumb and level and shall run on the surface of the walls, ceiling or in chases. Any deviation shall need approval of the Engineer. Meticulous care shall be taken to avoid chances of airlock and water hammer.

Pipes shall be laid on continuous unyielding surface or on reliable supports at least one near each joint and spacing as directed by the Engineer. The support must be strong, neat and shall have provisions for securing the pipes in every direction and easy maintenance. All pipes used for water supply should be thoroughly and efficiently disinfected before taken in to use.

3.02.02 Back Flow

The layout of pipe work shall be such that there is no possibility of back flow towards the source of supply from any cistern or appliances, whether by siphonage or otherwise. All pipe works shall be so laid or fixed and maintained as to be and to remain completely watertight, thereby avoiding waste of water, damage of property and the risk of contamination of the water conveyed.

3.02.03 Contamination

There shall be no cross connection whatsoever between a pipe/fitting for conveying or containing wholesome water and a pipe/fitting for containing impure water or water liable to contamination or of uncertain quality of water which has been used for any other purpose. No piping shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith.

3.02.04 Underground Piping

Underground piping shall be laid at such a depth that it is not likely to be damaged by traffic and other loads and frost, where applicable. The size and depth of the trench shall be as approved by the Engineer. Back filling shall be done with selected fine earth, unless otherwise permitted, in 150 mm layers and carefully consolidated. Special care shall be taken while filling in the vicinity of the pipe to avoid damage. Before backfilling, the laid pipe shall be fully tested and approved.

Where the pipe rests on rock it may be bedded on a layer of fine selected material or concrete to avoid local point support. The trench shall be so treated by gradient and filling in the area that it does not act as a drainage channel.

3.02.05 Concealed Piping

Where desired by the Engineer or shown on the drawings the pipes shall be concealed in masonry or concrete of the structure. The Contractor may co-ordinate with the building Contractor for leaving the chases, openings, and conduits as necessary. However, the Contractor will rectify if required the chases, openings, and conduits, supplement and make good after laying and testing of the concealed pipelines.

3.02.06 Jointing of Pipes

All G.I. pipes shall be properly thread/weld jointed and made completely water tight and durable. Burr from the joints shall be removed after screwing. Union joints shall be provided for all required location to facilitate maintance.

3.02.07 Painting

Where required, underground G.I. pipes shall be given 2 coats of bituminous paint on the outside after laying. When painting is to be done above ground G.I. pipes shall be given one coat of red lead or zinc chromate primer and top coats shall be minimum 2 coats of best quality paint as specified.

3.03.00 RAINWATER DOWN COMERS

3.03.01 Pipes

Rainwater down comers shall be standard Cast Iron or Asbestos Cement Pipes. In case where specifically desired, M.S. pipes may also be used. M.S. pipes shall be painted outside with two coats of anticorrosive paints under a coat of primer.

Rainwater down comers shall run along and be secured to walls, columns etc.

Where desired by the Engineer these may have to be installed in chases cut in the structure. All pipes shall be well secured and supported by adequately strong brackets. The brackets may be wrought iron clevis type, split ring type, 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 blocks shall be provided against the vertical surface to which the pipe is fixed.

All bends and junctions shall be supplied with watertight cleanouts.

Roof and floor drains and yard gullies shall be installed, if required, by cutting into the structure and grouted with 1:2:4 cement concrete. All gutters shall be provided with removable gratings.

All horizontal pipes shall have a minimum fall of 1 in 100.

3.03.02 Khurras

The khurras shall be constructed before the work in parapet wall is taken up and it shall be 45x45 cm in size, unless otherwise specified and shall be formed of cement concrete of M-20 grade.

3.03.03 Gutters

The gutters shall be made of G.I. or A.C and procured from reputed specialised manufacturers. Each section shall be sufficiently rigid, edges and corners straight and the slopes perfectly uniform. G.I. gutters shall have the edges strengthened by suitable means.

Unless noted otherwise the gutters shall have a minimum fall of 1 in 120. Adequate number of string supports shall be provided so that there is no sagging even when the gutter is full. Each joint must have a support. Unless otherwise specified the supports shall be fabricated M.S. brackets. All junctions shall be thoroughly watertight. The joints may be made by riveting, bolting or soldering. All joints between successive lengths of gutters shall have on overlap of at least 5 cm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed watertight. Junction with rainwater down comers shall be made fully watertight and secured.

3.04.00 SOIL AND DRAINAGE PIPES

3.04.01 Gradients

If not specified the minimum gradients of soil and drainage pipeline shall be as follows:

100 mm nominal dia	:	1 in 35
150 mm nominal dia	:	1 in 65
230 mm nominal dia	:	1 in 120
300 mm nominal dia	:	1 in 200

3.04.02 Relation with water supply pipelines

Unless specifically cleared by the Engineer, under no circumstances shall drainage and sewer pipes be allowed to come close to water supply pipelines.

3.04.03 Laying

Each separate pipe shall be individually set for line and for level. Where lengths of sewer or drain pipes are laid in trench, properly painted sight rails shall be fixed across the trench at a height, equal to length of the boning rod to be used, above the required invert level of the drain or sewer at the point where the sight is fixed. More sight rails shall be required at manholes, change of gradient and intermediate positions if the distance for sighting is more than 50 ft. apart. The excavation shall be boned in at least once in every 6 ft. The foot of the boning rod shall be set on a block of wood of the exact, thickness of the wall of the pipe. Each pipe shall be separately and accurately boned between sight rails.

3.04.04 Support and Protection of Pipelines

All pipes shall be laid with sockets leading uphill. Preferably the pipe shall rest on solid and even foundations for the full length of the barrel. However, the pipe manufacturer's instruction as approved by the Engineer shall be followed in the matter of support and jointing.

To achieve full and continuous support, concrete for bedding and packing is the best. Where pipes are not bedded on concrete, the floor shall be left slightly high and carefully placed so that the pipe barrels rest on undisturbed ground. If anywhere the excavation has been carried too low packing shall be done in concrete. Where laid on rock or very hard ground which cannot be easily excavated to a smooth surface, the pipes shall be laid on a cradle of fine concrete floor of gravel and crushed stone over laid with concrete or on a well consolidated gravel and crushed stone bed as desired by the Engineer. PVC or similar pipes shall be laid directly on stable soil and packed with selected soil.

The minimum support and protection for glazed stoneware pipes shall be as follows:

a) When cover is less than 2 metre below ground level and where pipes are unavoidably exposed above ground surface, the pipes shall be completely encased or surrounded with concrete.

b) Where pipes are laid on soft soil with the maximum water table laying at the invert of the pipe, the sewer shall be bedded on concrete.

c) Where the pipes have to be laid on soft soil with the maximum water table rising above the invert of the pipe, but below the top of the barrel, the pipe sewer shall be haunched.

d) Where maximum water table is likely to rise above the top of the barrel or wherever the pipe is laid on soft soil the pipe sewers shall be completely encased or surrounded with concrete.

Vitrified clay pipes shall be laid on a bed of 150 mm thick cement concrete (1:3:6) nominal mix by volume.

Cast iron pipes and concrete pipes may be supported on suitable concrete or brick support, where specified. The supports shall be unyielding and strong enough. At least one support shall be located close to ends. Spacing of intermediate supports shall be as decided by the Engineer. Pipes shall be secured to the supports by approved means.

Anchoring of pipes where necessary shall be achieved by suitable concrete encasing designed for the expected thrust.

3.04.05 Entry into structures

For entry of the pipe lines into any building of structure suitable conduits under the structure or sleeves shall be used. The conduits and sleeves shall be such as to allow easy repairs and replacement of the pipes. When openings or chases are required to be made in the structure for entry of pipelines, locations and sizes shall be marked and checked by the Engineer. After laying of the pipeline the openings and chases shall be mended.

3.04.06 Ducts

Where solid, waste and ventilating pipes are accommodated in ducts, access to cleaning areas shall be provided. Connection to drain shall be through a gully with sealed cover to guard against ingress of sewer gas, vermin, or backflow.

3.04.07 Traps and Ventilating Pipes

Pipes are carrying off the waste from water closets and waste water and overflow water from baths, wash basins, sinks to drains shall be trapped immediately beneath such fixtures. Traps shall have minimum water seal of 50 mm and shall be ventilated whenever such ventilation is necessary to maintain water seal of the trap. Ventilating pipes shall be carried up vertically from the drain to a height of at least 600 mm above the outer covering of the roof of the building or as shown on drawings. All vertical ventilating, anti-

syphonage and similar pipe shall be covered on top with a cowl. The cowl shall be made of C. I. unless desired otherwise by the Engineer.

3.04.08 Manhole & Inspection Chambers

At every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The maximum distance between manholes shall be 30 meter unless specially permitted otherwise. However, for truck route (for pipes above 900 mm dia.) this distance can be increased to 45 M. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 metres unless desired otherwise provision of IS: 4111 (Part-1) shall be followed for construction of a manhole. Manhole shall be constructed so as to be watertight under test. The change in alignment shall be carried out in such a manner as to provide no lodgement for any splashings in case of accidental flashing of the chamber. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement, sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow.

Connecting to existing sewer lines shall be through a manhole.

Unless otherwise specified, 560 mm dia. circular cast iron manhole cover with frame, heavy-duty, conforming to IS: 1726 shall be provided. The covers shall be close fittings so as to prevent gases from coming out.

3.04.09 Cutting of Pipes

Manufacturer's instructions shall be followed for cutting of pipes where necessary. Suitable and approved tools shall be used for the cutting so as to leave surface clean and square to the axis of the pipe.

3.04.10 Jointing

Jointing of pipes shall be so planned as to avoid completely any movement or strain to the joints already made. If any joint is suspected to be damaged it shall be opened out and redone.

All joints between pipes, pipes and fittings and manholes shall be gas-tight when above ground and watertight when underground. Method of jointing shall be as per instructions of the pipe and fittings manufacturer and as approved by the Engineer. However, in the absence of any instruction available from the manufacturer the methods as detailed hereunder shall be used.

a) Cast Iron Pipes

Socket and spigot pipes shall be jointed by the cast lead joints. The spigot shall be centred in the socket of the pipe by tightly caulking in sufficient

turns of tarred gasket or hemp yarn to have unfilled half the depth of socket. When the gasket or hemp yarn has been caulked tightly a jointing shall be placed round the barrel and tightened against the face of the socket to prevent airlock. Molten lead shall then be poured in to fill the remainder of the socket and caulked with suitable tools right round the joint to make up for shrinkage of the molten metal on cooling and shall be finished 3 mm behind the socket face.

Joints in cast iron pipes with special jointing arrangements like 'Tyton' Joints etc. shall follow the instructions of the manufactures.

In special cases if flanged joints are accepted by the Engineer the joints shall be made leak proof by inserting approved type of rubber gaskets. The bolts shall be secured in stages to avoid uneven strain.

b) Concrete Pipes

Jointing of concrete pipes shall be generally of rigid type. Unless otherwise stated collar type joint shall be provided. IS: 783 shall be followed for general guidance.

The two adjoining pipes shall be butted against each other and adjoined in correct position. The collar shall then be slipped over the joint, covering equally both the pipes. The angular space shall be filled with stiff mixture of cement mortar 1:2 (1 cement : 2 sand) which shall be rammed with caulking tool. After a day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured for 7 days.

c) Glazed Stoneware Pipes

Tarred gasket or hemp yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be placed into the socket of the pipe previously laid. The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly so as not to fill more than 1/4 of the total depth of the socket. The remainder of the socket shall be filled with a stiff mixture of cement mortar 1:1 (1 cement : 1 sand). A fillet shall be formed round the joint with a trowel, forming an angle of 45 deg. with the barrel of the pipe. The newly made joints shall be protected, until set and shall be cured by covering with damp cloth or other suitable materials.

d) Vitrified clay pipes

The vitrified clay pipe shall be made from refractory clay mixed with crushed pottery and stone and burnt at a high temperature. These shall be hard, compact, and glazed to make them acid resistant and impervious, and

shall be obtained from approved manufacturer.

Special care shall be taken in handling these pipes. The pipes shall not be jointed until the earth has been partly refilled over the portion of the pipe between the joint holes. Before laying the second pipe, the socket of the first pipe laid shall be thinly painted all round on the inside with cement slurry (1 part of cement and 2 parts of clean, sharp sand). A ring of rope yarn (closely twisted hemp or jute) dipped in neat cement paste or tar or bitumen, shall be inserted in the socket of pipe and driven home with caulking tools. The rope shall fully encircle the spigot with a slight overlap and shall not occupy more than one-fourth of the total depth of the socket. Where the spigot end of the pipe is made for receiving the gasket, it shall be wrapped with two or three turns of tarred spun, as close to the end as possible, before inserting into the socket. The joint shall then be completely filled with cement mortar (1:1), which shall have very little water. A fillet shall be formed round the joint with trowel, forming an angle of 45 degrees with the outside pipe. Special care shall be taken so that any excess mortar etc. left inside the pipe joints is neatly cleaned off immediately after each joint is made. A semi-circular wooden scrapper or a rubber disc to which a long handle is fixed could be used for this purpose.

e) Lead Pipes

The joints in lead pipes shall be made as wiped solder joint. The minimum and the maximum length of the wiped solder joints shall be 8 cm. and 9 cm. respectively. The solders shall generally consist of two parts of lead and one part of tin.

f) Polyethylene Pipes

The joints shall be thermo welded or bolted as per manufacturer's instructions.

g) Jointing Cast Iron Pipes with Stoneware Pipes

Where any cast iron drain pipe, ventilating pipe or trap is connected with a stoneware or semi-vitrified waste pipe, the beaded spigot end of such cast iron drain pipe, waste or ventilating pipe or trap shall be inserted into a socket of such stoneware pipe and the joint made with mortar consisting of one part of cement and one part of clean sand after placing a ratted gasket or hemp yarn soaked in neat cement slurry round the joint and inserted in it by means of a caulking tool.

h) Jointing Stoneware with Cast Iron Pipes

Where any water closet pan or earthware trap connected to such a pan is to

be jointed with a cast iron soil pipe, the joint between the stoneware spigot and the cast iron socket shall always be of a flexible nature. Such joint shall be made with a mixture of bitumen and chopped asbestos fibre.

3.04.11 Trenches and other excavations

Width of the trench at the bottom shall be such as to provide 200 mm clearance on either side of the pipe for facility of laying and jointing.

Excavated material shall be stacked sufficiently away from the edge of the trench and the side of the spoil bank shall not be allowed to endanger the stability of the excavation. Spoil may be carted away and used for filling the trench behind the work.

Turf, top soil or other surface material shall be set aside, turf being carefully rolled and stacked for use in reinstatement.

All excavation shall be properly timbered, where necessary.

Efficient arrangements for dewatering during excavation and keeping it dry till backfilling shall be made to the satisfaction of the Engineer. Sumps for dewatering shall be located away from the pipe layout.

Where the excavation proceeds through roads necessary permissions shall be secured by the Contractors from the appropriate authorities.

Special care shall be taken not to damage underground services, cables etc. These when exposed shall be kept adequately supported till the trench is backfilled.

The backfilling shall be done only after the pipeline has been tested and approved by the Engineer. Special care shall be taken under and sides of the pipe during hand packing with selected material. At least 300 mm over the pipe shall also be filled with soft earth or sand. Consolidation shall be done in 150 mm layers. The surface water shall be prevented from getting into the filled up trench. Traffic shall not be inconvenienced by heaping up unduly the backfilling material to compensate future settlement. All future settlements shall be made good regularly to minimize inconvenience of traffic where applicable.

3.04.12 Protection

Open end of each pipe shall be protected during installation by suitable covers or plugs so that the ends, threads, sockets, or spigot are not damaged and no foreign material can find its way into the pipeline. Fittings and fixtures liable to be misused or stolen during the construction phase shall be fitted only before testing and handing over.

3.05.00 WATER STORAGE TANKS

Overhead/loft type water storage tank shall be made of PVC. These tanks shall be provided for each toilet block and placed on the roof/loft of the building. Tank shall be installed with proper supports and anchorage for applicable wind and seismic condition. Installation of tank shall be carried out according to the recommendation of IS: 12701. These tanks shall rest preferable on flat surface so as to distribute the load evenly. The tank shall be leakproof and water tight.

The outlet pipe shall be 50 mm above the bottom of the tank and provided preferably with strainers. The wash out or draining pipe shall be connected at the lowest point and flush with bottom of tank.

Tank shall be provided with all fittings for inlet, outlet, overflow pipes and ball valves.

3.06.00 SEPTIC TANK AND EFFLUENT DISPOSAL

3.06.01 Septic tank

Septic tank shall consist of the tank itself with inlet and outlets there from complete with all necessary earthwork and backfilling. The details of septic tank shall be as shown on drawings. This item shall also include ventilating pipe of at least 100 m dia whose top shall he provided with a suitable mosquito proof wiremesh and cowl. Ventilating pipe shall extend to a height of about 2 meter when the septic tank is at least 15 meter away from the nearest building and to a height of 2 meter above the top of building when it is located closer than 15 meter. Ventilating pipes can be connected to the normal soil ventilating system of the building where allowed.

3.06.02 Effluent Disposal

The effluent from the septic tank shall be disposed by allowing it into an open channel or a body of water if the concerned authority approves or into a soak pit for absorption by soil or shall be allowed to be absorbed by soil through open jointed SW pipes laid in a trench filled with broken bricks.

3.06.03 Soak pit

The soak pit shall be complete. It shall consist of a 900 mm dia pit 1000 mm in depth below the invert level of the inlet pipe. The pit shall be lined with stone; brick or concrete blocks set in cement mortar (1:6) and filled with brickbats. Inlet pipe shall be taken down to a depth of 900 mm from the top as an anti-mosquito measure.

3.06.04 Open joined SW Pipe/dispersion trenches

Minimum dia of the SW pipes shall be 150 mm nominal. The trench for laying the pipes shall be a minimum 600 x 600 mm. The joints of the pipes shall be left unsealed. The entire length of the pipe within the trench shall be buried in a 250 mm layer gravel or crushed stone of uniform size. On top of gravel/crushed stone layer is a 150 mm bed of well-graded coarse aggregate. Ordinary soil is used for filling the top of trench.

3.06.05 Commissioning septic tank

After the septic tank has been proved watertight and the sewage system is checked the tank shall be filled with water to its outlet level before the sewage is let into the tank. It shall be seeded with well digested sludge obtained from septic tank or sludge digestion tank. In the absence of digested sludge a small quantity of decaying organic matter such as digested cow-dung may be introduced.

3.07.00 Related Works

All works, like earthwork, masonry, concrete, steelwork, cutting holes, chases, repairs and rectification associated directly with installation of water supply and sanitation systems shall come under scope of the Contractor unless specifically excluded. These works are not detailed out in this Section.

3.08.00 Regulation

The work which is required to be carried out under this section, shall be executed by a licensed Plumber only (engaged by the Contractor) and he shall obtain all necessary sanctions, permissions, certificates etc., from Municipal and/or other Local Authorities and shall abide by all the rules of such Authorities.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 Inspection Before installation

All pipes, fittings, and appliance shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as rejected and forthwith removed from the site.

4.02.00 Testing of Water Supply pipe line

4.02.01 Testing of Mains After Laying

After laying and jointing, the main shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25 mm inlet with a stop-cock, allowed to stand full of water for a few days if time permits, and then tested under pressure. The test pressure shall be 5 Kg/sq.cm or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or in the case of long mains or mains of a large diameter, by a power driven test pump, provided that the pump is not left unattached. In either case due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure gauges shall be accurate and shall preferably have been recalibrated before the test. The pump having been stopped, the test pressure shall maintain itself without measurable less for at least five minutes. The end of the main shall be closed by fitting a watertight expanding plug and the plug shall be secured by struts to resist the end thrust of the water pressure in the mains.

4.02.02 Testing of Service Pipes and Fittings

The service pipes shall be slowly and carefully charged with water allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under working conditions of pressure and flow. When all draw-off taps are closed, the service pipes shall be absolutely watertight. All piping, fittings, and appliances shall be checked for satisfactory support and protection from damage, corrosion, and frost.

4.03.00 Testing of Drain and Sewerage Pipelines

All soil pipes, waste pipes, ventilating pipes and all other pipes, when above ground, shall be gas tight. All sewers and drainpipes laid below ground shall be tested water tight. The method of actual tests shall be decided by the Engineer. All test data shall be recorded and submitted to the Engineer for review and instruction. The Engineer's discretion regarding tolerance shall be final.

General guidance for the tests are given below:

a) Smoke test

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be approved gastight by a smoke test conducted under a pressure of 25 mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tarpaper or similar material in the combustion chamber of a smoke machine. Chemical smokes shall not be used.

b) Water test

The pipes shall be subjected to a test pressure of at least 1.5 m head of water at the highest point of the section under tests. The tolerance figure of two litres per centimetre of diameter per kilometre may be allowed during a period of 10 (ten) minutes. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system, with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of the vertical pipe jointed to it so as to provide the required test head or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of test water may be due to one or more of the following cases:

a) Absorption by pipes and joints

b) Sweating of pipes or joints

c) Leakage at joints or from defective pipes

d) Trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased and after which the test proper should commence. Any leakage and the defective part of the work shall be cut out and made good.

c) For straightness

i) By inserting at the high end of the sewer or drain a smooth ball of a diameter 13 mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball with roll down the invert of the pipe end emerge at the lower end; and

ii) By means of a mirror at one end of the line and lamp at the other. If the pipeline is straight, the full circle of light may be observed. The mirror will also indicate obstruction in the barrel if the pipeline is not straight.

4.04.00 Fittings and Fixtures etc.

All fittings and fixtures shall be connected by water tight joints. No dripping of water shall be acceptable.

4.05.00 Testing Septic Tank

The septic tank shall be tested for water tightness. It shall be filled up with water and allowed to soak for 24 hours. Then, it shall be topped up and allowed to stand again for 24 hours and loss of level recorded. The fall shall not be more than 15 mm in 24 hrs.

5.00.00 I.S. CODES

Important relevant IS Codes for this specification are listed below:

Latest editions shall always be consulted.

IS: 404	:	Lead pipes.
IS: 407	:	Brass tubes for general purposes.
IS: 458	:	Concrete pipes (with or without reinforcement)
IS: 783	:	Code of Practice for laying of concrete pipes.
IS: 1172	:	Code of basic requirements for water supply, drainage and sanitation.
IS: 1200 (Pt.XVI)	:	Laying of water and sewer lines, including appurtenant items.
IS: 1230	:	Cast iron rain water pipes and fittings.
IS: 1239 (Pt.I & III)	:	Specification for Mild Steel Tubes and Mild Steel Tubulars and other wrought steel pipe fittings (10 mm to 15 mm nominal diameter).
IS: 1536	:	Specification for centrifugally cast (Spun) iron pressure pipes for water gas and sewage.
IS: 1537	:	Specification for vertically cast iron pressure pipes for water, gas and sewage.
IS: 1592	:	Asbestos cement pressure pipes,

IS: 1626 : Asbestos cement pressure pipes, gutters and fittings (Spigot and Socket types).

