15.6 Crimping of Spare Tubes

Spare tubes laid in the tube bundles for future usage will be crimped at the end .Proper identification tags should be provided prominently on spares tubes.

15.7 Butt Welding of S.S. Tubing by Auto Tube Welding M/C

Jointing between successive lengths of tubes and termination at the equipment / instrument end and take-off points are by butt welding, especially in high pressure D_2O systems. Refer PC-P-285 for machine qualification, procedure qualification, welder qualification and production mockup.

15.8 Swaging/Termination of S.S. Tube by Using Swage-Lok Fittings

Swaging / termination of S.S. tube shall be done by the qualified swage-lok fitter. Installation procedure (as per the Manufacturer's recommendation) shall be approved by site construction group and qualification of swage-lok fitter shall be approved by NPCIL QS.

15.9 Tagging of Tubing

The tubing shall be tagged with tube numbers punched on anodized aluminum tag of 8 cm x 1 cm x 0.5 cm thick and tied to the tubing using Stainless Steel. Nickel - Cadmium plated steel wire at take-off points and near instruments/equipments. If tube number or line number is not allotted in the drawings, only equipment number is to be punched on the aluminum tag. If the tube is passing through EP sleeve or bore through connectors, the Tag Nos. shall be painted on nearby wall or equipment to identify the same. An inspection report of tube laying shall be prepared in format as given.

15.10 Tube Identification

Long tubes are to be identified by blowing air through the tubes before making the final weld to ensure and certify the proper connection to their respective instruments or take-off points and identified tubes will be tagged. However, this will be further cross-checked before final weld by purging argon gas, if final joint is butt weld type.

15.11 Testing

The laid down tubing shall be tested along with the connected pipelines as per the Appendix E &G.

INSPECTION REPORT FOR LAYING OF S.S. TUBES

USI NO. : UNIT : REPORT NO. : Date :

Sl. No.	Line No. / Tag No.	Reference Drawing	Cleaning	Route and fabrication	Clamping	Tagging	Signature			Remarks
							Cont.	Engr.	QA	

Contractor QS Erection Engineer NPCIL (QA)

All the tubings and terminations shall be completed with checklist signed by erection agency and NPCIL QS .

APPENDIX – A

INSTRUCTIONS FOR SETTING AND ADJUSTING CONSTANT SUPPORT AND VARIABLE SPRING TYPE HANGERS IN THE FIELD

These instructions cover the general requirements with regard to constant and variable spring hangers for their installation, treatment during hydrostatic testing and techniques for making initial and final setting of hangers.

1. CONSTANT SUPPORTS

1.1 Installation

Constant support hangers are the devices, as their name indicate, provide a constant supporting force throughout their entire travel range. These units are shipped set in their "COLD" position with a positive locking pin. As long as this locking pin is in position, the unit has no flexibility and the hanger assembly will act as a rigid support. Thus, a pipe line supported by constant support hangers can be initially installed in its "COLD" position with these locks engaged.

With the locking pins still in position, mechanical adjustments for elevation of piping may be made by running the hanger rod further in, or out, of the free-turning load connection of the constant support or by adjustments to the remainder of the hanger assembly components. The amount of adjustment available in these units is dependent upon the size and type of the unit, but in most cases it permits up to 75 mm of adjustment. This shall be checked and ensured from the support supplier.

1.2 Hydrostatic Test

With locks engaged, the hydrostatic testing procedures may take place without any further effects on the piping system. For steam piping the need of temporary support during hydro test shall be checked and if temporary supports are required the same shall be provided.

1.3 Cold Position

When hydrostatic testing procedures have been completed, the insulation (if any) installed and the line readied for operating conditions (in the case of water piping, the system is filled with water), then the hydrostatic locking pins should be removed from the constant supports. To do this the load adjustment coupling mentioned earlier under "Installation", is adjusted either up or down by decreasing or increasing the amount of piping load which is applied to the constant support. When this load equals the load for

APPENDIX – A CONTD.....

which the units was designed and built (i.e. pointer of the scale at zero position / lever to be in horizontal position for counter weight type of supports), the hydrostatic lock pin can be readily removed. For exact arrangement of unlocking the spring from cold position support vendor's instruction shall be followed.

When all the hydrostatic locking pins have been removed on a line supported by constant supports, there may be an unbalancing effect, perhaps, due to the tolerance in the pipe wall thickness, tolerance in the pipe diameter and variations in the weight of the insulation. To compensate for these there is a readily accessible load adjustment screw, which permits a variation of plus or minus 10% or more of the constant supports initial load capacity. If any adjustment appears to be necessary, the situation shall be reviewed with the Engineer responsible for the hanger load calculations in order that the system may be properly balanced. For exact arrangement of setting the spring support vendor's instruction shall be followed.

If the hangers are correctly designed and installed, each hanger indicator will be in line with "COLD" position (c) marked on the hanger. All cold load settings as per actual field reading shall be recorded as base line data (for piping) for each support.

1.4 **Hot Position**

As the system is brought up to its required operating temperature conditions, periodic checks should be made to see that the constant support hangers are working within their calculated travel range. If units are found to be approaching the end of their travel, this should be reported immediately.

This is particularly true when a constant support has "UPWARD" travel from cold to hot, since the supporting force of the unit is lost when it reaches the extent of its travel and this load is redistributed to the piping and can cause reactions of serious magnitudes.

Sagging or "Pulled-Up" piping should be reviewed by the Engineer responsible for load calculations to see if load adjustments in the hangers are required to correct the conditions. All hot load field readings shall be recorded as base line data (for piping) for each support. The actual identification of constant spring support locking pin arrangement, locking / unlocking procedure and adjustments shall be as per manufacturer's catalogue.

APPENDIX – A CONTD.....

2.0 VARIABLE SUPPORTS

2.1 Installation

Variable spring hangers, as their name indicates, provide a variable pipe supporting force, which increases when the helical spring is compressed and decreases when the spring is extended.

Variable spring units are marked with their calculated design "HOT" and "COLD" positions, and are sent to the field for installation with a spacer holding the spring in the required cold load condition. These spacers /lock nuts are installed in the springs solely to reduce the installation time involved and do not prevent the overloading of the spring and consequent sagging of the piping.

2.2 Hydrostatic Test

In most steam pipe (hot piping) applications, hydrostatic testing takes place before insulation. In small pipe size the weight of the insulation is about equal to the weight of water required for testing. Under these conditions, the amount of sag which is introduced to the piping is nominal. It is standard procedure and good practice, however, when hydrostatically testing piping for steam service suspended on variable spring hangers, to put temporary supports at several points along the piping to prevent sagging and possible overstressing of the piping. For insulated lines on water service this is not necessary.

2.3 Cold Position

When the piping has been completely insulated and is ready for operation, (in case of water piping, filled with water and any temporary supports), the cold load spacers are to be removed. This is done by turning the load coupling of the variable spring hanger and placing additional loading on the spring hanger until sufficient loading on the helical spring allows the spacer to be removed by hand. When this is done, the spring setting is equal to the calculated cold load requirements.

When all the spacers have been removed, there is the possibility that a few of the spring units may be above or below their required "Cold load" setting or the pipe may be slightly above or below its required elevation. To compensate for larger deviations, minor adjustments can be made in the hanger rod length by turning the hanger rod further in or out of the variable spring load coupling. Again, if these initial adjustments do not correct the condition, the Engineer should be consulted. All cold load settings as per actual field reading shall be recorded as base line data (for piping) for each support.

APPENDIX – A CONTD.....

2.4 Hot Position

When the system has reached to its operating conditions, an inspection of the hanger should be made to see that the variable springs are still operating in their load scale range. It should be remembered that thermal expansion calculations which are based on many variable factors, and in most cases, they represent the maximum travel which is anticipated. In some cases, this travel is not attained.

When the equipment has reached its "HOT" or operating condition, the pipe should be checked for correction of elevation, pitch, etc. and any final adjustments required should be made onto the hanger components to achieve this result. This will result in minor variations in supporting force of the variable springs from the calculation loads, but it should not be a cause of concern as long as the unit is operating on the rated load scale, because it represents the actual load conditions of the piping system. All hot load field readings shall be recorded as base line data (for piping) for each support.
Pipe elevations may also be altered for the required pipe load adjustments by rotating the turn buckle. The actual identification of variable spring support locking pin arrangement, locking / unlocking procedure and adjustments shall be as per manufacturer's catalogue.

APPENDIX – B

DRY PACKING OF EQUIPMENT -TYPICAL PROCEDURE

1.0 Clean all the floor area which is chipped under the base plate. Then grout the sleeves around the bolt with a mortar of semi-hard consistency. Tap the bolts while grouting so that no voids will be left.

2.0 Provide wooden battens under the ribs to pack the gap between the floor and the ribs. Thus the whole area will be divided into four sections marked as (A) and (B).

3.0 Provide shuttering to close the said gap and keep one face open for dry pack.

(Note: Arrow shown on drawing shows the side from which dry packing is to be done).

4.0 Moisten the surface to be dry packed by covering with damp cloths (Burlap) for at least 12 hours before starting to dry-pack. No free moisture shall be present when starting to dry-pack, but the concrete surface must appear dark from moisture absorption.

5.0 Prepare dry packing mortar. Use fine sand passing no. 16 screen. Mix cement and sand in the ratio of 1:2.5 by weight. Add just sufficient water (say water / cement ratio not exceeding 0.2) so that a ball can be prepared out of the mortar in successive stages without squeezing water outside. Prepare as per requirement, the Engineer will approve the final mix before placing is started.