IS: 2065 : Code of Practice for Water Supply in buildings.

IS: 2501 : Copper tubes for general engineering purposes.

IS: 2556 : Specification for vitreous sanitary appliances (vitreous china) Part – I - General requirement

IS: 2633 : Method of testing, uniformity of coating on zinc coated articles.

IS: 3076 : Low density polyethylene pipes for portable water supplies.

IS: 3486 : Specification for Cast iron spigot and socket drain pipes (80 mm to 250 mm nominal diameter).

IS: 3589 : Specification for Electrically welded steel pipe for water, gas and sewage (200 mm to 2000 mm nominal diameter).

IS: 4827 : Specification for electro plated coatings of nickel and chromium on copper and copper alloy.

IS: 4964 : High-density polyethylene pipes for portable water supplies.

IS: 12701 : Rotational moulded polyethylene water storage tanks

6.00.00 RATE AND MEASUREMENT

6.01.00 RATE

6.01.01 G.I. Pipes For Water Supply

Rate shall include providing and fixing of the pipes including all specials and fittings, such as tees, bands, elbows, clamps, drain heads, cleanouts etc. with cutting, making chases and jointing of pipes, making good the walls.

6.01.02 Rainwater Down-comers

Rate shall include providing and fixing of the pipes including all specials and fittings, such as tees, bands, elbows, clamps, drain heads, cleanouts etc. The rate also include cost of jointing and making good the opening in structure.

6.01.03 Sanitary Fixtures

Rate shall include providing and fixing of sanitary appliances & fixtures and at all elevation, including all accessories and fittings, connections pipes, waste trap and pipes all complete as per description of "Schedule of Items". Rate shall also include the jointing of waste & traps to drain pipes.

6.01.04 Drainage and Sewer Pipes

Rate shall be inclusive of providing, laying and jointing of pipes as specified. Rate also include cost of lead joints or other joint as specified, cost for painting and cutting and making good walls, floors etc.

6.01.05 Floor and Gully Traps

Rate of traps is inclusive of all excavation, filling, repair, making good of opening in floor and walls, grating, painting etc. complete as described in "Schedule of Items".

6.01.06 Manholes, Septic Tank, Soak Pit and Cover

Rate of manholes, septic tank, soak pit shall be paid under respective items of work executed like brick work, plastering, concrete, reinforcement steel etc. provided for completion of the structure as per drawing and specifications. Manhole cover shall be paid separately as per description of item.

6.01.07 Water Storage Tank

The rate for water storage tank is inclusive of supply and installation of tank with all fittings, inlets, outlets, valves etc. complete.

6.02.00 MEASUREMENTS

6.02.01 Pipe for Water Supply and Drainage

For G.I.Pipe of water supply line, rainwater down comers, drainage and sewer pipe, the measurements shall be in running metres and shall be taken along centre line of pipe or specials.

The pipe shall be measured separately according to dia. and class of pipe.

Fixtures like bibcock, stopcocks, valves etc. shall be measured in numbers.

6.02.02 Sanitary Appliances & Fixtures and Allied Works

All sanitary appliances & fixtures like sink, washbasin, WC, shall be measured in numbers for the complete work as described in schedule of items.

Floor and gully traps shall be measured in numbers unless otherwise specified.

Water storage tank shall be measured in numbers for the capacity as specified in "Schedule of Items".

The item of work executed for completion of manholes, septic tank & soak pit shall be measured in respective items of work like brick work, RCC, plastering etc. CI cover shall be measured in numbers as specified in "Schedule of Items".

VOLUME: II B

SECTION - D

SUB-SECTION – D16

SPECIFICATION NO. PE-TS-999-600-C016

ROAD AND DRAINAGE

Maharatna Company

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.
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2.00.0	CODES AND STANDARDS	4
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Standard Technical Specification
For Road and Drainage

1.00.00 Scope

The scope include all works required for the construction of road including construction of embankment, sub-base course, base course, tack coat, bituminous macadam, wearing course, liquid seal coat, shoulder and all incidental items of work specified or not shown but reasonably implied or necessary for the completion of the work etc.

The scope also include all works required for the construction of drainage including construction of road side drains, RCC culverts, pipe culverts, drainage pipes, manholes and all other incidental items necessary for the completion of the work etc.

1.01.00 Works To Be Provided By The Contractor

The works to be provided by the contractor unless specified otherwise shall include but not be limited to the following.

a) Construction of roads including providing all materials, labour, supervision, services, equipments, tools and plants, transportation etc all required for the completion of the work.

b) Submission of detailed scheme of all operations required for executing the work (e.g. material handling, placement, services, approaches etc) to the engineer for approval.

c) Carrying out tests whenever required by the engineer to assess the quality of work and submission of the test results to the engineer after completion of the same etc.

1.02.00 Work To Be Provided By Others

No work under this specification will be provided for by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

1.03.00 Conformity With Designs

The contractor shall carryout the work as per the construction drawings, specification and as directed by the engineer.

1.04.00 Materials To Be Used

All materials required for the work shall be the best commercial variety and as approved by the engineer.

2.00.00 Codes and Standards

All works under this specification shall conform to the latest revision and/or replacement of the following or any other IRC/IS Codes and Standard Practices unless specified otherwise.

a) Specification for road and bridge works of Ministry of Shipping & Transport (Road Wing) Published by the IRC

b) IRC: 19 - Standard specification and code of practice for Water bound Macadam

c) IRC :SP 11 - Hand Book of Quality Control for Construction of Roads and Runways

d) IS:456 - Indian Standard Code of Practice for Plain and Reinforced Concrete.

e) IS:2212 - Code of Practice for Brick work

f) IS: 783 - Code of Practice for Laying of Concrete Pipes

g) IS: 1201 - Methods of testing tar and bituminous materials to 1220

h) IS: 73 - Specification for paving bitumen

i) IS: 215 - Specification for Road tar

j) IS: 216 - Coal tar pitch

k) IS: 217 - Specification for cut-back bitumen

l) IS: 454 - Specification for cut-back bitumen from waxy crude

m) IS: 1834 - Specification for hot applied sealing compound for joint in concrete

n) IS: 1838 - Specification for performed fillers for expansion joints in concrete, non extruding and resilient type
Part I Bitumen impregnated fibre

Part II CNSL Aldehyde resin and coconut pith

o) IS : 334 - Glossary of terms relating to bitumen and tar

p) IS: 1077 - Common burnt clay building bricks

q) IS : 3117 - Specification for bitumen emulsion roads (anionic type)

r) IS : 1200 - Method of measurement of building and civil engineering work (Part-17)- Road work including airfield pavements

s) Other specifications mentioned elsewhere in this specification.

In case any particular aspect of work is not covered specifically by the specification/Indian Standard Code of practices, any other standard practice as may be specified by the engineer shall be followed.

2.01.00 Quality Control

The Contractor shall establish and maintain quality control for all materials, procedures, workmanship and equipments used. All works shall conform to the lines, grades, cross sections and dimensions shown on the drawings, specification and as directed by the engineer. Permitted tolerances for road works are described hereinafter.

a) Horizontal Alignment

Horizontal alignment shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 25mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of the pavement shall be ± 40mm.

b) Longitudinal Profile

The finished levels of the sub-grade and different pavement courses as constructed shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the engineer and shall not exceed the tolerances as mentioned below.

Sub-grade ± 25 mm
Sub-base ± 20 mm
Base course ± 15 mm
Wearing course ± 10 mm

Tolerance in wearing course shall not be permitted in conjunction with the

positive tolerance on base course if the thickness of the wearing course is thereby reduced by more than 6 mm.

c) Surface Regularity of Sub-grade and Pavement Courses

The surface regularity of the completed sub-base, base course and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table - I. The longitudinal profile shall be checked with a 3m long straight edge at the middle of each traffic lane along a line parallel to the centre of the road. The transverse profile shall be checked with a set of three camber boards at intervals of 10m.

TABLE –I

PERMITTED TOLERANCE OF SURFACE REGULARITY FOR PAVEMENT COURSES

Sl. No.	Type of Construction	Longitudinal profile with 3m straight edge					Cross Profile
		Maximum permissible Undulation (mm)	Maximum number of undulations permitted in any 300m length with undulation exceeding (mm)				Maximum permissible variation from specified profile under camber template (mm)
			18	12	10	6	
1	2	3	4	5	6	7	8
1.	Earthen sub-grade	25	30	-	-	-	15
2.	Granular sub-base	15	-	30	-	-	12
3.	Water Bound Macadam with oversize metal (40-90 mm size)	15	-	30	-	-	12
4.	Water Bound Macadam with normal size metal (20-50 mm and 40-63 mm size), Bituminous Penetration Macadam	12	-	-	30	-	8
5.	Surface dressing** (two coat) over WBM (20-50 mm or 40-63 mm size metal), Bituminous penetration macadam	12	-	-	20	-	8
6.	Open graded premix carpet, mix seal Surfacing	10	-	-	-	30	6
7.	Bituminous macadam	10	-	-	-	20***	6

8.	Semi-dense carpet	10	-	-	-	20***	6	
9.	Asphaltic Concrete	8	-	-	-	10***	4	

Notes:

1. ** For surface dressing in all other cases, the standards of surface evenness will be the same as those for the surface receiving the surface dressing.

2. *** These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance upto 50 percent above these values in this column may be permitted at the discretion of the Engineer. However this relaxation does not apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the table.

3. Surface evenness requirements in respect of both the longitudinal and cross profiles should be simultaneously satisfied.

3.00.00 Execution

3.01.00 Setting Out

Within 15 days of the award of contract, the contractor shall prepare and submit to the Engineer detailed drawings/schemes of embankment filling and excavation works as proposed to be executed by him showing the dimensions as per construction drawings and specification adding his proposals of drainage and dewatering of pits, watering and compacting the embankment fill etc. On receiving the approval from the Engineer with modifications and corrections if any, the contractor shall set out the work from the control points furnished by the Engineer and fix permanent points and markers for ease of future checking. These permanent points and markers will be checked by the Engineer and certified by him after which the contractor shall proceed with the work. It should be noted that this checking by the Engineer prior to the start of the work will in no way absolve the contractor of his responsibility of carrying out the work to true lines and levels as per the approved drawings. If any errors are noticed in the Contractor's work at any stage, the contractor at his own risk and cost shall rectify the same. Profiles of the embankment made with Bamboo, earth or other convenient materials and strings shall be set up at suitable intervals for the guidance of the workmen.

3.02.00 Clearing and Grubbing

Before commencement of earthwork, the surface area of ground to be occupied shall be cleared of all fences, trees, logs, stumps, bushes, vegetation, rubbish, slush etc. Cutting of trees shall include trees having girth of any size and removing roots upto a depth of 600mm below ground level or 300mm below formation level whichever is deeper. After the removal of roots of

trees, the pot holes formed shall be filled with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the Engineer. The trees shall be cut into suitable pieces as instructed by the Engineer. Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burnt or removed from the site to the approved disposal areas as may be specified. Useful materials, saleable timbers, firewood etc shall be the property of the Owner and shall be stacked properly at the work site in a manner as directed by the Engineer.

3.03.00 Filling in Embankment

3.03.01 General

The material used for constructing the embankment shall be earth, moorum, gravel or a mixture of the above or any other material approved by the Engineer. The material shall be free from lumps and clods, boulders and rock pieces, roots and vegetation, harmful salts and chemicals, organic materials, loose silts, fine sands and expansive clays in order to provide a stable embankment. The filling and compaction operation should be such that the best available materials are saved for the top portion and will result in an acceptable and uniform gradation of material and provide impermeability and stability to the embankment when compacted. The size of the coarse material in the mixture of earth shall ordinarily not exceed 75mm. However the Engineer may at his discretion permit the use of material coarser than the specified if he is satisfied that the same will not present any difficulty as regard to the placement and compaction of the fill material are concerned. Ordinarily, only the materials satisfying the density requirements as given below in Table-II shall be employed for embankment construction.

Table - II

Density Requirements of Embankment Materials

Sl. No.	Type of Work	Maximum laboratory dry density when tested as per IS: 2720 (Part - VII)
1.	Embankment upto 3m height	Not less than 1.44 gm/cc
2.	Embankment exceeding 3m height and embankment of any height subject to long period of inundation	Not less than 1.52 gm/cc
3.	Top 0.5m of the embankment below sub-base and shoulders (where earth shoulders are specified)	Not less than 1.65 gm/cc

Expansive clays exhibiting marked swell and shrinkage properties shall not be used for embankment construction.

The material for embankment construction shall be obtained from approved sources with preference given to the materials available from nearby road excavation or any other excavation under the same contract.

3.03.02 Setting Out

After the site clearance, the work shall be set out true to lines, curves, slopes, grades and sections as shown on the approved drawings or as directed by the Engineer. The contractor shall provide all labour, survey instruments and materials such as strings, pegs, nails, bamboo, stones, lime, mortar, concrete etc required in connection with the setting out of the works and establishment of the bench marks. The limits of the embankment shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. To ensure the safety, the pegs should normally be fixed about 500mm away from the actual limits of the fill and to be painted in a distinct colour. The centreline of the embankment shall be pegged at regular intervals of 25/30m and at all skews/curves. The actual profile of the embankment shall be made at every third centre line peg with bamboo posts and strings. Preferably prototype profiles developed with wooden planks need to be fixed at every 200m and at the intersection points at curves. The profile shall be about 3m long.

3.03.03 Stripping and Storing top soil

The construction of the earthen embankment by filling shall conform to the dimensions, slopes and other details shown in the approved drawings. Before commencement of the embankment construction, the surface area of ground to be occupied after clearing and grubbing shall be stripped off to a minimum depth of 150mm or more as directed by the Engineer in order to remove all perishable materials and any soil which may become unstable on saturation or may interfere with the development or proper bonding between the foundation and embankment. It is not necessary to remove all the soil containing fine hair like roots but only the rather heavy mats are to be removed. In localities where most of the available embankment fill materials are not conducive to plant growth or when so directed by the Engineer, the top soil suitable for plant growth existing over the embankment foundation areas shall be stripped to specified depths not exceeding 150mm and stored for covering the embankment slopes where revegetation is desired.

3.03.04 Compacting Original Ground

In all cases, the original ground after stripping shall be compacted by rolling with a minimum six passes of 8-10 tonne roller and as directed by the Engineer.

Where the height of the proposed embankment is less than 0.5m and the original ground does not already have a relative compaction of atleast 95 percent of Standard Proctor density (maximum dry density), the same shall be loosened upto a depth of 0.5m and filled in layers not exceeding 250mm in loose thickness and each layer shall be watered and compacted to 100% maximum dry density of the fill material determined in accordance with IS:2720, Part-VII. However before relaying and compacting the loosened material, the surface below this level shall be suitably compacted as directed by the Engineer with a minimum six passes of 8 - 10 tonne roller.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced with approved materials suitably compacted. Embankment work shall not proceed until the foundation soil of the embankment is inspected by the Engineer and approved.

3.03.05 Filling

The embankment material shall be spread uniformly over the entire width of the embankment in layers not exceeding 250mm in loose thickness. Successive layers of embankment shall not be placed until the layer under construction has been thoroughly compacted to the requirements set down hereunder. Moisture content of the fill material shall be checked at the source of supply and if found less than that specified for compaction, the same shall

be made good either at the source or after spreading the soil in loose thickness for compaction. In the latter case water shall be sprinkled directly from a hose line or from a truck mounted water tank and flooding shall not be permitted under any circumstances. After adding required amount of water, the soil shall be processed by means of harrows, rotary mixers or by any other approved method until the layer is uniformly wet.

If the material delivered to the road bed is too wet, it shall be dried by aeration and exposure to the sun till the moisture content is acceptable for compaction. Should circumstances arise where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, the work on compaction shall be suspended.

Moisture content of each layer shall be checked in accordance with IS:2720, Part-II and unless otherwise specified shall be so maintained making due allowance for evaporation losses that during compaction, the moisture content shall be in the range of 1 percent above to 2 percent below the optimum moisture content as determined in accordance with IS:2720, Part-VII.

Clods or hard lumps of earth shall be broken to have a maximum size of 150mm when being placed in the lower layers of the embankment and a maximum size of 60mm when being placed in the top 0.5m portion of the embankment below sub-base.

Hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer to minimise rutting or uneven compaction.

Where the embankment is to be constructed across a low swampy ground that will not support the weight of trucks or other hauling equipments, the lower part of the fill shall be constructed by dumping successive loads in a uniformly distributed layer to a thickness not greater than that necessary to support the hauling equipment while placing subsequent layers.

3.03.06 Compaction

Compaction equipment approved by the Engineer shall only be employed for construction. If directed by the Engineer, the Contractor shall demonstrate the efficiency of the plant he intends to use by carrying out compaction trials.
Each layer shall be thoroughly compacted to the density as specified in Table-III. Subsequent layers shall be placed only after the finished layer has been tested and accepted by the Engineer.

Table - III

Compaction Requirements For Embankment

Sl. No.	Type of work/material	Field dry density as a percentage of maximum laboratory dry density as per IS : 2720, Part-VII
1.	Top 0.5m portion of embankment below sub-base and shoulders	Not less than 100
2.	Other portions of embankment	Not less than 95

When density measurements reveal any soft area in the embankment, further compaction shall be carried out as directed by the Engineer. If in spite of that the specified compaction is not achieved, the material in the soft area shall be removed and replaced with approved material and compacted to the density requirements and satisfaction of the Engineer.

3.03.07 Drainage

The surface of the embankment at all times during construction shall be maintained at such a cross fall as will shed water and prevent ponding.

3.03.08 Finishing Operations

Finishing operations shall include the work of shaping and dressing the shoulders, road bed and side slopes to conform the alignment, levels, cross sections and dimensions as shown on the drawings or as directed by the Engineer. Both the upper and lower ends of the side slopes shall be rounded off to improve the appearance and merge the embankment with the adjacent terrain.

3.04.00 Turfing With Sods

3.04.01 General

This work shall consist of furnishing and laying live sod of perennial turf forming grass on embankment slopes, shoulders or other locations as shown on the drawings or as directed by the Engineer. Unless otherwise specified the work shall be taken up following the construction of embankment provided the season is favourable for establishment of the sod.

3.04.02 Materials

The sod shall consist of dense, well rooted growth of permanent and desirable grasses indigenous to the locality where it is to be used and shall be practically

free from weeds and other undesirable matters. At the time the sod is cut, the grass shall have a length of approximately 50mm and the sod shall be free from any debris.

Thickness of the sod shall be as uniform as possible with about 50 to 80mm of soil covering the grass roots depending on the nature of the sod so that practically all the dense root system of the grass are retained in the sod strip. The sods shall be cut in rectangular strips of uniform width not less than 250mm x 300mm in size but not so large so that it is convenient to handle and transport without damage. During wet weather the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather it shall be watered before lifting to ensure its vitality and to prevent dropping of soil during handling.

3.04.03 Placing The Sods

The area to be sodded shall be previously constructed to the required slope and cross section. Soil in the area shall be loosened, freed from all stones larger than 50mm size, sticks, stumps and any other undesirable foreign matters etc and brought to a reasonably granular texture to a depth not less than 25mm for receiving the sod.

Where required, top soil shall be spread over the slopes. Prior to placing the top soil, the slopes shall be roughened and wetted in order to have a satisfactory bond. The depth of top soil (to be spread) shall be 75mm.

Following soil preparation and top soiling (if required), fertilizer and ground limestone when specified shall be spread uniformly. After spreading, the materials shall be incorporated in the soil by discing or other means. The prepared sod bed shall be moistened if not already sufficiently moist and the sod shall be placed thereon within 24 hours after the same has been cut. Each sod strip shall be laid in close contact with each other and shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil. At points where water may flow over the sod, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth shall be placed over it followed by thorough compaction.

3.04.04 Staking the Sods

Where the side slope is 2 to 1 or steeper and the distance along the slope is more than 2m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods and to be almost flushed with them.

3.04.05 Top Dressing

After the sods have been laid in position, the surface shall be cleaned of any loose sod, excess soil and other foreign materials. Thereafter a thin layer of top soil shall be scattered over the top dressed surface and the area shall be thoroughly moistened by sprinkling water.

3.04.06 Watering and Maintenance

The turfing so laid shall be well watered and protected until final acceptance. Watering shall be done in such a way that no erosion or damage to the sodded areas/embankment occur. The Contractor shall erect necessary warning signs and barriers, repair or replace the sods which are failing to show uniform growth of grass or damaged by his operation and shall maintain the sod at his own cost until final acceptance.

3.05.00 Shoulder Construction

3.05.01 Description

This work shall consist of constructing shoulder on either side of the pavement in accordance with the requirements of this specification and in conformity with the lines, grades and cross sections shown on the approved drawings and as directed by the Engineer.

3.05.02 Materials

Shoulder shall be made of selected earth or granular material as specified conforming to relevant IRC standards.

3.05.03 Construction Operations

Except in the case of bituminous pavements, the shoulders shall be constructed in advance to the laying of pavement courses. The compacted thickness of each layer of shoulder shall correspond to the compacted layer of pavement course to be laid adjacent to it. After compaction, the inside edges of shoulders shall be trimmed vertical and the area enclosed between the shoulders shall be cleaned of all spilled materials before proceeding with the construction of the pavement layer.

In the case of bituminous pavements, shoulder shall be constructed only after the pavement courses have been laid and compacted.

Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed without any damage to the

pavement and the area so affected shall be thoroughly cleaned. During all stages of shoulder construction, the required crossfall shall be maintained to drain off surface water.

3.06.00 Kerb

3.06.01 Material

Kerb if required for the construction of footpath shall consist of precast concrete blocks with concrete grade of M-20. The blocks shall be of 100mm thick and of suitable length. The depth of blocks unless otherwise mentioned elsewhere shall be 375mm considering 225mm height of footpath above the road level.

3.06.02 Laying

The kerb shall be laid by cutting trenches of 150mm deep. The width of the trench shall be minimum and just sufficient to insert the kerbs. The inside faces of the kerbs shall be in plumb and the gap between the block shall not be more than 10mm.The gap shall be filled with cement mortar as specified.

The kerbs shall be thoroughly packed with a mixture of stone chips (50%) and moorum (50%) at the outside face. The laying and packing shall be done in a proper workmanlike manner acceptable to the Engineer.

3.07.00 Sub-base (Granular Sub-base)

3.07.01 Description

This work shall consist of laying and compacting well graded material on the prepared sub-grade in accordance with the specification. The material shall be laid in one or more layers as shown on the drawings and shall conform to the lines, grades and cross sections shown on the drawings and as directed by the Engineer.

3.07.02 Materials

The materials to be used for the work shall be natural sand, moorum, gravel, crushed stone, crushed slag, crushed concrete, brick metal, laterite, kankar etc or combinations thereof depending upon the grading required. The mixed materials shall be free from organic and other deleterious constituents and conform to one of the three grading given in Table - IV below.

Table - IV
Grading for Granular Sub-base Material

Sieve designation	Percent by weight passing the sieve		
	Grading 1	Grading 2	Grading 3
80 mm 63 mm 4.75 mm 75 micron	100 90 - 100 35 - 70 0 - 20	100 90 - 100 40 - 90 0 - 25	100 90 - 100 50 - 100 0 - 30
Minimum CBR value for the fraction of material passing 20 mm sieve.	30 %	25%	20%

Note : The materials passing 425micron sieve for all the three gradings when tested according to IS : 2720, Part V shall have liquid limit and plasticity index not more than 25 percent and 6 percent respectively.

3.07.03 Physical Requirements

The fraction of materials passing 20mm sieve shall give a CBR value as specified in Table – IV when tested in accordance with IS : 2720, Part XVI after preparing the samples at maximum dry density and optimum moisture content corresponding to IS : 2720, Part VII and soaking the same in water for 4 days.

3.07.04 Spreading and Compacting

Immediately prior to laying of sub-base, the sub-grade already finished shall be prepared by removing all vegetations and other extraneous matters, lightly sprinkled with water if necessary and rolled with one pass of 8 - 10 tonne smooth wheeled roller.

The sub-base material shall be spread on the sub-grade with the help of a drag spreader, motor grader or other approved means. The thickness of loose layers shall be so regulated that the maximum thickness of each layer after compaction shall not exceed 150mm.

Moisture content of the loose material shall be checked in accordance with IS : 2720, Part II and shall be suitably adjusted by sprinkling additional water from a hose line, truck mounted water tank or other approved means so that at the time of compaction it shall be from 1 percent above to 2 percent below the optimum moisture content. While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means if so directed by the Engineer until the layer is uniformly wet.

Immediately thereafter, rolling shall be done with 8 to 10 tonne smooth wheeled rollers or with any other approved plant. Rolling shall commence from the edges and progress towards the centre longitudinally except on super elevated portions where it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and camber shall be checked and any high spots or depressions which become apparent shall be corrected by removing or adding fresh material.

Rolling shall be continued till the density achieved is at least 100% of the maximum dry density of the material determined as per IS : 2720, Part VII. The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose materials. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and recompacted.

3.08.00 Water Bound Macadam Sub-base/Base Course

3.08.01 Description

Water bound macadam shall consist of clean crushed aggregates mechanically interlocked by rolling and bonded together with screenings, binding material wherever necessary and water, laid on the prepared sub-grade or sub-base as the case may be and finished in accordance with the specification and in conformity with the lines, grades and cross-sections shown on the approved drawings.

3.08.02 Materials

a) Coarse Aggregates - General Requirements

Coarse aggregates shall be either crushed or broken stone. The aggregates shall conform to the physical requirements set forth in Table - V.

Table – V

Physical Requirements of Coarse Aggregates for Water Bound Macadam

Sl.No.	Type of Construction	Test	**Test method**	Requirements
1.	Sub-base	Los Angeles Abrasion Value *	IS : 2386 (Part IV)	50 percent maximum
		or		
		Aggregate Impact Value	IS : 2386 (Part IV) or IS : 5640**	40 percent maximum
2.	Base	a) Loss Angeles Abrasion value*	IS : 2386 (Part IV)	50 percent maximum
		or		
		Aggregate Impact Value	IS : 2386 (Part IV) or IS : 5640 **	40 percent maximum
		b) Flakiness Index ***	IS : 2386 (Part I)	15 percent maximum

* Aggregates shall satisfy requirements of either of the two tests.

** Aggregates like brick metal, kankar and laterite which get softened in presence of water shall be tested for impact value under conditions in accordance with IS : 5640.

*** The requirements of Flakiness Index shall be enforced only in case of crushed or broken stone and crushed slag.

b) Crushed or Broken Stone

Crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other objectionable matters.

c) Grading Requirements of Coarse Aggregates

The coarse aggregates shall conform to one of the gradings given in Table – VI. However the use of Grading-1 shall be restricted to sub-base courses only.

Table - VI
Grading Requirements of Coarse Aggregates

Grading	Size range	Sieve designation	Percent by weight passing the sieve
1.	90mm to 40 mm	100 mm 80 mm 63 mm 40 mm 20 mm	100 65 - 85 25 - 60 0 - 15 0 - 5
2.	63 mm to 40 mm	80 mm 63 mm 50 mm 40 mm 20 mm	100 90 - 100 35 - 70 0 - 15 0 - 5
3.	50 mm to 20 mm	63 mm 50 mm 40 mm 20 mm 10 mm	100 95 - 100 35 - 70 0 - 10 0 - 5

d) Screenings

Screenings to fill the voids in the coarse aggregate shall generally consist of the same material as the coarse aggregates. However where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

As far as possible, screenings shall conform to the grading set forth in Table-VII. Screenings of Type-A in Table-VII shall be used with coarse aggregates of Grading-1 in Table-VI. Screenings of Type-A or B shall be used with coarse aggregates of Grading-2. Screenings of Type-B shall be used with coarse aggregates of Grading-3.

Table - VII
Grading For Screenings

Grading classification	Size of screenings	Sieve designation	Percent by weight passing the sieve
A	12.5 mm	12.5 mm 10.0 mm 4.75 mm 150 micron	100 90 - 100 10 - 30 0 - 8
B	10 mm	10 mm 4.75 mm 150 micron	100 85 - 100 10 - 30

e) Binding Material

Binding material to be used for water bound macadam construction shall comprise of a suitable material approved by the Engineer having plasticity index value less than 6 as determined in accordance with IS : 2720,Part V. Application of binding material may not be necessary when the screenings used are of crushable type such as moorum or gravel.

3.08.03 Construction Operations

a) The sub-grade/sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of any dust and other extraneous materials. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm. Where water bound macadam is to be laid over an existing black topped surface, 50mm x 50mm furrows shall be cut at an angle of 45 degrees to the centre line of the road at 1m intervals in the latter before laying the coarse aggregates.

b) Inverted Choke

If water bound macadam is to be laid directly over the sub-grade without any other intervening pavement course, a 25mm course of screenings (Grading-B) shall be spread on the prepared sub-grade before application of coarse aggregates is taken up.

c) Spreading Coarse Aggregates

The coarse aggregates shall be spread uniformly over the prepared surface in such quantities that the thickness of each compacted layer is limited to 100mm for Grading-1 and 75 - 100mm for Grading-2 and 3. The spreading shall be

done from stockpiles along the side of the roadway or directly from the vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregates nor shall hauling over permitted. The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregates as spread shall be of uniform gradation with no pockets of fine material. The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operation.

d) Rolling

Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or with tandem or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road. Each pass of the roller shall uniformly overlap not less than one half the width of the track made in the preceding pass.

Rolling shall continue until the aggregates are thoroughly keyed and the creeping of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done if necessary. Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wavelike motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities found shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and rerolled until the entire surface conform to the desired camber and grade. In no case shall the use of screenings be permitted to make up the depressions.

e) Application of Screenings

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregates. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreader or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregates.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms or hand brooms or with both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregates.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of road which could be completed within one day's operation.

f) Sprinkling and Grouting

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to seep the wet screenings into the voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued with additional screenings applied as necessary until the coarse aggregates are thoroughly keyed, well bonded and firmly set to its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or sub-grade does not get damaged due to the addition of excess quantity of water during construction.

g) Application of Binding Material

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water and the resulting slurry shall be swept in with hand brooms or mechanical brooms to fill the voids properly and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling the voids form a wave ahead of the wheels of the moving roller.

h) Setting and Drying

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam is set. The Engineer shall have the discretion to stop hauling traffic from using the complete water bound macadam course if in his opinion it would cause excessive damage to the surface.

3.09.00 Tack Coat

3.09.01 Description

The work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction.

3.09.02 Materials

The binder used for tack coat shall be bitumen of a suitable grade as approved by the Engineer and conforming to IS-73, IS-217 or IS-454 as applicable or any other approved cutback.

3.09.03 Construction Operations

a) Preparation of Base

The surface on which the tack coat is to be applied shall be thoroughly swept and scraped clean of dust and any other extraneous materials before the application of the binder.

b) Application of Binder

Binder shall be heated to the temperature appropriate to the grade of bitumen used and approved by the Engineer and sprayed on the base at the rate specified below. The rate of spread in terms of straight run bitumen shall be 5 kg per 10 square metre area for an untreated water bound macadam surface. The binder shall be supplied uniformly with the aid of sprayers. The tack coat shall be applied just ahead of the oncoming bituminous construction.

3.10.00 Bituminous Macadam Binder Course

3.10.01 Description

This work shall consist of construction in a single course of 50mm/75mm thickness of compacted crushed aggregates premixed with a bituminous binder laid immediately after mixing on a base prepared previously in accordance with the specification and in conformity with the lines, grades and cross sections shown on the approved drawings.

3.10.02 Materials

a) Binder

The Binder shall be straight run bitumen of a suitable grade as directed by the

Engineer complying with IS : 73.

b) Aggregates

The aggregates shall consist of crushed stone, crushed gravel (shingle) or other stones. They shall be clean, strong, durable, fairly cubical in shape and free from any disintegrated pieces, organic and other deleterious matter and adherent coats. The aggregates shall preferably be hydrophobic and of low porosity.

The aggregates shall satisfy the physical requirements set forth in Table - VIII.

Table – VIII

Physical Requirements of Aggregates For Bituminous Macadam

Sl. No.	Test	Test method	Requirements
1.	Los Angeles Abrasion Value *	IS : 2386 (Part IV)	35 percent maximum
2.	Aggregate Impact Value *	IS : 2386 (Part IV)	30 percent maximum
3.	Flakiness Index	IS : 2386 (Part I)	35 percent maximum
4.	Stripping Value	IS : 6241 (Part IV)	25 percent maximum
5.	Water Absorption	IS : 2386 (Part III)	2 percent maximum

*Aggregates may satisfy requirements of either of the two tests.

The aggregates for bituminous macadam for different thickness shall conform to Grading- A or B as given in Table-IX or X as the case may be.

Table-IX
Aggregates Grading For 75mm Compacted Thickness of Bituminous Macadam

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
63 mm	100	
50 mm	90 - 100	
40 mm	35 - 65	100
25 mm	20 - 40	70 - 100
20 mm	-	50 - 80
12.5 mm	5 - 20	-
4.75 mm	-	10 - 30
2.36 mm	-	5 - 20
75 micron	0 - 5	0 - 4

Table-X
Aggregates Grading For 50mm Compacted Thickness of Bituminous Macadam

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
50 mm	100	
40 mm	90 - 100	
25 mm	50 - 80	100
20 mm	-	70 -100
12.5 mm	10 - 30	-
10 mm	-	35 - 60
4.75 mm	-	15 - 35
2.36 mm	-	5 - 20
75 micron	0 - 5	0 - 4

c) Proportioning of Materials

The binder content for premixing shall be 3.5 and 4.0 percent by weight of the total mix for aggregate Grading-A and B respectively unless directed otherwise by the Engineer. The quantity of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

d) Variation in Proportioning of Materials

The Contractor shall have the responsibility for ensuring proper proportio ning of materials and producing a uniform mix. A variation in binder content

upto ± 0.3 percent by weight of total mix shall however be permissible for individual specimens taken for quality control tests.

3.10.03 Construction Operations

a) Weather and Seasonal Limitations

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

b) Preparation of Base

The base on which the bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as shown on the drawings and as directed by the Engineer. The surface shall be thoroughly swept and scraped clean and free of any dust and foreign matter.

c) Tack Coat

A tack coat shall be applied over the base.

d) Preparation and Transport of Mix

Hot mix plant of adequate capacity shall be used for preparing the mix. The temperature of binder at the time of mixing shall be in the range 150 Deg. - 165 Deg. C and to that of aggregates shall be in the range 125 Deg. - 150 Deg. C provided the temperature difference between the binder and the aggregate at no time exceeds 25 Deg. C. Mixing shall be thorough to ensure that a homogenous mixture is obtained in which all particles of the aggregates are coated uniformly. The mixture shall be transported from the mixing plant to the point of use in a suitable vehicle. The vehicle employed for transport shall be clean and be covered over in transit if so directed by the Engineer.

e) Spreading

After mixing, the mix shall be spread immediately by means of a self propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to the specified lines, grade and cross sections. However in restricted locations and in narrow widths where the available plants cannot operate in the opinion of the Engineer may permit manual laying of the mix. The temperature of mix at the time of laying shall be in the range 110 Deg. - 135 Deg. C.

In multilayer construction, the longitudinal joint in one layer shall offset into the layer below by about 150mm. However, the joint in the topmost layer shall be at the centre line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.

f) Rolling

After spreading of mix, the rolling shall be done with 8 to 10 tonne power roller or with any other approved plant. Rolling should start as soon as the materials are spread. Rolling shall be done with care to avoid any undulation in the pavement surface.

Rolling on the longitudinal joint shall be done immediately after the paving operation. After this, the rolling shall commence at the edges and progress towards the centre longitudinally except on superelevated portions where it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface and no mix pick up on the roller wheels. The second or intermediate rolling shall follow the break down rolling as early as possible and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh materials. The rolling shall then be continued till the entire surface has been rolled to compaction and there is no crushing of aggregates and till all the roller marks are eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller wheels shall be kept damp if necessary to avoid the bituminous material from sticking on the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose.

Rolling operation shall be completed in every respect before the temperature of the mix fall below 80 Deg. C.

Rollers shall not stand on the newly laid material as it may lead to undue deformation. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

The bituminous macadam shall be provided with a final surfacing without any delay. If there is to be any delay the course shall be covered by seal coat before allowing any traffic over it.

3.11.00 Open Graded Premix Carpet

3.11.01 Description

This work shall consist of laying and compacting open graded carpet of specified thickness in a single course of suitable small sized aggregates premixed with bituminous binder on a previously prepared base to form wearing course in accordance with the specification.

3.11.02 Materials

a) Binder

The binder shall be bitumen of suitable grade as approved by the Engineer and satisfying the requirements of IS: 73, 217, 454 or any other approved cutback as applicable.

b) Aggregates

The aggregates shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be obtained by crushing rock, gravel or river shingle and be free of elongated and flaky pieces, soft and disintegrated materials, vegetable and any other deleterious matter etc. They shall preferably be hydrophobic type. The aggregates shall satisfy the quality requirements set forth in Table-VIII except that the flakiness Index shall be limited to a maximum of 30.

c) Proportioning of Materials

The materials shall be proportioned as per the quantities given in Table-XI for 20mm thick open graded premix carpet.

Table - XI

Quantity of Materials Required For 10 Sq. M of Road Surface For 20mm Thick Open Graded Premix Carpet

Aggregates for Carpet		
i)	Stone Chippings - 12mm size ; passing 20 mm sieve and retained on 10 mm sieve	0.18 Cu.m
ii)	Stone Chippings - 10 mm size; passing 12.5 mm sieve and retained on 6.3 mm sieve	0.09 Cu.m
	Total	0. 27 Cu.m
Binder for premixing (quantities in terms of straight run bitumen)		
i)	For 0. 18 Cu.m of 12 mm size stone Chippings at 52 Kg per Cu.m	9.5 Kg
ii)	For 0.09 Cu. M of 10mm size stone Chippings at 56 Kg per Cu.m	5.1 Kg
	Total	14.6 Kg

3.11.03 Construction Operation

a) Weather and Seasonal Limitations

Open graded premix carpet shall not be laid during rainy weather or when the base course is damp or wet or when the atmospheric temperature in shade is 16 Deg. C or below.

b) Preparation of Base

The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with the drawing, specification and as directed by the Engineer. The surface shall be well cleaned by removing caked earth and other foreign matters with wire brushes, sweeping with brooms and finally dusting with sacks as necessary.

c) Tack Coat

A tack coat complying with clause 3.09.00 shall be applied over the base preparatory to laying of the carpet. However application of tack coat shall not be necessary when the laying of carpet follows soon after laying the bituminous course.

d) Preparation of Premix

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder. The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer in boilers of suitable design avoiding local overheating and ensuring a continuous supply. The aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified. The mixing of binder with chipping shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and be covered over in transit if so directed.

e) Spreading and Rolling

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material are laid, rolling shall be commenced with 6 to 8 tonne power rollers preferably with smooth wheel tandem type or with any other approved plant. Rolling shall begin at the edges and progress toward the centre longitudinally except on the superelevated portions where it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roller marks have been eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose. Rollers shall not stand on newly laid material as it may lead to undue deformations.

The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted

with a thin surface coat of approved binder before the new mix is placed against it.

f) Seal Coat

A seal coat conforming to clause 3.12.00 shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

3.12.00 Seal Coat

3.12.01 Description

This work shall consist of application of a seal coat as specified for sealing the voids in the bituminous surface laid to the specified levels, grade and camber.

Type-A : Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chippings.

Type-B : Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

3.12.02 Materials

a) Binder

The binder shall be bitumen of suitable grade as directed by the Engineer and conforming to the requirements of IS : 73, 217 or 454 as applicable or any other approved cutback.

The quantity of binder to be adopted in terms of straight run bitumen shall be 9.8 Kg and 6.8 Kg per 10 square metre area for Type-A and Type-B seal coat respectively.

b) Stone Chippings for Type A Seal Coat

The stone chippings shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matters etc. Stone chippings shall be of 6mm size defined as 100 percent passing through 10mm sieve and retained on 2.36mm sieve. The quantity used for spreading shall be 0.09 cu.m per 10 sq.m area. The chippings shall satisfy the quality requirements spelled out in Table- VIII except that the upper limit for flakiness Index shall be 30.

c) Fine Aggregate for Type B Seal Coat

The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material, organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cubic metre per 10 square metre area.

3.12.03 Construction Operations

a) Preparation of Base

The seal coat shall be applied immediately after laying the bituminous course which is required to be sealed. Before application of seal coat, the surface shall be cleaned free of any dust or other extraneous matters.

b) Construction of Type-A Seal Coat

The binder shall be heated in boilers of suitable design to the temperature appropriate to the grade of bitumen approved by the Engineer and sprayed on the dry surface in a uniform manner preferably with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or due to any other reason shall be suitably corrected before the stone chippings are spread.

Immediately after the application of binder, stone chippings in a dry and clean state shall be spread uniformly on the surface preferably by means of a mechanical grittier or otherwise manually so as to cover the surface completely. If necessary the surface shall be broomed to ensure uniform spread of chippings. Immediately after the application of the cover material, the entire surface shall be rolled with a 8 - 10 tonne smooth wheeled roller. Rolling shall commence from the edges and progress towards the centre except in superelevated portions where it shall proceed from the inner edge to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up the irregularities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present an uniform closed surface.

c) Construction of Type-B Seal Coat

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder. The binder shall be heated in boilers of suitable design to the temperature appropriate to the grade of bitumen approved by the Engineer. Also the aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before the same are placed in the mixer. Mixing of

binder with aggregates to the specified proportions shall be continued till the latter is thoroughly coated with the former. The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed. As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 6 - 8 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

3.12.04 Opening to Traffic

In case of Type-B Seal coat, traffic may be allowed soon after the final rolling when the premixed materials are cooled down to the surrounding temperature. However in case of Type- A seal coat, the traffic shall not be permitted until the following day.

3.13.00 Repair of Existing Water Bound Macadam Surfaces

Pot holes or patches and ruts in the water bound macadam base or surface course which is to be surface treated shall be repaired by removing all loose materials by cutting in rectangular patches and replacing with suitable materials. The repair shall be done as under.

Pot holes, patches and ruts shall be drained of any water and cut to regular shape with vertical sides and then be filled either with i) coarse aggregates and screenings conforming to the specification for water bound macadam and compacted with rollers or other approved rammer etc or with ii) premixed material conforming to the specification for open graded premix carpet and compacted with rollers or other approved means after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both as directed by the Engineer.

3.14.00 Road Side Drains

3.14.01 Drains

The road side drains shall be made in sizes and slopes as shown on the approved drawings. The sides and bottom shall be neatly dressed after excavation. Proper connections shall be made to the culverts outside the plant area as per the drawings and instructions of the Engineer.

The excavated spoils other than that required for backfilling shall be transported and filled in low areas within the plant area or in embankments as instructed by the Engineer. The lining for drains shall be as per the drawings. Lining of drains may be of bricks or cement concrete blocks of specified grade as shown on the approved drawing or as directed by the Engineer. If shown

on approved drawing, drains shall be of R.C.C. construction with necessary slopes.

3.15.00 Culverts

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per the drawings and instructions of the Engineer after clearing the site etc. As described in the "Specification for Earthwork in Excavation and Backfilling", backfilling in layers with watering and compaction shall be done after the construction of foundations. The construction of culverts shall be done true to the lines and levels as shown on the drawings. The specification for Masonry and/or Plain and Reinforced Cement concrete shall be followed as applicable.

3.16.00 Pipe Culverts and Drainage Pipes

3.16.01 Materials

The drainage pipes shall be made of R.C.C and shall be either class NP-2 or NP-3 as shown on the approved drawings. Pipe culverts shall be made of reinforced concrete pipe and shall be of class NP4 or RDSO class for railways as shown in the drawing. All pipes shall meet the requirements of IS : 458 and shall be procured from approved manufacturers with collars as per manufacturer's specification. The tenderer shall specifically mention the particular manufacturer's product he proposes to use.

Cement shall be ordinary Portland Cement as per IS:269. Coarse Aggregates shall be as per IS:383. Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller. Fine aggregates for concrete shall be as per IS:383.

3.16.02 Laying of Pipes

Laying of concrete pipes shall correspond to IS:783 and as per the specification given below.

a) The foundation bed for pipe shall be excavated true to lines and grades shown on the drawings and as directed by the Engineer. When trenching is involved, its width on either side of the pipe shall not be less than 150mm and 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.

Side slips if there be any shall be removed by the Contractor. After laying of the pipes are completed, backfilling of the trenches shall be done as per "Specification for Earthwork in Excavation and Backfilling" to the

satisfaction of the Engineer. The surplus spoils shall be transported and filled in low areas within the plant area as instructed by the Engineer.

When bedrock or boulder stratum is encountered during excavation, the excavation shall be taken down to at least 200mm below the bottom 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 or fragmented materials, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur and shall be done as per the "Specification for Earthwork in Excavation and Backfilling". 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. Laying of pipes shall start from the outlet and proceed towards inlet. All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care to avoid any damage. Under no circumstances the pipes shall be dropped into the trench or on supports from heights.

b) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS : 783 having a projection ratio not greater than 0.70. The pipe shall be carefully laid on bedding made up of fine granular materials in an earth foundation; the bedding shall be carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height and in which the fill material is thoroughly compacted in layers not exceeding 150mm in depth around the pipe for the remainder of the pipe laid in trench.

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 M-15. The shape and dimension of the cradle shall be as indicated on the drawing or as directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete is set.

c) The drop walls shall be made with first class brickwork in 1:4 cement mortar.

d) The pipe culverts shall be made with proper care with respect to the invert of the pipe, gradient if any etc as specified on the drawings and as instructed by the Engineer.

e) Where R.C.C pipes are encased in concrete at road crossings or at other places the pipes need be suitably supported avoiding reinforcements of concrete blocks, joints properly done before concreting is taken up. Concreting of total height of block may be done in a single operation or may be done upto some height for pipes to be properly laid in position and the balance height of the block shall be concreted subsequently.

f) The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part of cement and 2 part of clean sand with only enough water for workability. Procedure of jointing shall be as per IS : 783.

3.16.03 Relation With Water Supply Pipeline

Unless specifically cleared by the Engineer, under no circumstances shall the drainage pipes be allowed to come close to water supply pipelines.

3.17.00 Manholes and Inspection Chambers

The maximum distance between the manholes shall be 30m unless specifically permitted otherwise. In addition, at every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The distance between the manhole or inspection chamber and gully chamber shall not exceed 6 meters unless permitted otherwise. Manhole shall be constructed so as to be water tight under test. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide a smooth flow. Connection to the existing pipelines shall be through a manhole. Manholes shall be provided with standard covers usually of C.I. or as directed by the Engineer. The cover shall be closely fitted so as to prevent gases from coming out.

4.00.00 Testing and Acceptance Criteria

All testing as mentioned in the specification and as mentioned in Clause No. 900 of the "Specification for Roads and Bridge Works, 1983" published by IRC on behalf of Ministry of Shipping and Transport (Roads Wing) shall be carried out by the Contractor as per the direction of the Engineer.

5.00.00 MEASUREMENT

Method of measurement shall be as per the latest version of IS:1200, Part-17 and as directed by the Engineer.

VOLUME: II B

SECTION - D
(PART I)

SUB-SECTION – D 17

FABRICATION OF STRUCTURAL STEEL WORK

Maharatna Company

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.
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SUB-SECTION – D XVII

FABRICATION OF STRUCTURAL STEEL WORK

1.00.00 SCOPE

This specification covers supply, fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and rivets, bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the contract.

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 elsewhere in the contract, shall include, but not be limited to the following

a) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on the approved design drawings. As decided by the Engineer, some or all of these detailed drawings will have to be submitted for approval.

b) To submit revised design with calculations and detailed fabrication drawings in case any substitution of the designed sections are to be made.

c) To submit design calculations for joints and. connections developed by the contractor along with detailed fabrication drawings.

d) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary rivets, bolts, nuts, washers, tie rods and welding electrodes for field connections,

e) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.

f) Suitably mark, bundle, and pack for transport all fabricated materials.

g) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Rivet and Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

h) Insure, load and transport all fabricated steelwork field connection materials to site.

i) Maintain a fully equipped workshop at site for fabrication, modification

and repairs of steelwork at site as may be required to complete the works in accordance with the Contract.

2.02.00 Work by others

No work under this specification will be provided for by any agency other than the contractor, unless specifically mentioned otherwise elsewhere in the contract.

2.03.00 Codes and standards

All work under this specification shall, unless otherwise specified in the contract, conform to the requirements of the latest revision and/or replacements of the following or any other relevant Indian Standard specifications and codes of practice. In case any particular aspect of the work is not specifically covered by any Indian Standard specification, any other standard practice, as may be specified by the Engineer shall be followed:

IS : 226 - Structural steel (Standard Quality)

IS : 800 - Code of Practice for general construction in steel.

IS : 806 - Code of practice for use of steel tubes in general building construction.

IS : 808 - Rolled steel beams, channels, and angle sections

IS : 813 - Scheme of symbols for welding

IS : 814 - Covered electrodes for metal arc welding of structural steel

IS : 815 - Classification and coding of covered electrodes for metal arc welding of structural steels.

IS : 816 - Code of practice for use of metal arc welding for general construction in mild steel

IS : 817 - Code of practice for training and testing metal arc welders

IS : 818 - Code of practice for safety and health requirements in electric and gas welding and cutting operations

IS : 822 - Code of practice for inspection of welds

IS : 919 - Recommendations for limits and fits for Engineering
IS : 961 - Structural Steel (High Tensile)

IS : 1148 - Rivet bars for structural purposes

IS : 1149 - High tensile rivet bars for structural purposes

IS : 1161 - Steel Tubes for structural purposes

IS : 1200 - Method of measurement of steelwork and ironwork (Part 8)

IS : 1239 - Mild Steel Tubes

IS : 1363 - Black hexagon bolts, nuts and lock nuts (dia. 6 to 30 mm) and black hexagon screws (dia 6 to 24 mm)

IS : 1364 - Precision and semi-precision hexagon bolts, screws, nuts and l locknuts (dia, range 6 to 39 mm)

IS : 1367 - Technical supply conditions for threaded fasteners

IS : 1442 - Covered electrodes for the metal are welding of high tensile structural steel

IS : 1608 - Method for tensile testing of steel products other than sheet strip, wire and tube

IS : 1730 - Dimensions for steel plate, sheet, and strip for structural and general engineering purposes.

IS : 1731 - Dimensions for steel flats for structural and general engineering purposes

IS : 1852 - Rolling and cutting tolerances for hot-rolled steel products

IS : 1977 - Structural steel (ordinary quality) St-42-0

IS : 2062 - Steel for General Structural Purposes

IS : 2074 - Ready mixed paint, red oxide Zinc chromate priming

IS : 2595 - Code of Practice for Radiographic Testing

IS : 2629 - Recommended practice for Hot-Dip Galvanizing of Iron and Steel

IS : 2633 - Method for testing uniformity of coating on Zinc Coated Articles

IS : 3757 - High strength structural bolts

IS : 4759 - Specifications for Hot-Dip Zinc Coatings on Structural Steel and other allied products

IS : 7205 - Safety Code for Erection of Structural Steelwork

IS : 7215 - Tolerances for fabrication of steel structures

IS : 7280 - Bare wire electrodes for submerged arc welding of structural steels.

IS : 9595 - Recommendations for metal arc welding of carbon and carbon manganese steels.

2.04.00 Conformity with Designs

The contractor shall design all connections, supply and fabricate all steelwork and furnish all connection materials in accordance with the approved drawings and/or as instructed by the Engineer keeping in view the maximum Utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and/or as approved by the Engineer. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

2.05.00 Materials to be used

2.05.01 General

All steel materials required for the work will be supplied by the contractor unless otherwise specified elsewhere in the contract. The materials shall be free from all imperfections, mill scales, slag intrusions, laminations, fittings, rusts etc. that may impair their strength, durability, and appearance. All materials shall be of tested quality only unless otherwise permitted by the Engineer and/or Consultant. If desired by the Engineer, Test Certificates in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Engineer, a random sample shall be tested at an approved laboratory from each lot of 50 tones or less of any particular section.

The arc welding electrodes shall be of approved reputed manufacture and conforming to the relevant Indian Standard Codes of Practice and Specifications and shall be of heavily coated type and the thickness of the coating shall be uniform and concentric. With each container of electrodes, the manufacturer shall furnish instructions giving recommended voltage and amperage (Polarity in case of D.C. supply) for which the electrodes are suitable.

2.05.02 Steel

All steel materials to be used in construction within the purview of this specification shall comply with any of the following Indian Standard Specifications as may be applicable:

a) IS : 2062 - Steel for general structural purposes

b) IS : 961 - Structural steel High Tensile

c) IS : 1977 - Structural steel (Ordinary quality) St-42-0

In case of imported steel materials being used, these shall conform to specifications equivalent to any of the above as may be applicable.

2.05.03 Rivet Steel

All rivet steel used in construction within the purview of this Specification shall comply with one of the following Indian Standard Specifications as may be applicable:

a) IS : 1148 - Rivet Bars for structural purpose

b) IS : 1149 - High tensile rivet bars for structural purposes. Where high tensile steel is specified for rivets, steps shall be taken to ensure that the rivets are so manufactured that they can be driven and heads formed satisfactorily without the physical properties of steel being impaired.

2.05.04 Electrodes

All electrodes to be used under the Contract shall be of approved reputed manufacture, low hydrogen electrode and shall comply with any of the following Indian Standard Specifications as may be applicable

a) IS : 814 - Covered electrodes for metal arc welding of structural steel

b) IS : 815 - Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel

c) IS : 1442 - Covered electrodes for the metal arc welding of high tensile structural steel

d) IS : 7280 - Bare wire electrodes for submerged arc welding of

structural steels

2.05.05 Bolts and Nuts

All bolts and nuts shall conform to the requirements of Indian Standard Specification IS: 1367 - Technical Supply Conditions for Threaded Fasteners.

Materials for Bolts and nuts under the purview of this contract shall comply with any of the following Indian Standard Specifications as may be applicable.

a) Mild Steel

All mild steel for bolts and nuts when tested in accordance with the following Indian Standard Specification shall have a tensile strength of not less than 44 Kg/mm² and a minimum elongation of 23 per cent on a gauge length of 5.6 _/A, where "A" is the cross sectional area of the test specimen

i) IS: 1367: Technical supply conditions for threaded fasteners

ii) IS: 1608: Method for tensile testing of steel products other than sheet, strip, wire and tube

b) High Tensile Steel

The material used for the manufacture of high tensile steel bolts and nuts shall have the mechanical properties appropriate to the particular class of steel as set out in IS: 1367 or as approved by the Engineer.

2.05.06 Washers

Washers shall be made of steel conforming to any of the following Indian Standard Specifications as may be applicable under the provisions of the Contract:

a) IS : 2062 - Steel for general structural purposes

b) IS : 961 - Structural Steel (High Tensile Quality)

c) IS : 1977 - Structural steel (Ordinary Quality) St-42-0

d) IS : 6649 - Hardened washers

2.05.07 Paints

Paints to be used for shop coat of fabricated steel under the purview of this

contract shall conform to the Indian Standard Specification IS: 2074 - Ready mixed Paint, Red oxide Zinc Chromate Priming.

2.06.00 Coal Bin

2.06.01 Shape of bins shall be circular, polygonal, square, or rectangular in plan. Bottom hopper portion may have be conical-cum-hyperbolic or any other profile shape as shown in the drawing. Bin shall be termed as bunkers or silos according to their shape and plane of rupture of coal.

2.06.02 For general requirements, fabrication and construction details IS: 9178 (Pt.l & 11) shall be followed as general guidance. The bins shall be fabricated and erected in segments.

2.06.03 The Coal bins shall be made of mild steel plates joined together with full strength butt weld and provided with stiffeners at regular interval. Stiffeners shall be provided on the external face and it may be welded with external face.

2.06.04 Bending of plates and rolled sections to the required shape for fabrication shall be done by plate bending machine or cold bending process Without resorting to heating, hammering, angle smithy and black smithy process.

2.06.05 Poking hole (manual or pneumatic) and striking plate shall be provided to facilitate coal flow. Poking holes shall have circular MS pipe and cover cap as detailed in the drawing.

2.07.00 New Erection Marks

2.07.01 Additional structures involving new erection marks may be required to be added at any stage of work.

2.07.02 All such new erection marks shall be detailed and included in marking schemes and fabrication carded out thereafter.

2.07.03 All such new erection marks shall be considered under item of original fabrication work. As a result of additional structures becoming necessary if the work is delayed beyond the time schedule stipulated, the Engineer shall give suitable extension of time provided he is satisfied about the reasonableness of the delay involved. However, no claim for extra payments or revision of rates due to delay shall be entertained.

2.08.00 ELECTRO FORGED STEEL GRATINGS

2.08.01 Factory made fabricated electro forged gratings unit with steel conforming to IS: 2062 shall be supplied, fabricated, transported, erected and aligned in floorings, platforms, drain and trench covers, walkways, passages, staircases with edge binding strips and anti skid nosing in treads etc.

2.08.02 All grating units shall be rectangular in pattern and electro forged. The size and the spacing of the bearing bars and cross bars shall be as detailed in fabrication drawings. The contractor shall submit the grating design for different spans and load intensities along with fabrication drawings. The depth of the grating unit shall be 40 mm, unless specified otherwise.

2.08.03 The gratings shall be made up in panel units designed to coincide with the span of the structural steel framing or openings as indicated in the design/ scope drawings. Maximum possible standardization of the grating panel sizes shall be tried and designed.

2.08.04 The grating unit shall be accurately fabricated and finished, free from wraps, twists, or any defects that would impair their strength, serviceability, and appearance.

2.08.05 Grating work shall include cut outs and clearance opening for all columns, pipes, ducts, conduits or any other installation penetrating through the grating work. Such cut outs and clearances shall be treated as specified in subsequent clauses.

2.08.06 The gratings shall be notched, trimmed and neatly finished around flanges and webs of the columns, moment connections, cap plates, and such other components of the steel structures encountered during the placement of the gratings. In all such cases, the trimming shall be done to follow the profile of the components encountered. After trimming, the binding strip shall be provided on the grating to suit the profile so obtained.

2.08.07 Opening in gratings for pipes or ducts that are 150mm in size or diameter or larger shall be provided with steel bar toe plates of not less than 5mm thickness and appropriate width, set flush with the bottom of the bearing bars.

2.08.08 Penetrations in gratings that are more than 50mm but less than 150mm in size or diameter shall be welded with plates of size shown in the detailed drawings set flush with the bottom of the grating panel.

2.08.09 Unless otherwise indicated on the drawings, grating units at all penetrations shall be made up in split section, accurately fitted and neatly finished to provide for proper assembly and erection at the job site.

2.08.10 Grating units shall be provided with all necessary clips, bolts, nuts and lock washers required for proper assembly and rigid installation and fastening to abutting units supporting structural steel framing members.

2.08.11 The gratings shall be of reputed make and manufacturer, as approved by Engineer. The unit rate quoted by him for this item shall be inclusive of transport of gratings to the project site, all taxes, duties etc. He shall also provide all facilities and access to the Engineer or his representative to carry out inspection during all stages of manufacturing of gratings.

2.08.12 Maximum deviation in linear dimension from the approved dimension shall not exceed 12mm.

2.08.13 All fabricated grating section and accessories shall be blast cleaned to near white metal surface (Sa 2½) followed by either of the following two:

(a) Two coats of red lead primer and two coats of black enamel finish paint.

(b) Hot dipped galvanization at 610 gm/sq.m.

in the shop prior to erection at site, as the approved drawing.

2.08.14 Prior to finishing all surfaces shall be cleaned, free from rust, mill scale, grease, oil, or any other foreign matter by blast cleaning. BS: 4232 shall be followed for blast cleaning.

2.08.15 Primer can be applied by spray guns or by brushes, however the finish paint shall necessarily be applied by means of spray guns. The applied coatings shall be uniform, free from voids and streaks; drilled or punched holes shall be touched up prior to erection or assembly.

2.09.00 GALVANIZATION OF GRATINGS

2.09.01 Purity of Zinc to be used-for galvanizing shall be 99.5% as per IS: 2 15

2.09.02 After the shop work is complete, the structural material shall be punched with erection mark and be hot double dip galvanized. Before galvanizing the steel section shall be thoroughly blast cleaned to near white metal surface (Sa 2½).

2.09.03 The weight of the zinc coating shall be at least 610 gm/m² - unless noted otherwise.

2.09.04 The galvanized surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be cleaned and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter that is loosely attached to the steel, blistered surface, flaking or peeling off etc. The presence of any of

these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

2.09.05 There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The galvanized steel member shall withstand minimum four one minute dips in copper sulphate solution as per IS: 2633.

2.09.06 When the steel section is removed from the galvanizing kettle, excess spelter shall be removed by 'bumping'. The processes known as 'wiping' or 'scrapping' shall not be used for this purpose.

2.09.07 Defects in certain members indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the specifications or lack of quality control in any manner in the galvanizing plant, shall render the entire, production in the relevant shift liable to rejection.

2.09.08 All structural steel shall be treated with sodium dichromate or an approved equivalent solution after galvanizing; so as to prevent white storage stains.

2.09.09 If the galvanizing of any member is damaged, the Engineer shall be shown of the extent of damage, if so directed the galvanizing may have to the redone in the similar manner as stated above at no extra cost to the Owner.

2.10.00 STAINLESS STEEL HOPPERS (As per BOQ item)

2.10.01 Material

In case SS Hopper is to be fabricated & erected as per BOQ item with SS415M, following specification shall be followed.
Stainless steel hopper of grade SS 415M as manufactured by SAIL or equivalent shall be provided in the lower portion of bunker hopper. SS 4 15M having the following chemical composition shall be used.

Material	**%**	**Remarks**
Carbon	10.03%	Max.
Silicon	1.60%	Max.
Manganese	0.80% to 1.50%	
Phosphorous	0.03%	Max.
Sulpher	0.03%	Max.
Chromium	10.80% to 12.50%	

Nickel	1.50%	Max.
Titanium	0.75%	Max.
Nitrogen	0.03%	Max.

The mechanical properties shall be as follows:

Description	**Value**	**Remarks**
Hardness Rock Well B Scale	90	Max.
Tensile Strength	450 MPa	Min.
Yield Strength	300 MPa	Min.
Elongation	25%	Min.

2.10.02 Fabrication

The fabrication, erection, alignment and welding shall be carried out as per the accepted practice and in accordance with relevant I.S. and international specification as well as stipulations contained herein. Fabrication drawings shall be prepared by the contractor on the basis of the design / scope drawings furnished by Engineer. The fabrication and erection works shall be done as per the approved fabrication drawings.

2.10.03 Fabrication Drawings

a) Fabrication drawing shall give the cutting plan for each hopper plate. Such, cutting plan shall be based on the size of the Stainless Steel plate available at store. In order to reduce the wastage and ensure the maximum utilization of stainless steel plate, the cutting plan shall take in the consideration of the reverse curvature and place the various elements of hopper plate in opposite fashion to reduce the end wastage. Similarly the hopper plate element having different radii shall be placed one inside the other, to optimize the stainless steel plate use. Such optimization may also required adjustment in the size of the each element of hopper plate and also additional weld joints.

b) The bill of material of hopper plate shall indicate the inner surface area of the hopper, weight of the hopper based on the inner surface area, weight of each of the cut plate of hopper fabrication, weight of cut and scrap pieces generated. Contractor shall return to the Owner's store all unutilized (surplus) stainless steel plates and all waste and cut pieces generated. Non return of any part of the surplus/waste steel pieces to the Owner's store will call for the penal recovery at three (03) times the maximum

procurement rate for the weight of stainless steel pieces not returned to the store.

c) In case the contractor does the cutting of the stainless steel without approved cutting plan then all the wastage (i.e. the difference between the weight of stainless steel plate cuts and the actual finished weight considered for the measurement for payment) shall be subjected to the penal recovery at the rate mentioned above.

2.10.04 Cuffing

Cutting may be affected by shearing, or by using plasma. The cut edges of all plates shall be perfectly straight and uniform through out. Cutting shall be done as per the cutting plan shown in the fabrication drawing. Should the Engineer find it necessary, the edges shall be ground smooth afterwards by contractor within the unit rates quoted by him. All the edge s shall be ground smooth before they are welded.

2.10.05 Jointing

Welding shall join stainless steel. All weld joints (along the inclined plane) shall be staggered. Any common welding process can weld stainless steel viz. MIG, metal arc or plasma using the covered compatible electrodes as per IS: 5206 or by inert gas arc welding as per IS: 2811. Shielding gas shall be Argon + Hydrogen mixture or Argon + Oxygen mixture. However, Argon + Oxygen mixture shall be preferred. Carbon-di-oxide mixture shall be avoided. 308L and 315L electrodes/fillers shall be used for the welding of Stainless Steel to Stainless Steel and Stainless Steel to Mild Steel respectively. However, the welding process and the type of the electrodes to be used for welding shall be as per welding procedure, as approved by the Engineer. On the basis of the welding procedure, the Contractor shall conduct qualification test.

2.10.06 Bending

The stainless steel plates shall be subjected to cold forming and bending in order to get the desired shape and profile.

2.10.07 Welding sequence

The type of electrodes, welding sequence, preheat and interpass temperature and post weld heat treatment shall be as approved by the Engineer.

2.10.08 Acceptance Criteria of Fabricated Structures

The acceptance of the fabricated structure work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the inspection and testing of the welded structure joints and the

test specimens, general workmanship being good meeting the tolerance requirements given in IS: 7215.

2.11.00 BEARINGS

2.11.01 PTFE (Poly tetra fluorethylene) slide bearing

a) General

The bearings shall consist of upper and lower units. The upper unit shall include a sole plate with mirror finish stainless steel facing bonded to the bottom surface of the sole plate. The lower unit shall consist of a relevant laminated elastomers pad surfaced with PTFE. A rigid confining medium substructure bonds the PTFE to the pad. When the upper and lower units are mated the stainless steel slides on the PTFE surface with an extremely low coefficient of friction. These bearings shall be designed as per the performance requirements. The bearing shall be of reputed make and manufacturer as approved by Engineer, for required vertical loads, as per the construction drawings and for a maximum displacement of ± 50 mm.

b) Material

PTFE bearing shall be sliding against highly polished stainless steel and the coefficient of friction between them shall be less than 0.06 at 55 kg/cm². In order to prevent cold flow in the PTFE surface it shall be rigidly bonded by a special high temperature resistant adhesive to the stainless steel sub-strata. The stainless steel surface, which slides against the PTFE, is mirror polished. The stainless steel shall be bonded to the top plate by special high strength adhesive. The thickness of the stainless steel shall be between 1.0 to 1.5mm.

The resilient bearing pad shall consist of multiple layers of lightweight fabric impregnated with a high quality elastomer compound vulcanized into slabs of uniform standard thickness as per the requirement. This shall withstand vertical (compressive) load not less than 500 kg/cm² and shear loads upto 40 kg/cm².

c) Installation

The seating area for PTFE bearing shall be prepared accurately level and furnished with a thin layer of epoxy resin mortar. The bearing will be placed on this layer while it is still workable and the bearing is levelled. The bearing should not be displaced as the beam is lowered into position. When the mortar and adhesive are fully set and the beam slightly above the top of the bearing. The upper surface of the bearing shall then be coated with sufficient thickness of epoxy resin mortar so that when the beam is lowered on to the temporary supports it comes into full contact

with the mortar and some is squeezed out. The surplus shall be troweled off and after the mortar is fully set the temporary supports removed.

2.12.00 Storage of material

2.12.01 General

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged, shall be removed from the contractor's yard immediately, failing which, the Engineer shall be at liberty to get the material removed and the cost incurred thereof shall be realised from the Contractor. The Contractor shall maintain upto date accounts in respect of receipt, use, and balance of all sizes and sections of steel and other materials. In case the fabrication is carried out in contractor's fabrication shop outside the plant site where other fabrication works are also carried out, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

2.12.02 Steel

The steel to be used in fabrication and the resulting cut-pieces shall be stored in separate stacks off the ground section wise and lengthwise so that they can be easily inspected, measured, and accounted for at any time. If required by the Engineer, the materials may have to be stored under cover and suitably painted for protection against weather.

2.12.03 Electrodes

The electrodes for electric arc welding shall be stored in properly designed racks, separating different types of electrodes in distinctly marked compartments. The electrodes shall be kept in a dry and warm condition if necessary by resorting to heating.

2.12.04 Bolts, Nuts and Washers

Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments according to diameter, length, and quality.

2.12.05 Paints

Paints shall be stored under cover in air tight containers. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

2.13.00 Quality Control

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer or Engineer's representative. As far as possible, all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at Site or elsewhere. The Contractor shall co-operate with the Engineer or Engineer's representative in permitting access for inspection to all places where work is being done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Contractor.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work

a) Steel: Quality manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.

b) Rivets, Bolts, Nuts & Washers : Manufacturer's certificate, dimension checks, material testing.

c) Electrodes : Manufacturer's certificate, thickness and quality of flux coating.

d) Welders : Qualifying Tests

e) Welding sets : Performance Tests

f) Welds : Inspection, X-ray, Ultrasonic tests

g) Paints : Manufacturer's certificate, physical inspection reports

h) Galvanizing : Tests in accordance with IS 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS : 4759 - Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products.

2.14.00 Standard dimensions, forms and weights

The dimensions, forms, weights and tolerances of all rolled shapes rivets, bolts, nuts, studs, washers etc. and other members used in the fabrication of any structure shall, wherever applicable, conform to the requirements of the latest relevant Indian Standards, wherever they exist, or, in the absence of Indian Standards, to other equivalent standards.

2.15.00 Fabrication Drawings

The contractor shall within thirty (30) days after the award of the Contract submit to the Engineer the Schedule of Fabrication and erection of structural Steelworks, for approval. Within one week after receipt of approval on design of any steel structure (part or full) based on the approved design. As decided by the Engineer, six (6) copies each of some or all of the detailed fabrication drawings will have to be submitted for approval.

The sequence of preparation of fabrication drawings shall match with the approved fabrication and erection schedule. The above-mentioned approval for fabrication drawings will be accorded only towards the general conformity with the design requirements as well as specifications. The approval of drawing however shall not relieve the contractor of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The fabrication drawings shall include but not limited to the following:

a) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.

b) Dimensional drawings of base plates, foundation bolts location etc.

c) Comparison sheets to show that the proposed alternative section, if any, is as strong as the original sections shown on the Design Drawings.

d) Complete Bill of Materials and detailed drawings of all sections as also their billing weights.

e) Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof.

These drawings shall give all the necessary information for the fabrication, erection, and painting of the steelwork in accordance with the provisions of this Specification. Fabrication drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection. Fabrication drawings shall give complete information necessary for fabrication of the various components of the steelwork,

including the location, type, size, and extent of welds. These shall also clearly distinguish between shop and field rivets, bolts, and welds and specify the class of bolts and nuts. The drawings shall be drawn to a scale large enough to convey all the necessary information adequately. Notes on the fabrication drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding shall be carefully controlled to minimize the locked up stresses and distortion. Welding symbols used shall be in accordance with the requirements of the Indian Standard Specification. IS: 813 - Scheme of symbols for Welding, and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.

The Contractor shall be responsible for and shall carry out at his cost any alterations of the work due to any discrepancies, errors or omissions on the drawings or other particulars supplied by him, whether such drawings or other particulars have been duly approved or not in accordance with the Contract.

3.00.00 WORKMANSHIP

3.01.00 Fabrication

3.01.01 General

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of the Indian Standard IS: 800 - Code of Practice for general construction in steel and other relevant Indian Standards or equivalent.

3.01.02 Straightening Material

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed by the Indian Standard Specification on IS: 1552 - Specification for rolling and cutting tolerance for hot-rolled steel products. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600°C.

3.01.03 Cutting

Shearing, cropping, or sawing shall affect cutting. Use of a mechanically controlled gas-cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Engineer.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges, occasional notches or gouges not more than 4 mm deep will be permitted. Gouges greater than 4 mm that remain from cutting shall be removed by grinding. All re-entrant corners shall be shaped notch free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

3.01.04 Planning of edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Engineer.

3.01.05 Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams web shall be not more than 3 mm at each end, but where for practical reasons greater clearance is necessary, suitably designed cheatings shall be provided.

3.02.00 Riveted and bolted construction

3.02.01 Holes

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of rivet or bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for rivets or black bolts shall be not more than 1.5 mm or 2.0 mm (depending on whether the diameter of the rivet or bolt is less or more than or equal to 25 mm) larger in diameter than the nominal diameter of the rivet or black bolt passing through them.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of BS as specified in IS: 919. Parts to be connected shall be firmly held together by

tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for rivets or bolts shall not be formed by gas cutting process.

3.02.02 Assembly

All parts of riveted members shall be well pinned or bolted and rigidly held together while riveting. Drifting to enlarge unmatching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the rivets or bolts shall be reamed. Poor matching of holes shall be cause for rejection .The component parts shall be so assembled that they are neither twisted not otherwise damaged, and shall be so prepared that the specified cambers, if any, are maintained.

Rivets shall ordinarily be hot driven, in which case their finished heads shall be approximately hemispherical in shape and shall be of uniform size throughout the work for rivets of the same size full, neatly finished and concentric with he holes. Rivets shall be heated uniformly to a temperature not exceeding 1 125°C they shall not be driven after their temperature has fallen below 540°C.

Rivets shall be driven by power riveters, of either compression or manually operated type, employing pneumatic, hydraulic or electric power. Hand driven rivets shall not be allowed unless in exceptional cases specifically approved by the Engineer. After driving, rivets shall be tight, shall completely fill the holes and their heads shall be in full contact with the surface. In case of countersunk rivets, the countersinking shall be fully filled by the rivet, any proudness of the countersunk head being dressed off flush, if required.

Riveted members shall have all parts firmly drawn and held together before and during riveting and special care shall be taken in this respect for all single riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

All loose, burnt, or otherwise defective rivets shall be cut out and replaced and special care shall be taken to inspect all single riveted connections. Special care shall also be taken in heating and driving long rivets. The Contractor shall prove the quality of riveting by cutting some rivets chosen at random by the Engineer. No extra payment will be made to the Contractor for such cutting and replacing. Riveting work, for any particular section or group, will be considered satisfactory when at least 90% of the corresponding cut rivets is found to be sound. If the ratio is below 75%, all the rivets in the particular section or group shall be cut, removed and replaced and tested again at the

Contractor's expense. For cases between 75% and 90% the engineer shall have the option to instruct cutting and replacing any number of further rivets at the Contractor's cost as he deems necessary.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if shown on drawing or directed by the Engineer.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project trough the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer one spring washer or lock nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

3.03.00 Welded Construction

3.03.01 General

Welding shall be in accordance with relevant Indian Standards and as supplemented in the Specification. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS: 817.

3.03.02 Preparation of material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint, and any other foreign material except that mill scale, which withstands vigorous wire brushing, may remain. Joint surfaces shall be free from fins and tears. Preparation of edges by gas cutting shall, wherever practicable, be done by a mechanically guided torch.

3.03.03 Assembling

Parts to be fillet welded shall be brought in, as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces, which are not completely sealed by, welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2°).

The work shall be positioned for flat welding whenever practicable.

3.03.04 Welding Sequence

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shod splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Engineer, welded assemblies shall be stress relieved by heat-treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Engineer.

3.03.05 Welding technique

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 m thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material, as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the contract.
To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

3.03. 12 Temperature

No welding shall normally be done on parent material at a temperature below (-) 5°C. However, if welding is to undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When

the parent material is less than 40 mm thick and the temperature is between (-) 5°C and 0°C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is hand warm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 20°C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

3.03. 13 Peening

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool, peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

3.03. 14 Equipment

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the engineer.

3.04.00 Finish

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.1 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc; after welding/riveting together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles of channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 1.0 mm.

3.05.00 Slab bases and caps

Bases and caps fabricated out of steel slabs, except when cut material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face, which is to be grouted direct to a foundation, need not be machined if such face is true and parallel to the upper face.

To facilitate grouting, holes shall be provided, where necessary, in stanchion bases for the escape of air.

3. 12.00 Lacing bars

The ends of lacing bars shall be neat and free from burns.

3. 13.00 Separators

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

3.14.00 Bearing Plates

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

3.15.00 Floor Grating

All grating units shall be rectangular in pattern and of pressure locked assembly. The size and spacing of bearing bars and cross bars shall be as approved in detailed drawings. Alternatively diamond pattern grating if approved may be used.

The grating shall be made in panel units designed to span as indicated in structural steel framing drawing or as directed by the Engineer.

The grating units shall be finished free from warps, twists, or any other defects. Grating work shall include cutouts and clearance openings for all columns, pipes, ducts, conduits etc. The gratings shall be notched, trimmed, and neatly finished around components of the steel structures encountered. Binding strip shall be provided on the grating to suit the profile. Openings in gratings shall be provided with steel bar toe plates of not less than 5 mm thickness and 100 mm width.

Unless otherwise indicated on drawings, all penetrations of grating units shall be made up in split section, accurately fitted, and neatly finished. Grating units shall be provided with all necessary clips, bolts, lock washers etc. for proper assembly and installation on supporting steel members. Maximum deviation in linear dimension shall not exceed 12 mm.

3.10.00 Chequered Plates

Minimum thickness of chequered plate floorings, covers etc. shall be 6 mm O/P. Chequered plate shall be accurately cut to the required sizes and shapes and the cut edges properly ground. Stiffeners shall be provided wherever required from design consideration.

3.11.00 Architectural Clearances

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

3.11.00 Shop connections

a) All shop connections shall be otherwise riveted or welded as specified on the Drawings.

b) Heads of rivets on surfaces carrying brick walls shall be flattened to 10 mm thick projection.

c) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Engineer for convenience of erection and the contractor will have to make the desired changes at no extra cost to the exchequer.

3.13.00 Castings

Steel castings shall be annealed.

3.14.00 Shop erection

The steelwork shall be temporarily shop-erected complete or as directed by the Engineer so that accuracy of fit may be checked before dispatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchange ability.

3.15.00 Shop painting

3.15.01 General

Unless otherwise specified, steelwork, which will be concealed by interior building finish, need not be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned, in accordance with the following paragraph, by brush, spray, roller coating, flow-coating or dipping as may be approved by the Engineer.

After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand-wire brushing or by other methods of loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by the solvent. Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil or grease by solvent cleaners and be cleaned of dirt and other foreign material by trough sweeping with a fibre brush.

3.15.02 Inaccessible parts

Surfaces not in contact, but inaccessible after assembly, shall receive two coats of shop paint, Positively of different colours to prove application of two coats before assembly. This does not apply to the interior of sealed hollow sections.

3.15.03 Contact surfaces

Contact surface shall be cleaned in accordance with sub-clause 3.13.1 before assembly.

3.15.04 Finished surfaces

Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

3.15.05 Surfaces adjacent to field welds

Unless otherwise provided for, surfaces within 50 of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

3.16.00 Galvanizing

3.16.01 General

Structural steelwork for switchyard or other structures as may be specified in the contract shall be hot dip galvanized in accordance with the American Society for Testing and Materials Specification ASTM-A 123 or IS: 2629 - Recommended practice for Hot-Dip Galvanizing of Iron and steel. Where the steel structures are required to be galvanized the field connection materials like bolts, nuts and washers shall also be galvanized.

3.16.02 Surface Preparation

All members to be galvanized shall be cleaned, by the process of pickling of rust, loose scale, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing. Pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

3.16.03 Procedure

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with IS: 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS: 4759 - Specification for Hot-dip zinc coatings on Structural Steel & other allied products.

After finishing the threads of bolts, galvanizing shall be applied over the entire surface uniformly. The threads of bolts shall not be machined after galvanizing and shall not be clogged with zinc. The threads of nuts may be tapped after galvanizing but care shall be taken to use oil in the threads of nuts during erection.

The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized. Where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after leaving been dipped twice, it shall be rejected. Special care shall be taken not to injure the skin on galvanized surfaces during transport, handling, and

erection. Damages, if occur, shall be made good in accordance or as directed by the Engineer.

4.00.00 INSPECTION, TESTING, ACCEPTANCE CRITERIA AND DELIVERY

4.01.00 Inspection

Unless specified otherwise, inspection to all, work shall be made by the or Engineer's representative at the place of manufacture prior to delivery. The Engineer or his representative shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification.

The Contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Engineer to carry out inspection and/or tests in accordance with the Contract. The Contractor shall guarantee compliance with the provisions of this Specification.

4.02.00 Testing and Acceptance Criteria

4.02.01 General

The Contractor shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own Cost. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

4.02.02 Steel

All steel supplied by, the Contractor shall conform, to the relevant Indian Standards. Except otherwise mentioned in the contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Engineer, random samples of materials will be taken from each unidentified lot of 50 M.T or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be born by the contractor.

All material shall be free from all imperfections, mill scales, slag intrusions, laminations, fittings, rusts etc. that may impair their strength, durability, and appearance.

4.02.02 Welding

a) The weld surface shall be cleaned with steel wire brush to remove spatter metal, slag etc. and 100% of welds shall be inspected visually for size, length of weldment and external defects. Weld gauges shall be used for checking weld sizes. The surface shall be clean with regular beads and free from slags, cracks, blow-holes etc.

b) Non-destructive examination shall be carried out to determine soundness of weldments as follows:

i) 10% at random on fillet-joints.

ii) 100% on all butt-joints.

c) Should the ND tests indicate defects like improper root penetration, extensive blowholes, slag intrusion etc., such welds shall be back gauged, joints prepared again and rewelded. All defects shall be rectified by the Contractor at no extra costs.

d) All electrodes shall be procured from approved reputed manufacturers with test certificates. The correct grade and size of electrode, which has not deteriorated in storage, shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tones of welded fabrication, the Engineer may ask for 1(one) test-destructive or non-destructive including X -ray, ultrasonic test or similar, the cost of which shall be borne by the Contractor.

4.02.04 Rivets, bolts, nuts and washers

All rivets, bolts, nuts, and washers shall be procured from M/s. Guest Keen William Ltd. or equivalent and shall confirm to the relevant Indian Standards. If desired by the Engineer, representative samples of these materials may have to be tested in an approved laboratory and in accordance with the procedures described in relevant Indian Standards. Cost of all such testing shall have to be borne by the Contractor. In addition to testing the rivets by hammer, 2% (two per cent) of the rivets done shall have to be cut off by chisels to ascertain the fit, quality of material and workmanship. The removal of the cut rivets and re-installing new rivets shall be done by the Contractor at his own cost.

4.02.05 Shop painting

All paints and primers shall be of standard quality and procured from approved manufacturers and shall conform to the provisions of the relevant Indian Standards.

4.02. 12 Galvanizing

All galvanizing shall be uniform and of standard quality when tested in accordance with IS: 2633 - Method for testing uniformity of coating on Zinc Coated Articles and 15: 4759 - specification for Hot-Dip Zinc Coatings on Structural Steel & other allied products.

4.03.00 Tolerance

The tolerances on the dimensions of individual rolled steel components shall be as specified in IS: 1852 - specification for rolling and Cutting Tolerances for Hot-rolled Steel Products. The tolerances on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures shall be as specified in IS: 721 - Tolerances for Fabrication of Steel Structures.

4.04.00 Acceptance

Should any structure or part of a structure be found not to comply with any of the provisions of this specification, the same shall be liable to rejection. No Structure or part of the structure once rejected, shall be offered again for test, except in cases where the Engineer considers the defects rectifiable. The Engineer may, at his discretion, check some of the tests at an appropriate laboratory at the contractors cost.

When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steelwork will be accepted forthwith and the Engineer will issue acceptance certificate, upon receipt of which, the items will be shop painted, packed and dispatched. No item to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

4.05.00 Delivery of materials

4.05.01 General

The Contractor will deliver the fabricated structural steel materials to site with all necessary field connection materials in such sequence as will permit the most efficient and economical performance of the erection work. The Owner may prescribe or control the sequence of delivery of materials, at his own discretion.

4.05.02 Marking

Each separate piece of fabricated steelwork shall be distinctly marked on all surfaces before delivery in accordance with the markings shown on approved erection drawings and shall bear such other marks as will further facilitate identification and erection.

4.05.03 Shipping

Shipping shall be strictly in accordance with the sequence stipulated in the agreed Programme. Contractor shall dispatch the materials to the e worksite securely protecting and packing the materials to avoid loss or damage during transport by rail, road or water. All parts shall be adequately braced to prevent damage in transit.

Each bundle, bale or package delivered under this contract shall be marked on as many sides as possible and such distinct marking (all previous irrelevant markings being carefully obliterated) shall show the following:

a) Name and address of the consignee

b) Name and address of the consignor

c) Gross weight of the package in tonnes and its dimensions

d) Identification marks and/or number of the package

e) Custom registration number, if required

All markings shall be carried out with such materials as would ensure quick drying and indelibility.

Each component or part or piece of material when shipped, shall be indelibly marked and/or tagged with reference to assembly drawings and corresponding piece numbers.

Each packing case shall contain in duplicate in English a packing list pasted on to the inside of the cover in a water-proof envelope, quoting especially -

a) Name of the Contractor

b) Number and date of the Contract

c) Name of the office placing the contract

d) Nomenclature of stores

e) A schedule of parts or pieces, giving the parts or piece number with reference to assembly drawings and the quantity of each.

The shipping dimensions of each packing shall not exceed the maximum dimensions permissible for transport over the Indian Railways/Roads.

After delivery of the materials at site, all packing materials shall automatically become the property of the Owner.

Notwithstanding anything stated hereinbefore, any loss or damage resulting from inadequate packing shall be made good by the Contractor at no additional cost to the Owner. When facilities exist, all shipments shall be covered by approved Insurance Policy for transit at the cost of the Contractor.

The contractor shall ship the complete materials or part on board a vessel belonging to an agency approved by the Owner or on rail and/or road transport as directed. The Contractor shall take all reasonable steps to ensure correct appraisal of freight rates, weights and volumes and in no case will the Owner be liable to pay any warehouse, wharfage, demurrage and other charges.

If, however, the Owner has to make payment of any of the above-mentioned charges, the amount paid will be deducted from the bills of the Contractor.

Necessary advise regarding the shipment with relevant details shall reach the Engineer at least a week in advance.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 With Tender

The following information is required to be submitted with the Tender:

a) Progress Schedule

The Contractor shall quote in his Tender a detailed schedule of progress of work and total time of completion, itemizing the time required for each of the following aspects of work.

i) Preparation and approval of fabrication drawing

ii) Procurement of Materials

iii) Fabrication and shipping of all anchor bolts

iv) Fabrication and shipping of main steelwork.

v) Fabrication and shipping of steelwork for bunkers, tanks and/or silos

as applicable.

vi) Fabrication and shipping of all other remaining steelwork including miscellaneous steelwork.

vii) Final date of completion of all shipments.

b) Shop

Location of the Tenderer's fabrication workshop giving details of equipment, manpower, the total capacity, and the capacity that will be available exclusively for this contract shall be submitted.

5.02.00 After Award

After award of the Contract the successful Tenderer is to submit the following:

a) Complete fabrication drawings, material lists, cutting lists, rive and bolt lists, field welding schedules based on the approved design drawings prepared by him in accordance with the approved schedule.

b) Monthly Progress Report with necessary photographs in six (6) copies to reach the Engineer on or before the 7th day o. each month, giving the up-to-date status of preparation of detailed shop drawings, bill of materials, procurement of materials, actual fabrication done, shipping and all other relevant information.

c) Detailed monthly material reconciliation statements relevant to the Work done and reported in the Progress Report, giving the stock at hand of raw steel, work in progress, finished materials.

d) Results of any test as and when conducted and as require by the engineer.

e) Manufacturer’s mill test report in respect of steel materials, rivets, bolts, nuts, and electrodes as may be applicable.

6.00.00 RATES AND MEASUREMENT

6.01.00 Rates

6.01.01 The items of work in the Schedule of items describe the work in brief. The various items of the Schedule of items shall be read in conjunction with these specifications including amendments and additions, general conditions of contract, special conditions of contracts, and other tender documents, if any. For each item of Schedule of Items, the bidder's rates shall include the activities covered in the description of the item as well as all necessary

operations described in the Specifications.

6.01.02 The bidder's rates shall include cost of all 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. Rates shall also include for taking all safety measures.

6.01.03 The bidder's -rates for all items of schedule of items shall include complete cost towards plant, equipment, erection and dismantling of scaffolding, men, materials and consumables, skilled and unskilled labour, levies, taxes, royalties, duties, transport, storage, repair/rectification/maintenance until handing over, contingencies, overhead and all incidental items not specifically mentioned but reasonably implied and necessary to complete the work.

6.01.04 No claims shall be entertained, if the details shown on the `Released for Construction' drawings differ from those shown on the bid/tender drawings.

6.01.05 Rates shall be inclusive of all leads and lifts/elevation.

6.01.06 The bidder's rates for Structural Steel shall include for fabrication and erection, transportation to site, preparation checking collecting and distributing of the fabrication drawings and design calculations, erection scheme, alignment, welding, including preheating and post heating, testing of welders, inspection of welds, visual inspection, non destructive and special testing, rectification and correction of defective welding works, production test plate, inspection and testing, erection scheme, protection against damage in transit, stability of structures, etc. The rates shall also be inclusive of providing and installing temporary structures, transport of Owner issue material from store, return of surplus/waste steel materials including cut pieces/waste steel, provision of additional butt/weld joint to reduce the wastage and all other general, special, such requirements as may be required, for the successful completion of the work.

The rates for fabrication are inclusive of all tests on welds and material and no extra shall be payable for quality tests specified for fabrication of structure in shop or at site.

Separate BOQ items for test on welds like radiography or Ultrasonic, DPT, magnetic particle tests are kept for tests on material/fabrication not covered under regular fabrication item of BOQ.

6.01.07 The bidder's rates for foundation bolts assembly shall include fabrication, threading, heat treatment, erection, installation, and alignment of complete bolt assembly with nuts, locknuts, anchor plates, stiffener plates, protective tape, etc. This shall also include the cost of all materials not issued by the Owner. Material issued by Owner will be specified in GCC.

6.01.08 The bidders rates for application of inorganic primer shall include surface preparation to near white metal surface by blast cleaning, abrasives, touch up painting, suitable enclosure to avoid contamination and the necessary statutory approval from the factory inspector/pollution control board etc. regarding the method of blast cleaning and abrasives used, and getting approval of the specialized agency supplying the primer specified.

6.01.09 The bidder's rates for application of finish painting system shall include surface preparation, application of intermediate (under) coat, finish coat and final finish coat, and getting approval of the specialized agency supplying the finish paint.

6.01.10 The bidder's rates for electro-forged gratings (if specified) shall include supply, fabrication, transportation to the site, erection and alignment of factory made electro-forged gratings, all taxes, duties thereon etc. The rates shall also include preparation of grating design for different spans and load intensifies, preparation of design and fabrication drawings, edge preparation, blast cleaning followed by finish paint.

6.01.11 The bidder's rates for galvanization of factory made electro-forged gratings (if specified) shall include the application of hot dipped galvanization as finish over the fabricated gratings and the treatment to be given for prevention of white storage stains, as per the technical Aspiration.

6.01.12 The bidder’s rates for permanent mild steel bolts, nuts and washers shall include the supply and fixing of such bolts, nuts and washers in position, for various types of Structural Steel works, as per the technical specification.

6.01.13 The bidder’s rates for high strength structural bolts, nuts and washers shall include the supply and fixing of such bolts, nuts and washers in position, for various types, of Structural Steel works, as per the technical specification.

6.01.14 The bidder’s rates for dismantling, additions to, alterations in and/or modifications shall be inclusive of all operations such as lowering of material, carriage etc., as mentioned in the technical specification. Unutilised steel pieces cut/removed shall be returned to the project stores free of charge. Non-return of unublized steel pieces to the Owner's store would be considered as wastage and recovery would be affected as per the provision of contract for structural steel consumption. This shall not include the weight of temporarily dismantled/supported members, connected member.

The bidder should prepare an optimised cutting plan as per fabrication drawing to utilise the steel material upto maximum extent and minimise the wastage/scrap. Quantity of wastage/scrap of material should be limited to the percentage mentioned elsewhere in the conditions of tender/ contract specifications.

6.01.15 The bidder's rates for re-erection of erection marks after additions to, alterations in and/or modifications shall be inclusive of all operations mentioned in technical specification for the calculated weight of the rectified/modified erection mark rejected at site. This shall not include the weight of temporarily dismantled/supported members, connected member. All the operations mentioned above for restoring such members shall be carried out at no extra cost. The work of erection of any erection mark which has not been dismantled but have been modified/rectified before erection shall not be paid under this item but shall be paid under relevant item of fabrication and erection of steel work of Schedule of items for the modified weight.

6.01.16 The bidder's rates for PTFE shall include design, supply, transportation of the complete assembly with guides and dust protection cover and installation of bearings in position drilling, bolting, erecting aligning etc. along with any taxes, duties thereon etc.

6.01.17 The bidder's rates for Stainless Steel hopper (if specified) shall include fabrication and erection, transportation to site, preparation checking collecting and distributing of the fabrication drawings and design calculations, all other operations mentioned in the technical specification. The rates shall also include for erection scheme, alignment, making cutting plan, cutting, jointing, bending, rolling, grinding, drilling, bolting, assembly, edge preparation, welding including pre-heating, post-heating, testing of welders, inspection of welds, inspection and testing, protection against damage in transit, stability of structures, installation of temporary structures etc. The rates shall also be inclusive of providing and installing temporary structures, transport of Owner issue material from store, return of surplus / waste steel materials including cut pieces/waste steel, provision of additional butt / weld joint to reduce the wastage and all other general, special, such requirements as may be required, for the successful completion of the work.

6.01.18 The bidders rates for preformed flexible open ended bellow strap of neoprene (if specified) shall include supply and transportation, installation in position, drilling, bolting, aligning etc. complete along with any taxes, duties thereon etc.

6.01.19 The bidder's rates for Stainless Steel Hand Rail (if specified) shall include complete Hand Rail including, materials, fabrication, grinding & finishing, stainless steel beading, stainless steel cleats, stainless steel fasteners, neoprene gaskets, preparation of shop drawing but excluding the cost of glazing. The Owner shall supply no material for this item of work.

6.02.00 MODE OF MEASUREMENT

6.02.01 The measurement for the item of foundation bolts assembly including that of nuts; locknuts shall be based on the calculated weight of steel installed in Metric Tonne, corrected to second place of decimal. The weight of the

foundation bolt shall be calculated in the same way as that done for the item of fabrication, erection, alignment of structural steel. The weight of the nut / locknut shall be taken as per actual weight supplied by the contractor and accepted by the Engineer.

6.02.02 The measurement for the item of fabrication, erection, alignment, welding, etc. of structural steel work shall be based on the approved weight of steel nearest to a Kg, by applying the unit weight as adopted at the time of issue of structural steel on the measurements worked out as given below.

6.02.03 For ISMB, ISMC, ISA, flats, round bars, square bars and pipes, length shall be taken as per distance between planes normal to the axis of the member passing through the extreme points of the section.

6.02.04 Gussets plates in trusses, and bracings, brackets plates, stiffeners, and skew cuts if any in plates for butt welds, the area shall be assumed as the minimum circumscribed rectangle. However deduction for any notch/skew cut shall be made as mentioned in clause no-6.02.06.

6.02.05 For bunker wall plates, the minimum-circumscribing rectangle of the individual plate/pieces out of which these wall plates are assembled by butt-welding, shall be measured. Care shall be taken to ensure maximum utilization of cut-pieces generated by providing extra butt joints (for which no extra payment shall be made).

6.02.06 For all other plates, where the area of any notch/skew cut in the plate is less than 0.05 sq.m. the area of the plate shall be assumed as that of the minimum circumscribing rectangle for the purpose of measurement and calculation of area for the purpose of payment. However, if the area of any notch/skew cuts in a plate is more than 0.05 sq.m, the area of notch/skew cut shall be deducted from assumed minimum circumscribing rectangular area for the purpose of payment.

6.02.07 No deduction shall be made for the hole in the members, if the area of individual hole is less than 0.05 sq.m. The weight shall be calculated by deducting the area of holes, if area of individual hole is more than 0.05 sq.m.

6.02.08 All cut-pieces and scrap generated due to cutting of holes, skew-cuts of plates, gussets, brackets, stiffeners, etc. shall be stacked separately and handed over to the project stores without being considered for material accounting as the circumscribing rectangle has been considered for payment.

6.02.09 The splice plate shown in the fabrication drawing or approved by the Engineer shall only be measured for payment.

6.02.10 The weight of permanent bolts, washers and nuts and welds shall not be included in the weights of the members. No extra payment shall be made for

welding/bolting.

6.02.11 The bolts and nuts required for erection purpose shall not be paid for and may be taken away by the Contractor after final welding for members. Erection boltholes left after removal of erection bolts shall be suitably plugged with welds.

6.02.12 The measurement for the item of application of inorganic primer including blast cleaning of steel surfaces shall be based on the weight on which the zinc silicate primer is applied, after blast cleaning in Metric Tonne, corrected to third place of decimal. The weight shall be the weight as approved, for erection mark/element of the mark painted, for payment of the item of fabrication and erection of structural steel works.

6.02.13 The measurement for the item of application of finish primer system shall be based on the weight on which the epoxy based finish primer is applied in Metric Tonne, corrected to third place of decimal. The weight shall be the weight as approved, for erection mark/element of the mark painted, for payment of the item of fabrication and erection of structural steel works.

6.02.14 The measurement for the item of gratings shall be based on the actual weight in Kgs, corrected to second place of decimal, as supplied by the Contractor, and accepted by the Engineer. Nothing extra shall be payable for making cutouts, notches, openings of any profile, trimming profiles etc. in the grating units.

6.02.15 The measurement for the item of hot dipped galvanization of gratings shall be based on the actual weight in Kgs, corrected to second place of decimal of gratings galvanized by the Contractor and accepted by the Engineer.

6.02.16 The measurement for the item of permanent bolts with nuts and washers shall be based on the actual weight in Kgs, corrected to second place of decimal, as supplied by the Contractor and accepted by the Engineer, and as per the approved bolts and nuts schedules.

6.02.17 The measurement for the item of High Strength Structural bolts with nuts and washers shall be based on the actual weight in Kgs, corrected to second place of decimal, as supplied by the Contractor and accepted by the Engineer, and as per the approved bolts and nuts schedules.

6.02.18 The measurement for the item of the work of dismantling, additions, alterations, reerection etc. shall be as given below

6.02.19 For dismantling, the unmodified weight of the actually dismantled erection marks shall only be measured.

6.02.20 For the work of addition to, alteration in and / or modification of 'erection

marks' either in erected position or in the fabrication yard, measurement of weight for payment purpose shall be calculated as the arithmetic sum of weight of steel cut and removed from the erection mark, weight of steel reutilised out of such cut and removed pieces and weight of additional new steel pieces added to the erection mark.

6.02.21 For re-erection the weight of the modified erection mark shall only be measured.

6.02.22 The weight shall be measured nearest to kg. and shall be arrived in a manner similar to the measurement for the item of fabrication, erection, alignment and welding of structural steel.

6.02.23 The measurement for the item of PTFE bearings shall be based on the load carrying capacity of PTFE in MT, corrected to third place of decimal, supplied by the contractor and as accepted by the Engineer and as per the approved bearing schedule, for the total vertical load carrying capacity, for all bearings.

6.02.24 The measurement for the item of stainless steel hopper shall be based on the actual finished weight of hopper weight in Kgs, corrected to second place of decimal. The hopper weight shall be arrived by multiplying of the inner surface area of the hopper with the unit weight of the hopper plate.

6.02.25 The measurement for the item of flexible open-ended bellows straps of neoprene shall be based in running meter, corrected to second place of decimal. Bellow Straps shall be supplied as per the requirement of the approved drawings. The measurement shall be done for the inner circumference of the bunker on which neoprene has been fixed and for the length supplied by the Contractor 'and as accepted by the Engineer.

6.02.26 The measurement for the item of Stainless Steel Hand Railing shall be based on finished weight of handrail in Kgs corrected to second place of decimal. The weight shall also include the weight of Stainless Steel fasteners, Stainless Steel beading, Stainless Steel cleats etc. The weight shall be the finished weight of Hand Rail, as accepted by the Engineer.

VOLUME: II B

SECTION - D
(PART I)

SUB-SECTION – D 18

ERECTION OF STRUCTURAL STEELWORK

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.
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SUB-SECTION – D 18

ERECTION OF STRUCTURAL STEELWORK

1.00.00 SCOPE

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at site, installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Contractor, unless otherwise specified in the Contract, shall include but not be limited to the following:

a) The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour, and supervision required for erection of the structural steelwork.

b) Receiving, unloading, checking, and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Contractor shall pay all demurrage and/or wharfage charges etc. on account of default on his part.

c) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, riveting, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures.

d) Checking center lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be rectified with Engineer's approval. The Contractor shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.

e) Aligning, plumbing, leveling, riveting, bolting, welding and securely fixing the fabricated steel structures including floor gratings, chequered plates etc. in accordance with the Drawings or as directed by the Engineer.

f) Painting of the erected steel structures.

g) All minor modifications of the fabricated steel structures as directed by the

Engineer including but not limited to the following:

i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.

ii) Cutting, chipping, filling, grinding, etc. if required for preparation and finishing of site connections.

iii) Reaming of holes for use of higher size rivet or bolt if required.

iv) Refabrication of parts damaged beyond repair during transport and handling or refabrication of parts, which are incorrectly fabricated.

v) Fabrication of parts omitted during fabrication by error, or subsequently found necessary.

vi) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.

vii) Carry out tests in accordance with this specification.

2.02.00 Work by Others

No work under this Specification will be provided for by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

2.03.00 Codes and Standards

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 Specification and codes of Practice of equivalent:

IS: 800 - Code of practice for general construction in steel.

IS: 456 - Code of practice for main or reinforced concrete.

2.04.00 Conformity with Designs

The Contractor will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the sequence and the design criteria laid down by the Engineer. All work shall conform to the provisions of this specification and /or instructions of the engineer. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specifications and/or the instructions o the Engineer.

2.05.00 Material

2.05.01 General

All fabricated steel structures and connection materials shall be supplied by the Contractor to the site. The Contractor shall take delivery from railway wagons or trucks at site, and unload the materials and perform all formalities like checking of materials and attend to insurance matters in accordance with Sub-Clause 2.01.00 and as specified hereinbefore.

2.05.02 Materials to conform to Indian standards

All materials required to be supplied by the Contractor under this contract shall conform to the relevant Indian Standard specifications.

2.06.00 Storage of Materials

2.06.01 General

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site, failing which, the engineer shall be at liberty to get the materials removed by agency and the cost incurred thereof shall be realised from the Contractor's dues.

2.06.02 Yard

The Contractor will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other raw steel materials such as structural sections and plates as required. The yard shall have facilities like drainage, lighting, and suitable access for large cranes, trailers, and other heavy equipments. The yard shall be fenced all around with security arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved Programme of work.

The Tenderer must visit the site prior to submission of his tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor at his own cost as directed by the Engineer.

2.06.03 Covered Store

All field connection materials, paints, cement etc. shall be stored on well

designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Contractor.

2.07.00 Quality Control

The contractor shall establish and maintain quality control procedures for different items of work and materials as may be directed by the Engineer to assure compliance with the provisions of the Contract and shall submit the records of the same to the Engineer. The quality control operation shall include but not be limited to the Following items of work :

i) Erection: Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.

ii) Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency, and strength of grout.

iii) Painting: Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

2.08.00 Taking Delivery

The Contractor shall take delivery of fabricated structural steel and necessary connection materials from railhead/trucks as may be necessary and as directed by the Engineer. He shall check, unload; transport the materials to his stores for proper storing at his own cost. The Contractor shall submit claims to insurance or other authorities and pursue the same in case of loss or damage during transit and handling and all loss thereof shall be borne by him.

The Contractor shall also take all precautions against damage of the materials in his custody after taking delivery and till the same are erected in place and accepted. The Contractor shall salvage, collect, and deliver all the packing materials to the Owner free of charge.

3.00.00 WORKMANSHIP

3.01.00 Erection

3.01.01 Plant and Equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be thoroughly verified. They shall be efficient, dependable, in good working condition and shall have the approval of the Engineer.

3.01.02 Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Engineer. The Contractor shall arrange for most economical method and sequence available to him consistent with the drawings and specifications and other relevant stipulations of the contract.

3.01.03 Temporary Bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erecrtion shall install, free of cost to the Owne, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The requirement of temporary bracings and guys shall cease when the structural steel is once located, plumbed, levelled, aligned, and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Engineer.

The temporary guys, braces, false work, and cribbing shall not be the property of the Owner and they may be removed immediately upon completion of the steel erection.

3.01.04 Temporary Floors for Buildings

It shall be the responsibility of the Contractor to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and/or bylaws of state, Municipal or other local authorities.

3.01.05 Setting Out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Engineer. For heavy columns, etc. the Contractor shall set proper screed bars to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance under this Specification.
No permanent field connections by riveting, bolting or shall be carried out until proper alignment and plumbing has been attained.

3.01.06 Field Riveting

All rivets shall be heated and driven with pneumatic tools. Hand passing or "throwing" of rivets are desirable. Any other method of conveying hot rivets from the furnace to the driving point must be approved by the engineer. No-cold rivets shall be driven. All other requirements of riveting including quality and acceptance criteria shall be in accordance with the relevant portions of the Specification for Fabrication of Structural Steelwork of the Project.

3.01.07 Field Bolting

All relevant Portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other, defects that would prevent solid seating of the parts. Contact surfaces within friction type joints shall be free of oil, paint, lacquer, or galvanizing.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum bolt tension by any of the following methods.

a) Turn-of-nut Method

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the Joint are brought into good contact with each other. 'Snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table-I with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation

there shall be no rotation of the part not turned by the wrench.

TABLE-I

Bolts length not exceeding 8 times dia or 200 mm	Bolt length exceeding 8 times dia or 200 mm	Remarks
1/2 turn	2/3 turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation-30° over or under.

Bolts may be installed without hardened washers when tightening is done by the turn -of-nut -method. However, normal washers shall be used.

Bolts tightened by the turn-of-nut method may have the outer face of the match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

b) Torque Wrench Tightening

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE-II (See Note below the Table). Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

TABLE-II

Nominal Bolt Diameter (mm) (Kg.M) of IS:1367	Torque to be applied for bolt class 8.8
20	59.94
22	81.63
24	103.73

Note: The above torque values are approximate for providing tensions of 14.

7 T for 20 mm dia.; and 21.2 T for 24 mm dia. bolts under moderately lubricated condition. The torque wrench shall be calibrated at least once daily to find out the actual torque required to produce the above required tension in the bolt by placing it in a tension indicating device. These torques shall be applied for tightening the bolts on that day with the particular wrench.

In either of the above two methods, if required, for bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches if used shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds. Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this sub clause.

3.01.08 Field Welding

All field assembly and welding shall be carried out in accordance with the requirements of the specification for fabrication work applicable to the project, excepting such provisions therein which manifestly apply to shop conditions only. Where the fabricated structural steel members have been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joints.

3.01.09 Holes, Cutting and Fitting

No cutting of sections, flanges, webs, cleats, rivets, bolts, welds etc. shall be done unless specifically approved and /or instructed by the Engineer.

The erector shall not cut, drill, or otherwise alter the work of other trades, unless such work is clearly specified in the Contract or directed by the Engineer. Wherever such work is obtain specified the Contractor shall obtain complete information as to size, location and number of alterations prior to carrying out any work. The Contractor shall not be entitled for any payment on account of any such work.

3.02.00 Drifting

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member

or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

3.03.00 Grouting of stanchion bases and bearings of beams and girders on stone, brick or concrete (Plain or reinforced)

Grouting shall be carried out with Ordinary Cement grout as described below:

The mix shall be one (1) part cement and one (1) part sand and just enough water to make it workable. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water and any accumulated water shall be removed. These shall be placed under expert supervision, taking care to avoid air locks. Edges shall be finished properly. If the thickness of grout is 25 mm or more, two (2) parts of 6 mm down graded stone chips may be added to the above noted cement-sand grout mix, if required, by the Engineer or shown on the drawings.

No grouting shall be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, leveled, and plumbed and sufficient floor beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

If required by the Engineer, certain admixtures like aluminium powder, “ironite” or equivalent, may be required to be added to the grout to enhance certain desirable properties of the grout. Approved non-shrink pre-mixed grout having required flowability and compressive strength may also be used with Engineer's approval.

3.04.00 Painting after Erection

Field painting shall only be done after the structure is erected, levelled, plumbed, aligned and grouted in its final position, tested and accepted by the Engineer. Normally, final painting shall be done only after the floor slabs are concreted and masonry walls are built. However, touch up painting, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Contractor free of cost to the Owner. The materials and specification for such painting in the field shall be in accordance with the requirements of the specification for fabrication of structural

steelwork applicable for the project.

Painting shall not be done in frosty or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted. Before painting of steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

All field rivets, bolts, welds, and abrasions to the shop coat shall be spot painted with the same paint used for the shop coat. Where specified, surfaces, which will be in contact after site assembling, shall receive a coat of paint (in addition to the shop coat, if any) and shall be brought together while the paint is still wet.

Surface, which will be inaccessible after field assembly shall receive the full, specified protective treatment before Bolts and fabricated steel members who are galvanized or otherwise treated and steel members to be encased shall not be painted.

The final painting shall be of tow coats of Synthetics Enamel painting or Aluminium paint of approved manufacture as per the approved "Schedule of Painting". The shades shall also be as per the approved schedule. Synthetic enamel paint shall conform to IS: 2932.

3.05.00 Final cleaning up

Upon completion of erection and before final acceptance of the work by the Engineer, the contractor shall remove free of cost all false work, rubbish and all Temporary Works resulting in connection with the performance of his work.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 General

Loading tests shall be carried out on erected structures, if required by the Engineer, to check adequacy of fabrication and/or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract and no payment towards the cost of the dismantled portion and any connected work shall be made to the contractor. In course of dismantling, if any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Contractor, to the satisfaction of the Engineer. The Cost of the tests specified hereinafter shall be borne by the Owner; but if the structure fails to pass the tests, the cost of the tests shall be recovered from the Contractor. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed.

The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated in the following sub-clauses 4.01.01, 4.01.02 and 4.01.03. The method of testing and application of loading shall be as approved by the Engineer.

4.01.01 Stiffness Test

In this test, the structure or member shall be subjected, addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 per cent of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 per cent of the maximum increase in strain or deflection recorded during the second test.

4.01.02 Strength Test

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours.

In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on the removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

4.01.03 Structure of same design

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous Sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure.

When a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Engineer. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20% of the maximum strain or deflection recorded at similar load in the test on the prototype.

4.01.04 Repair for subsequent test and use after strength tests

An actual structure which has passed the "Strength Test" as specified in Sub-clause 4.1.2 hereinbefore and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' as specified in Sub-clause 4.01.01 hereinbefore.

4.02.00 Tolerances

Some variation is to be expected in the finished dimensions of structural steel frames. Unless otherwise specified, such variations are deemed to be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabricating tolerances for the finished parts and the rolling tolerances for the profile dimensions permitted under the Specifications for fabrication of structural steel work applicable to this Project and as specified below: The specified tolerance is mainly for welded erection. In case of bolted erection, no tolerance is desired so that all prefabricated bolt holes are matched on erection.

I. For Buildings Containing Cranes

Component	Description	Variation Allowed
1.	2.	3.
Main columns	a) shifting of column axis at foundation level with respect to building line	
	i) In longitudinal direction	i) ± 3.0 mm
	ii) In lateral direction	ii) ± 3.0 mm
	b) Deviation of both major column axis from vertical between foundation and	

	other member connection levels:	
	i) For a column upto and including 10M height	i) ± 3.5 mm from true vertical
	ii) For a column greater than 10M but less than 40M height	ii) ± 3.5 mm from true vertical for any 10 M length measured between connection levels, but not more than ±7 mm per 30m length.
	c) For adjacent pairs of columns across the width of the building prior to placing of truss	± 9.0 mm on true span.
	d) For any individual column deviation of any bearing or resting level from levels shown on drawings.	± 3.0 mm
	e) For adjacent pairs of columns either across the width of building or longitudinally level difference allowed between bearing or seating	3.0 mm
Trusses	a) Deviation at centre of span of upper chord member from vertical plane running through centre of bottom chord.	1/1500 of the span or greater than 10mm whichever is the least.
Trusses	b) Lateral displacement of top chord at center of span from vertical plane running through center of supports.	1/250 of depth of truss or 20 mm which ever is the - least.
Crane Cirders	a) Difference in levels of crane rail measured between adjacent columns.	2.0 mm.
	b) Deviation to crane rail-gauge	± 3.0 mm

	c) Relative shifting of ends of adjacent crane rail in plan and elevation after thermite welding.	1.0 mm.
	d) Deviation of crane rail axis from centre line of web.	± 3.5 mm
Setting of Expansion gaps	At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30°C. The coefficient of expansion or contraction shall be taken as 0.000012 per °C per unit length.	

iv) For Building without Cranes

The maximum tolerances for line and level of the steel work shall be ±3.0 mm on any part of the structure. The structure shall not be Out of Plumb more than 3.5 mm on each lox section of height and not more than 7.0 mm per 30 m section.

These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.

4.03.00 Acceptance

Structures and members have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.01.00, 4.01.01, 4.01.02, 4.01.03 and 4.01.04 and other applicable provisions of this specification and are within the limits of tolerances specified in Sub-clause 4.02.00 and/or otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfillment of the provisions of this contract.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 Before Tender

5.01.01 Tentative Programme

The Tenderer shall submit a tentative programme based on the information available in the Tender Document and visit to site indicating the structure-wise erection schedule proposed to be maintained by the Contractor to complete the job in time in accordance with the Contract.

5.01.02 Constructional Plant and Equipment, Tools, Temporary works & manpower A detailed list Of all constructional plant and equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the Tenderer which he will be able to employ on the job to maintain the progress of work in accordance with the Contract shall be submitted along with the Tender. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.

5.01.03 Erection Yard

A site plan showing the layout and location of the erection yard proposed to be established by the tenderer shall also be attached with the tender indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the Contractor shall comply with the same without any claim whatsoever.

5.02.00 After award of the Contract

After award of the contract, the Contractor shall submit the following:

5.02.01 Detailed Programme

The Contractor shall submit a detailed erection programme within a month of the award of the Contract for completion of the work in time in accordance with the Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required, and an assessment of required strength of various categories of workers in a proforma approved by the Engineer.

5.02.02 Fortnightly Progress Report

The Contractor shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and all details of actual achievements against the target programme specified in Sub-clause 5.02.01 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the Contractor shall also furnish details of fabricated materials in hand at site and the strength of his workers.

VOLUME: II B

SECTION - D

SUB-SECTION – D19

ROOF DECKING

SPECIFICATION NO. PE-TS-999-600-C019

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	MATERIALS	3
3.00.00	INSTALLATION	3
4.00.00	ACCEPTANCE CRITERIA	6
5.00.00	IS CODES	6
6.00.00	RATES AND MEASUREMENTS	7

ROOF DECKING

1.00.00 Scope

This section of the specification covers the supply, fabrication and erection of profiled light gauge Metal Decks (coated and painted) as roof decking to the main plant building and any other area as indicated in the drawings.

2.00.00 Material

2.01.01 Roof of main plant TG and Deareator bay and bunker building consists of permanently colour coated (on exposed face) galvanized MS trough metal sheet decking plate of approved colour over roof purlins for cast-in-situ roof slab as per IS: 14246 and conform to class 3. Thickness of deck plate shall be minimum 0.8mm and minimum trough depth of 44 mm and centre to centre of the valley shall be 130mm with minimum yield strength of 250 Mpa. Silicon modified polyester paint shall be used for permanent coating over galvanized surface with minimum rate of galvanization 150 gm/sqm. DFT of permanent colour coating shall be 20 microns. It shall serve as permanent shuttering for cast-in-situ roof slab. It should have adequate strength to support weight of green concrete and imposed load during construction. The thickness of the deck plate shall however be designed suitably according to the spacing of roof purlins.

3.00.00 INSTALLATION

The Contractor shall furnish all labour, equipment and materials as required for the design, fabrication, coating, erection and fixing of the decking over purlins, painting and for the complete performance of the work in accordance with the construction drawings and as described herein.

The description, which follows, gives a general indication of the nature and extent of the work but is not necessarily exhaustive and does not purport to cover all the details/operations which will be necessary in order to carry out the work.

3.01.00 Detailed Design of Roof Decking

The Contractor, in conjunction with the manufacturer, shall be responsible for the detailing of the profiled decking, fittings and fixtures and shall submit with his tender particulars of the proposed manufacturer and of the particular product proposed for use. The detailing is to be based on typical details furnished by the Engineer. The Contractor shall submit to the Engineer, two copies of the general arrangement and detailed working drawings for the proposed design, together with all calculations necessary to verify the adequacy and completeness of the design & detailing of decking sheets,

fixtures, flashings and trims. After approval he shall supply further eight copies.

The Engineer will verify the correct interpretation of his requirements but may not necessarily check the design and details, and the Contractor shall be entirely responsible for the accuracy of the drawings and the correctness of the design and the suitability of the details. Manufacture of roof decking sheets shall not commence until the necessary approval of the Engineer has been obtained.

3.02.00 Erection & Fixing

3.02.01 Sequence of Manufacture/Erection

Cutting Schedules, delivery to site and stacking arrangements in store shall ensure that sheets are erected in a sequence which follows that for the manufacture. The decking sheets shall be erected using an arrangement of sheets and joints to conform with the requirements of this specification. Decking erection for each elevation or feature shall commence at one end only and proceed towards the other end, in order to ensure tight fitting laps.

3.02.02 Position and Location of Laps

Side and end laps of roof decking sheets 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.

The lines formed by horizontal laps and fixing shall where possible, be continuous and coincide with the edges of large openings in the roof.

3.02.03 Alignment of Sheets and Fixings

All roof decking sheets shall be fixed plumb and level with all fixings evenly spaced and accurately lined. All dirt and grease shall be removed from the surfaces of the sheets as the work proceeds.

3.02.04 Site Cutting

Approval must be obtained before the roof decking sheets are cut at site. Generally cutting of sheets to length will not be permitted, only special cutting and trimming for small openings shall allowed. Where possible, site cut edges shall be concealed at laps.

3.02.05 Damaged Sheets

Distorted, blemished or water stained sheets and any other fittings shall not be used.

3.02.06 Laps

End laps and side laps to roof decking sheets shall be sufficiently large to ensure that the decking complies with the weather tightness and other requirements of this specification. The length of each decking sheet shall be adjusted so that the end laps shall bear on the purlins. In no case end laps shall not be less than 150 mm and side laps shall not be less than 53 mm.

3.02.07 End Lap Fixings

End lap fixings shall be located at least 25 mm from the end of each sheet.

3.02.08 Side Lap Fixings

The spacing of side lap fixings shall ensure compliance with this specification regarding tightness. The spacing of these fixing screws shall not exceed 500mm. The fixing shall be located in the bottom flat of the corrugation.

3.02.09 Holes

Holes in MS decking sheets shall be punched. In case holes are drilled holes, it is to be ensured that the holes do not go oversize due to the small thickness of the sheeting. All drilling swarf shall be removed from the surfaces of decking, supporting steel work, purlins etc.

3.02.10 Location and Spacing of Fixings

Fixings shall be accurately located in position in the centre of the corrugations to ensure that the heads of bolts, nuts and washers bear squarely down on the surface of the sheeting and are not located at the edge or on the joints in supporting purlins.

3.02.11 Fixings

The tenderer shall submit with his tender details of the proposed method for securing the roofing sheets to the metal purlins. The roof decking sheets are to be fixed to the roof purlins with hex washer head white zinc plated heat treated carbon steel self drilling / self tapping screws of minimum thread diameter of 5.6mm. These self drilling screws shall be drilled through the roofing sheets and purlins supporting the roofing sheets. These purlins shall be suitably spaced as per the requirement of roofing sheets and the roofing sheets shall not sag more than span/250 for the loads likely to be imposed during concreting and in future. The self-drilling screws are to be spaced at a maximum distance of 390mm centre to centre along the length of the purlins and top chord of truss. The screws are to be located preferably in the valley only and shall be installed in accordance with the manufacturer's

recommendations using tools approved by the manufacturer which do not damage the coating of the decking sheets.

3.03.00 Protection during Construction

Precautions shall be taken during the erection of the roof decking to ensure that partially erected decking are protected during inclement weather and damage at all times.

3.04.00 Damage

Any damage to coating & primer during transportation is to redone with the similar type of coating as per the manufacturer's specification at no extra cost to the Owner.

4.00.00 Acceptance Criteria

The installation shall present a neat appearance and shall be checked for water tightness. The following shall be checked :

a) Side and end laps

b) Absence of damage in the sheeting.

c) Conformity of fixings with the approved design.

5.00.00 IS Codes

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 : 513 - Specification for cold rolled carbon steel sheets.

IS : 3618 - Specification for phosphate treatment of iron and steel for protection against corrosion.

IS : 4431 - Specification for carbon & carbon manganese free cutting steel.

IS : 1573 - Electroplated Coatings of zinc on iron and steel.

6.00.0 RATES AND MEASUREMENTS

6.01.00 Rates

Rates shall be unit rate for complete item described in the Schedule of Items and shall include all wastage.

6.02.00 Method of Measurement

Roofing shall be measured for net area of the work done. Profiled sheeting (coated & painted) shall be measured in plan area of sheets and not girthed. No deduction shall be made for openings measuring up to 0.1 sq.m. in area. No extra shall be paid for extra labour in cutting and for wastage etc. in making opening and cutting to size.

No payments shall be made for laps.

VOLUME: II B

SECTION - D

SUB-SECTION – D20

FALSE FLOORING

SPECIFICATION NO. PE-TS-999-600-C020

Maharatna Company

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	GENERAL	3
2.00.00	MATERIALS	3
3.00.00	INSTALLATION	4
4.00.00	ACCEPTANCE CRITERIA	5
5.00.00	IS CODES	6
6.00.00	RATES AND MEASUREMENTS	6

FALSE FLOORING

1.00.00 General

This section of the specification covers the supply, fabrication and installation of false flooring system having PVC top finish particle board, GI supporting system, painting etc. as per schedule of items in the main plant building and any other area as indicated in the drawings.

The scope of contractor covers supply of all materials, fabrication & installation works required to be carried out for completion of false flooring in the area specified in the drawings.

2.00.00 MATERIAL

2.01.00 Supporting structure

Supporting pedestals shall be made of steel and will be of height as required. Supporting pedestal shall be truly vertical and located at distances to conform with size of floor panels and shall be equipped with locking devices to prevent disturbances of finished elevation. Base of pedestal shall have integral load dispersion plate of size 100x100x8mm to transmit the load evenly to the base floor. Adjustment of pedestal shall be provided by threaded vertical rod of 25mm diameter and elevating nut. The pedestal head shall provide positive interlocking of the steel grid channels supporting system and shall prevent lateral shifting.

The grid channels shall be made of galvanised steel of 40mm x 40mm x 3.15mm thick and shall be placed at 610mm centre to centre both ways to support floor panels in uniform levelled elevations. Nominal height of the false flooring system shall be 600 mm unless otherwise indicated. Pedestal head shall be equipped with conducting grounding pad if so desired by the Engineer

2.02.00 Floor Panels

The floor panels shall be made of fire resistant particle board, phenol formaldehyde bonded. Size of each panel shall be 610mm x 610mm with all panel edges finished to a tolerance of $\pm$ 0.2mm. Floor panel shall have 2mm thick non-static PVC on top, 2mm thick hard PVC strip lipping on four edges and 26 G aluminium sheet fixed with araldite at bottom. Minimum thickness of the panel shall be 35mm, unless otherwise noted. All panels shall be completely interchangeable and easily removable with a suction lift tool. Panels shall be square within a tolerance of $\pm$ 0.25 mm on the diagonal. The floor panels shall be cut, wherever required for providing suitable outlets for cables and edges shall be lipped with hard PVC sheets.

2.02.01 Strength

Each 610mm x 610 mm floor panel must be capable of withstanding the designed service load. The ultimate strength shall provide a safety factor of 3. The false flooring shall be capable of carrying a axial load of 800 kg and uniform load of 2000 kg/sq.m with maximum deflection of 1/350. If required by the Engineer, the samples shall be accepted only after carrying out load tests. The Engineer may relax the test requirements with concentrated load in case cabinets are not handled with castor fitting arrangement.

One additional pedestal shall be provided under floor stringer along front panel area of each control board for taking possible additional load that may occur from time to time.

2.02.02 Surface finish

All removable panels shall have the top surface finished with 2 mm thick flexible PVC flooring conforming to IS:3462 and shall be fixed to the surface with compatible high-creep resistant adhesive. The PVC floor tile shall be in single piece for each floor panel. Under side of panels shall also be painted with suitable epoxy or oil based paint.

2.02.03 Damaged Floor Panels

Distorted, blemished or stained floor panels shall not be used.

2.03.00 Skirting

Skirting shall be 150 mm high and 2 mm thick, completely matching with false flooring surface finish materials and shall be fixed to the wall surface as per manufacturer's installation instructions.

3.00.00 INSTALLATION

3.01.00 Base

The system shall be placed over a base of RCC floor slab and beams. Any grouting etc. that is necessary to fix the supporting structure shall be done.

The concrete sub floor shall be sealed with two coats of polyurethane paint to prevent moisture from coming in contact with cables and to minimise dust problem.

The floor panels and channels shall be completely interchangeable and remain in position without screwing or bolting under working/imposed loadings.

Any damage to the sub floor during installation of the false flooring system

shall be made good by the contractor without any extra cost to the Owner. All steel surfaces are to be protected by two coats of polyurethane paint over a compatible primer and any damage to the paint during installation shall be made good. In case the loads exerted by the weight of machines are above the stated characteristics of floor finish material, the floor shall be protected by overlaying hard board during installation of machine or equipment.

All installation work of the false flooring system shall be supervised by the manufacturer's authorised representative.

3.03.00 Painting

After fixing the false flooring supporting system the sub floor shall be given a coat of polyurethane paint.

3.04.00 Protection during Construction

All precautions shall be taken during the erection of the false flooring to ensure that partially erected flooring are protected and shall not be damaged before handing over to owner.

3.05.00 Damage

Any damage of coating to supporting system caused during transportation is to be redone with the similar type of coating as per the manufacturer’s specification at no extra cost to the Owner.

4.00.00 ACCEPTANCE CRITERIA

The false flooring system shall only be accepted after completion of following checks :

a. Level

b. Alignment of joints

c. Thickness of joints

d. Surface finish

e. Colour and texture

f. Details of edges, junctions etc.

g. Performance

h. Criteria specified for strength.

5.00.00 IS CODES

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:5318 Laying of flexible sheet and flooring.

IS:3462 Flexible PVC flooring

IS:3087 Wood particle boards (medium density) for general purposes.

6.00.0 RATES AND MEASUREMENTS

6.01.00 Rates

Rates shall be unit rate for complete item described in the Schedule of Items and shall include, but not limited to, supply & installation of floor panels, supporting systems, paintings atc.

6.02.00 Method of Measurement

False flooring shall be measured in Sq.M for net area of the work done. No deduction shall be made for openings measuring up to 0.4 sq.m. in area. No extra shall be paid for extra labour in cutting and for wastage etc. in making opening and cutting to size.

VOLUME: II B

SECTION - D

SUB-SECTION – D21

BORED CAST-IN-SITU RCC PILES

SPECIFICATION NO. PE-TS-999-600-C021

Maharatna Company

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 proper-ties 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 bind-ing 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	

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SECTION - D

SUB-SECTION – D22

SITE LEVELLING & GRADING WORKS

SPECIFICATION NO. PE-TS-999-600-C022

Maharatna Company

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	GENERAL	3
2.00.00	SCOPE	3
3.00.00	MATERIALS	4
4.00.00	QUALITY CONTROL	6
5.00.00	EXECUTION	6
6.00.00	RATES AND MEASUREMENTS	15

GENERAL TECHNICAL SPECIFICATION FOR SITE LEVELLING AND GRADING

1.00 GENERAL

This specification cover the works to be carried out for **"Site Levelling and Grading Works including Slope Protection"** etc for the entire plant and associated areas. The specified formation level(s) shall be achieved either by excavation or by raising with controlled fill with excavated/borrowed earth as the case may be.

2.00 SCOPE

2.01 The scope include all works involved in levelling the site to the lines, grades, cross sections and dimensions as shown on the approved drawings and/or as directed by the engineer including site clearance, setting out, earth work in excavation, stacking, loading, transportation, unloading, dewatering, drainage, filling, watering, compaction, turfing on slopes (if required), lighting, disposal of residual/surplus earth etc. It also include supplying and providing all labour, materials, supervision, services, equipments, tools and plants, testing and all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work etc.

2.02 All tools and plants, equipments and machineries to be used in this work shall be of standard quality and manufactured by reputed concerns conforming to Indian Standard (IS) codes or equivalent thereof.

2.03 Work to be provided by the Contractor

The works to be provided by the contractor unless specified otherwise shall include but not be limited to the following.

a) Supplying and providing all labour, supervision, services including as required under statutory labour regulations, materials, equipments, tools and plants, approaches, transportation etc required for the completion of the work.

b) Preparation and submission of detailed scheme of all operations required for executing the work (material handling, placement, services, approaches etc) to the engineer for approval.

c) Carrying out sampling and testing on fill materials/fills to assess the quality/moisture content/degree of compaction and submission of the test results whenever required by the engineer.

d) Design, construction and maintenance of Magazine of proper capacity for storage of explosives for blasting work and removal of the same after completion of the work etc.

2.04 Work to be provided by others

No work under this specification will be provided for by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

2.05 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.

IS: 1200 Methods of measurement of building and civil engineering works, Part-1: Earthwork

IS: 2720 Method of test for soils (Relevant parts)

IS: 3764 Excavation work- Code of safety

IS: 4081 Safety code for blasting and related drilling operations

IS: 4701 Code of practice for earthwork on canals

IS: 6922 Criteria for safety and design of structures subject to underground Blasts

In case of conflict between this specification and those (IS codes) referred to herein, the former shall prevail. In case any particular aspect of work is not covered specifically by the specification or/and by the IS codes, any other standard practice as may be specified by the engineer shall be followed.

2.06 Conformity with Designs

The contractor shall carry out the work as per the approved drawings, specification and as directed by the engineer.

3.00 MATERIALS

All materials required for the work shall be of best variety and approved by the engineer.

3.01 Materials for Excavation

For the purpose of identifying the various strata met during the course of excavation, the following classification is to be followed.

a) Soil

It include all type of soil including laterite, moorum etc with/without any percentage of kankars which can be excavated by normal means such as shovel, pick axe, crow bar, spade etc and those which do not fall under **clause** 3.01 (b) and (c) etc.

b) Soft Rock

It include the rocks (including weathered rock) which are removable by splitting with the help of crow bar, pick axe, wedges, pavement breakers, pneumatic tools, hammers or such implements etc and not requiring blasting (for excavation) in the opinion of the engineer.

c) Hard Rock

It includes the rocks, which require blasting for excavation in the opinion of the engineer. Where blasting is prohibited for any reasons, the excavation shall be carried out by chiselling or any other method as approved by the engineer. The mere fact that the contractor resorts to blasting shall not classify the soft rock under hard rock.

However, the engineer's decision on the type of strata encountered during excavation shall be the final and binding on the contractor.

3.02 Materials for Filling

Any coarse grained or fine grained low plastic soil free from vegetation, roots, shingle, salts, organic matters, sod and any other harmful chemicals shall be used for filling. The contractor shall test the fill material to establish its suitability and submit the results to the engineer for approval. Fill material shall be got approved by the engineer. The following type of materials shall not be used for filling.

a)Materials from swamps, marshes and bogs
b)Expansive clays
c)Peat, logs, sod and perishable materials
d)Materials susceptible to combustion
e)Any material or industrial and domestic produce which will adversely affect other materials of work
f)Materials from prohibited areas

The earth available by cutting the high grounds within the project site and the materials (if) available from the road excavation or any other excavation under the same contract shall be used for filling depending upon its suitability as fill material. Filling with excavated rock (in the project site) shall be done only with

the written permission of the engineer in the following manner. The boulders shall be broken into pieces not exceeding 150mm size in any direction and mixed with fine materials consisting of decomposed rock, moorum or any approved earth to fill the voids as for as possible and the mixture shall then be used for filling. In case the earth required for filling is over and above the earth available from the compulsory excavations within the project area, then borrow areas for obtaining suitable fill material shall be arranged by the contractor himself from outside the plant boundary limits and all expenses including royalties, taxes, duties etc shall be borne by him. He shall obtain and submit the necessary clearances/permissions from the concerned authorities to the engineer for the borrow areas/materials acquired.

4.00 QUALITY CONTROL

All works shall conform to the lines, levels, grades, cross sections and dimensions shown on the approved drawings and/or as directed by the engineer. The contractor shall establish and maintain quality control for the various aspects of the work, method of construction, materials and equipments used etc. The quality control operation shall include but not be limited to the following.

Sl. No.	Activity	Check
1	Lines, levels & grades	a) By periodic surveys b) By establishing markers, boards etc
2	Filling	(a) On quality of fill material (b) On moisture content of fill material (c) On degree of compaction achieved

5.00 EXECUTION

The contractor shall prepare and submit the detailed drawings/schemes for excavation and filling works as proposed to be executed by him showing the dimensions as per the construction drawings and specification adding his proposal of approaches, dewatering (if any), drainage and compaction etc within 15 days of award of the contract to the engineer for approval.

5.01 Site Clearance

Before the commencement of earthwork, the entire area of cutting and filling shall be cleared of all trees, stumps, bushes, grasses, vegetation etc with their roots, fences, logs, rubbish, water, slush etc. It is not necessary to remove all the soil containing fine hair like roots but only the rather heavy mats are to be removed. Cutting of trees shall include trees having girth of any size and removing roots upto a depth of 600mm below the existing ground level or 300mm below the formation level whichever is deeper. After the removal of roots of trees, the pot holes formed shall be filled with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the engineer. The trees shall be cut in to suitable pieces as instructed by the engineer. Before earthwork is started, all the spoils, unserviceable materials and

rubbish shall be burnt or removed and disposed off to the approved disposal area(s) as specified by the engineer. Useful materials, saleable timbers, fire woods etc shall be the property of owner and shall be stacked properly at the worksite in a manner as directed by the engineer.

5.02 Setting Out

On receiving the approval from the engineer with modifications and corrections if any, the contractor shall set out the work from the control points furnished by the engineer and fix permanent points and markers for the ease of periodic checking as the work proceeds. These permanent points and markers shall be fixed at the interval as prescribed by the engineer and shall be got checked and certified by the engineer after whom the contractor shall proceed with the work. It should be noted that this checking by the engineer prior to the start of the work will in no way relieve the contractor of his responsibility of carrying out the work to true lines, levels and grades as per the drawings and specification. If any errors are noticed in the contractor's work at any stage, the contractor at his own risk and cost shall rectify the same. The contractor shall take spot levels of the area (with respect to the bench mark/ available source as provided by the engineer) to be excavated or to be filled at an interval of not more than 10m or as directed by the engineer before starting any earth work and shall be submitted to the engineer for prior approval.

5.03 Excavation

Levelling by excavation shall be carried out where the existing ground levels are higher than the specified formation level. Excavation shall include removal of all materials whatever nature as may be and whether wet or dry shall be carried out exactly in accordance with the line, levels, grades and curves shown on the approved drawings and/or as directed by the engineer. All excavations shall be done to the minimum dimensions as required. The contractor shall obtain prior approval of the engineer for the method he proposes to adopt for excavation in different types of strata including dimensions, side slopes and dewatering if any, stacking or disposal etc. This approval however shall not in any way make the engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to any other activities in the area. **Prior to starting the excavation, the ground level at the location shall be checked jointly with the engineer.**
The rough excavation may be carried up to a maximum depth of 150mm above the final formation level. The balance shall be excavated with special care and the final surface shall be compacted by rolling with 6 passes of 8 to 10 tonne roller. If directed by the engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the engineer. The contractor shall be paid for the extra excavation and filling at the appropriate items of work.

If the excavation is done to a depth greater than that shown on the drawing or as directed by the engineer due to the contractor's fault, the excess depth shall be filled up to the required level with good earth in 250mm layers (loose thickness) and compacted unless otherwise directed by the engineer at the own risk and cost of the contractor.

Suitable slope in cutting as per the requirements and as directed by the engineer shall be adopted to withhold the face of earth. The contractor shall be held responsible for any damage to any part of the work caused by the collapse of the side of excavations.

5.03.01 Excavation in Hard Rock

Excavation in hard rock shall normally be done with blasting. In case where blasting is prohibited for any reasons, the excavation shall be carried out by chiselling or any other approved method as directed by the engineer. Personnel deployed for rock excavation shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces.

5.03.02 Blasting

a) General

Storage, handing and use of explosives shall be governed by the current explosive rules/regulations laid down by the Central and the State Governments. The contractor shall ensure that these rules/regulations are strictly adhere to. The following instructions are also to be strictly followed and the instructions wherever found in variance with the above said rules/regulations, the former (instructions) shall be superseded with the later (above said rules/regulations).

No child under the age of 16 and no person who is in a state of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives. The contractor shall obtain licence from the District Authorities for undertaking the blasting work as well as for obtaining and storing the explosives as per Explosives Rules, 1940 corrected upto date. The contractor shall purchase the explosives, fuses, detonators etc only from a licensed dealer and shall be responsible for the safe custody and proper accounting of the explosive materials. The engineer or his authorized representative shall have the access to check the contractor's store of explosives and his accounts at any time. It is the full responsibility of the contractor to

transport the explosives as and when required for the work in a safe manner to the work spot.

Further, the engineer may issue modifications, alterations and new instructions to the contractor from time to time. The contractor shall comply with the same without these being made a cause for any extra claim.

b) Materials

All materials such as explosives, detonators, fuses, tamping materials etc proposed to be used in the blasting operation shall have the prior approval of the engineer. Only explosives of approved make and strength are to be used. The fuses known as instantaneous fuse must not be used. The issue of fuse with only one protective coat is prohibited. The fuse shall be sufficiently water resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and shall be not less than 4 seconds per inch of length with 10% tolerance on either side. Before use, the fuse shall be inspected. Moist, damaged or broken ones shall be discarded. When the fuses are in stock for long, the rate of burning of fuses shall be tested before use. The detonators shall be capable of giving an effective blasting of the explosives. Moist and damaged detonators shall be discarded.

c) Storage of Explosives

The current Explosive Rules shall govern the storage of explosives. Explosives shall be stored in a clean, dry and well-ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400m of the actual work site or any source of fire. The space surrounding the magazine shall be fenced and the ground inside shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be through a single gate only and no person shall be allowed without the permission of the officerin-charge. The clear space between the fence and the magazine shall not be less than 90m. The magazine shall be well drained. Two lightning conductors, one at each end shall be provided to the magazine. The lightning conductors shall be tested once in every year.

Explosives, fuses and detonators shall each be separately stored. Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides. Special care shall be taken to keep the floor free from any grains of explosives. Cases containing explosives shall not be opened inside the magazine and the explosives in open cases shall not be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine but must be removed without delay to a safe distance and be destroyed.

Artificial light, matches, inflammable materials, oily cotton, rag waste and articles liable to spontaneous ignition shall not be allowed inside the magazine.

Illumination shall be obtained from an electric storage battery lantern. No smoking shall be allowed within 100m distance from any magazine. Magazine shoes without nails shall be used while entering the magazine. The persons entering the magazine must put on the magazine shoes which shall be provided at the magazine for this purpose and should be careful

* not to put their feet on the clean floor unless the magazine shoes on.

* not to touch the magazine shoes on ground outside the clean floor.

* not to allow any dirt or grit to fall on the clean floor.

Persons with bare feet shall dip their feet in water before entering the magazine and then step directly from the tub to the clean floor. No person having article of steel or iron with/on him shall be allowed to enter the magazine. Workmen shall be examined before entering the magazine to check none of the prohibited articles are with them. A brush broom shall be kept in the lobby of the magazine for cleaning the magazine. Cleaning shall be done immediately after each occasion whenever the magazine is opened for receipt, delivery or inspection of the explosives.

The mallets, levers, wedges etc for opening the barrels or cases shall be of wood. The cases of explosives are to be carried by hand and shall not be rolled or dragged inside the magazine. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been stored long in the store are to be issued first. Neither the magazine shall be opened nor any person shall be allowed in the vicinity of the magazine during any dust storm or thunderstorm. All magazines shall be officially inspected at definite intervals and a record of such inspections shall be kept.

d) Carriage of Explosives

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from direct rays of the sun, artificial lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each case or package shall be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on the vehicle conveying explosives. No explosive shall be transported in a carriage or vessel unless all iron or steel therein the carriage or vessel which are likely to contact the package containing explosives are effectually covered with lead, leather, wood, cloth or any other suitable material. No light shall be carried on the vehicle carrying explosives and no operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

e) Use of Explosives

The contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with his responsibilities. Holes for charging the explosives shall be drilled with pneumatic drills and the drilling pattern shall be so planned that the rock pieces after blasting will be suitable for handling. The hole diameter shall be of such a size that the cartridges can easily pass down through them and any undue force is not required during charging. Charging operation shall be carried out by or under the personal supervision of the shot firer. Wrappings shall never be removed

from the explosive cartridges. Only one cartridge at a time shall be inserted in a hole and wooden rods shall only be used for loading and stemming the shot holes. Only such quantities of explosives as are required for a particular work shall be brought to the work site. Should any surplus remain when all the holes have been charged shall be carefully removed to a point at least 300m away from the firing point.

The authorized shot firer himself shall make all the connections. The shot firing cable shall not be dragged along the ground to avoid any damage to the insulation. The shot firing cable shall be tested each time for its continuity and possible short circuiting. The shot firer shall always carry the exploder handle with him until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits. Before any blasting is carried out it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300m radius from the firing point or as required by the statutory regulations at least 10 minutes before the time of firing by sounding a warning siren and the area shall be encircled by red flags.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges, the electric detonators shall be connected with the exploder through the shot firing cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current etc and keep the lead wires short circuited until it is ready to fire. Any kink in the detonator leading wire shall be avoided. For simultaneous firing of a large number of shot holes, use of cordtex may be done. An electric detonator attached to its side with adhesive tape shall initiate cordtex connecting wire or string. Blasting shall only be carried out at certain specified times to be agreed jointly by the contractor and the engineer.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations, the authorized shot firer shall return to the blast area and inspect carefully the work and satisfy himself that all the charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole at a distance of not less than 600mm from the misfired hole and by exploding a new charge. The authorized shot firer shall be

present during the removal of debris as it may contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until at least half an hour after firing.

Where blasting is to be carried out in proximity of other structures, controlled blasting by drilling shallow shot holes and proper muffling arrangements with steel plates loaded with sand bags etc shall be used on top of the blast holes to prevent the rock fragments from causing any damage to the adjacent structures and other properties. Adequate safety precautions as per building byelaws, safety codes, statutory regulations etc shall be taken during blasting operations.

5.03.04 Restrictions on Blasting

a) Blasting which may disturb or endanger the stability, safety or quality of the adjacent structures/foundations shall not be permitted.
b) Blasting within 200m of a permanent structure or construction work in progress shall not be permitted.
c) Progressive blasting shall be limited to two third of the total remaining depth of excavation.
d) No large scale blasting operations will be resorted to when the excavation reaches the last one metre and only small charge preferably black powder may be allowed so as not to shatter the parent rock.
e) The last blast shall not be more than 0.50 m in depth.
f) In rocky formations, at locations where specifically indicated or ordered in writing by the engineer, the use of explosives shall be discontinued and excavation shall be completed by chiselling or any other suitable method as approved by the engineer.

5.04 Sorting of Excavated Materials

The excavated material shall be carefully sorted for use in filling the areas in the project site by removing roots, grasses, organic matters and other objectionable materials and be sorted out into different types of materials for use and as directed by the engineer. The excavated material which is not considered fit for filling purpose shall be immediately removed and disposed at such a place and in such a manner as will be directed by the engineer. The material found unusable should be got approved by the engineer before actually disposing it off. The useful materials that cannot be used directly shall be heaped in separate area as stock piles. Stockpiles shall be of regular size as for as possible for ease of measurement. The materials heaped shall be utilised as and when required and as directed by the engineer. The cost of complete item of earthwork includes the cost of rehandling of the materials and temporarily heaped and reused.

5.05 Disposal of Surplus/ Waste Materials

Surplus and other waste materials shall be removed and disposed of from the construction site to the area demarcated by the engineer. No material shall be wasted unless approved by the engineer.

5.06 Earth Work in Filling

Levelling by raising with controlled fill of approved excavated/borrowed earth shall be carried out where the existing ground levels are lower than the specified formation level. After clearing site as per clause 5.01, the original ground shall be compacted by rolling subject to a minimum 6 passes of 8 to 10 tonne roller. The approved earth/fill material shall then be spread in horizontal layers not exceeding 300mm in compacted thickness. Each layer shall be watered and thoroughly compacted with proper moisture content and such equipments as may be required to obtain a minimum of 95% of its maximum dry density as

determined by standard Proctor's test as per IS: 2720 part-VII or 85% of relative density as per IS:2720 part-XIV as specified. Moisture content of the fill material shall be controlled near optimum moisture content during compaction.

The fill material shall be tested for its optimum moisture content and maximum dry density as per IS: 2720, part-VII. Moisture content shall be checked at the source of supply in accordance with IS:2720 part- II and if found less than that required for proper compaction, the same shall be made good either at the source or after spreading the soil in loose thickness for compaction. In the latter case, water shall be sprinkled directly from the hose line or from the truck-mounted water tank etc making due allowance for evaporation losses and the fill material be thoroughly mixed by means of harrows, rotary mixers or by any other suitable approved method until the layer is uniformly wet. **Flooding shall not be permitted for watering purpose under any circumstances.** If the material delivered is too wet, it shall then be dried by aeration and exposure to the sun till the moisture content is suitable for compaction. Should circumstances arise owing to wet weather the moisture content cannot be reduced to the required amount by the above procedure, the work on compaction shall be suspended. Clods or hard lumps of earth shall be broken to have a maximum size of 150mm when being placed in the layers before compaction. For each of the above tests on the fill material, one sample for every 10,000cu.m shall be tested. Additional samples shall be tested whenever there is a change of source or type of material.

Before start of filling, the contractor shall submit the engineer his proposal for the methodology to be adopted for compaction. The compaction equipments as approved by the engineer shall only be employed to compact the different type materials encountered during construction. If directed by the engineer, the contractor shall demonstrate the efficacy of the plant he intends to use by carrying out compaction trials. Moisture content of the fill material shall be controlled near optimum moisture content during compaction.

The compacted layer shall be tested for its dry density as per IS:2720**,** part-XXVIII or XXIX as directed by the engineer. Samples shall be taken at the rate of one sample for every 10,000sq.m area of each compacted layer. In addition random checks shall be carried out in compacted layers by means of Proctor needle penetration test. Contractor shall submit all the test results to the engineer immediately after completion of the tests. A sample shall be deemed to have passed the test when the dry density of the compacted fill is equal to or more than 95% of its maximum dry density. When field density measurements reveal any soft areas in the fills, further compaction shall be carried out as directed by the engineer. If in spite of that, the specified compaction is not achieved, the material in the soft areas shall be replaced with approved material compacted to the density requirements and satisfaction of the engineer.

Subsequent layers shall be placed only after the finished layer has been tested and accepted by the engineer.

Where the filling is to be done across low swampy ground that will not support the weight of trucks or other hauling equipments, the lower part of the fill shall be constructed by dumping successive loads in a uniformly distributed

layer of a thickness not greater than that necessary to support the hauling equipment while placing subsequent layers.

5.07 Dewatering and Drainage

It shall be ensured that the area to be excavated/filled shall be free from water. The contractor shall remove the water (if any) by pumping or by any other means as approved by the engineer. At all times, the surface of cutting/filling during execution shall be maintained at such a cross fall as will shed water and prevent ponding. All existing drains/channels (if any) in the work area shall be suitably diverted by the contractor before taking up any excavation or filling. These diversions shall be such that it shall ensure effective disposal of water without any accumulation or flooding within the project site and in adjoining areas.

5.08 Finishing Operations

Finishing operation shall include the work of shaping and dressing the excavated/filled ground to the required grades, levels, lines, side slopes, crosssections
and dimensions as shown on the approved drawings or as directed by the engineer.

5.09 Turfing

Turfing shall be provided at the slopes and other locations as shown on the drawings or as directed by the engineer. The turf shall be of approved quality of grass. The sod shall consist of dense, well rooted growth of permanent and desirable grasses indigenous to the locality where it is to be used and shall be practically free from weeds or other undesirable matter. The grass on the sod shall have a length of approximately 50mm and the sod shall be free of any

debris. Thickness of the sod shall be as uniform as possible with 50 to 80mm of soil covering the grass roots depending on the nature of the sod so that all the dense root system of the grasses are retained in the sod strip. The sods shall be cut in rectangular strips of uniform width not less than about 300mm x 250mm size but not so large so that it is convenient to handle and transport without damage.

The area to be sodded shall be previously constructed to the required slope and cross section. Prior to placing the sods, the slopes shall be **roughned** and wetted in order to have a satisfactory bond. The strips of sod shall be laid in close contact with each other and be tamped firmly in place so as to fill and close the joints between them. The turfing so laid shall be well watered and protected until final acceptance.

5.10 Approaches

The contractor shall provide proper approaches for workmen and inspection.

5.11 Lighting

Full scale lighting are to be provided if night work is permitted or directed by the engineer. If no night work is in progress, red warning lights should be provided at the edges of excavations and fills.

6.00 RATES AND MEASUREMENTS

6.01 Rates

a) The item of work in the schedule of quantities describe the work very briefly. The various items of the schedule of quantities shall be read in conjunction with the corresponding sections in the technical specification including amendments and additions if any. For each item in the schedule of quantities, the bidder's rate shall include all the activities covered in the description of the items as well as for all necessary operations in detail as described in the technical specification.

b) No claims shall be entertained if the details shown on the released for construction drawings differ in any way from those shown on the tender drawings.

c) The unit rate quoted shall include minor details which are obviously and fairly intended and which may not have been included in these documents but are essential for the satisfactory completion of the work.

d) The bidder's quoted rate shall be inclusive of supplying and providing all labour, men, materials, equipments, tools and plants, supervision, services, approaches, schemes etc.

6.02 Measurements

Method of measurements are specified in the proceeding sections. Where not so specified, the latest version of IS:1200, Part-1 shall be applicable.

a) The length, breadth and depth shall be measured correct to the nearest centimetre if measurements are taken by tape. Rounding of numericals shall be as per relevant IS Codes. If the measurements are taken with staff and level, the levels shall be recorded correct to 5mm. The area and volume shall be worked out in square meter and cubic meter correct to the nearest of two decimal places.

b) For earth work in excavation, the ground levels shall be taken before and after completion of the work in the actually excavated area. The quantity of earth work in cutting shall be computed from these levels in cubic meter.

c) Where soft rock and hard rock are mixed, the measurement shall be done as follows. The two types of rock shall be stacked separately and measured in stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in the stacks. If the sum of net quantity of the two types of rock so arrived exceeds the total quantity of excavation then the quantity of each type of rock shall be worked out from the total quantity (from excavation) in the ratio of net quantities in stack measurements of the two types of rock. If stacking is not feasible, the method as suggested by the engineer shall be followed.

d) Where soil, soft rock and hard rock are mixed, the measurement shall be done as follows. The soft and hard rock shall be removed from the excavated material and stacked separately and measured in stacks. The net quantity of each type of rock shall be so arrived by applying a deduction of 50% for looseness/voids in stacks. The difference between the entire excavation and the sum of the quantities of soft and hard rocks so arrived shall be taken as soil.

e) For earth work in filling, the actual measurements of fill shall be calculated by taking levels of the original ground before start of the work but after site clearance and after compaction of fills. The quantity of earth work in filling shall be computed from these levels in cubic meter.

f) For turfing, the measurement shall be made on the finished work in square meter.

VOLUME – II B

SECTION – D

SUB SECTION – D23

ANTI-TERMITE TREATMENT

SPECIFICATION NO. PE-TS-999-600-C023

Maharatna Company

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 ANTI-TERMITE TREATMENT

1.00.00 SCOPE

The scope of work is to set up a chemical barrier against attack by subterranean termites while the building is under construction.

2.00.00 EXECUTION

2.01.00 General

All work shall in general be executed as specified in IS: 6313 Part II-1981 and as per approved specification of the agency having special know-how for the job.
All necessary work to ensure uniform distribution and proper penetration of treatment of treating solution shall be done according to the instruction of the Engineer.
Soil treatment shall not be done when it is raining or when the soil is wet with rain or subsoil water. Once formed, the treated soil barrier shall not be disturbed.

2.02.00 Chemicals and Rate of Application

Any of the following chemicals (conforming to relevant Indian Standards) in water emulsion shall be applied by pressure pumps, uniformly over the area treated.

Chemicals		Concentration by Weight, Percentage
Chlorpyrifos Emulsifiable (IS 8944 - 1978)	:	1.0
Heptachlor Emulsifiable Concentrate (IS: 6439 - 1978)	:	0.5
Chlordane Emulsifiable Concentrate (IS: 2682 - 1984)	:	1.0

2.02.01 Treatment of Column Pits, Wall Trenches and Basement Excavations

Foundations, basements etc. may either be fully enveloped by the chemical barrier or the treatment may start 500 mm below ground level. The bottom surface and sides of excavation (upto a height of about 300 mm) for column pits, walls trenches and basements shall be treated with chemicals at the rate of 5 litres / M^2 of surface area. Backfills around columns, walls etc. shall be treated at the rate of 7.5 litres / M^2 of the vertical surface. Chemical treatment shall be done in stages following the compaction of earth in layers. The treatment shall be carried out after the ramming operation is done by

rodding the earth at 150 mm centres close to the wall surface and spraying the chemicals in the specified dose.

2.02.02 **Treatment of Top Surface of Plinth Filling**

Holes 50 mm to 75 mm deep at 150 mm centres both ways shall be made with crowbars on the surface of compacted plinth fill. Chemical emulsion at the rate of 5 litres / M^2 of surface shall be applied prior to laying soling or sub-grade. Special care shall be taken to maintain continuity of the chemical barrier at the junction of vertical and horizontal surfaces.

2.02.03 **Treatment of Soil Surrounding Pipes, Wastes and Conduits**

Special care shall be taken at the points where pipes and conduits enter the building and the soil shall be treated for a distance of 150 mm and a depth of 75 mm at the point where they enter the building.

2.02.04 **Treatment of Expansion Joints**

These shall receive special attention and shall be treated in a manner approved by the Engineer.

2.02.05 **Treatment at Junction of the Wall and the Floor**

Special care shall be taken to establish continuity of the vertical chemical barrier on inner wall surfaces from ground level up to the level of the filled earth surface.
A small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor. Rod holes made in the channel up to the ground level 150 mm apart and the chemical emulsion poured along the channel at the rate of 7.5 litres per square meter of the vertical wall or column surface. The soil should be tamped back into place after this operation.

3.00.00 **ACCEPTANCE CRITERIA**

The Contractor shall give a 10-year service guarantee in writing supplemented by a separate and unilateral guarantee from the specialised agency for the job to keep the building free of termites for the specified period.

4.00.00 **RATES**

Rates shall be of complete work per unit area as stated in the Schedule.

5.00.00 **METHOD OF MEASUREMENT**

Complete work of anti-termite treatment shall be measured for plinth area treated.

This includes treatment, to foundations, walls, trenches, basements, plinth, burried pipes, conduits etc. The extended portions of foundation and like beyond plinth limit shall be the part of complete work.

6.00.00 **I.S. CODE**

Relevant code applicable for this Specification.

IS: 6313 (Part-II) 1981 : Code of Practice of Anti-Termite Measures in Buildings
Pre-constructional chemical treatment measures.