6.0 Take sufficient mortar and insert under the base plate from the open face. Go on packing with the help of tools. Use a wooden mallet or 5 Kg. hammer. Hammer for sufficient time till full compactor is achieved.

7.0 Fill the whole gap under the base plate with successive compacted layers of mortar. Close the open face till 24 hours by shuttering after completion of dry packing.

8.0 Remove the wooden battens under the ribs next day. Dry pack the remaining (B) areas by the method as above.

Cure the dry packed open surfaces by covering with burlap cloths kept continuously moist for a period of at least 4 days(Failure to keep the burlap moist, shall call for the attention to keep the mortar moist for further 4 days from the time the cloths are rewetted)

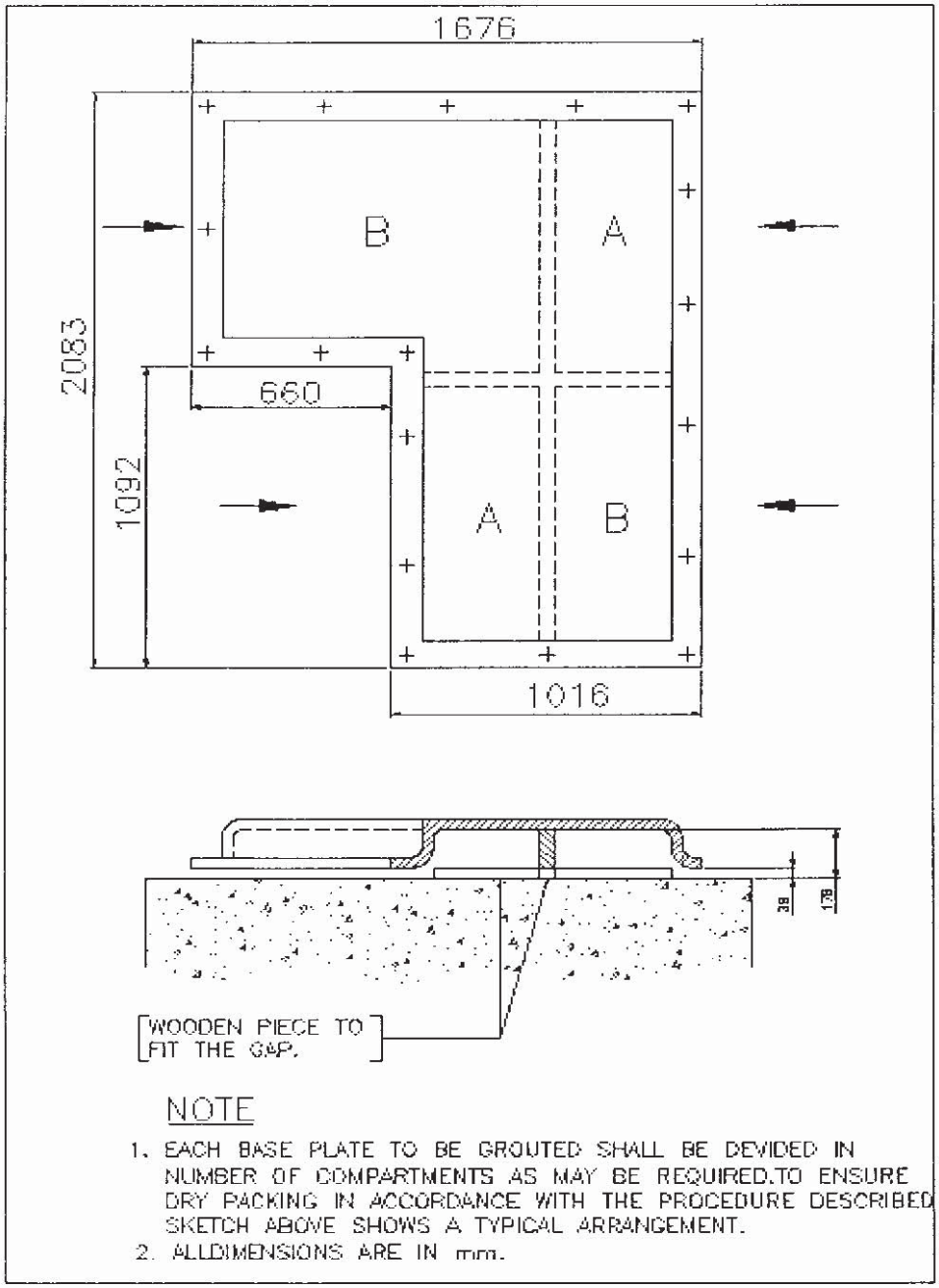
After two days the shims shall be removed and the voids left by their removal, dry packed as per above.

APPENDIX – B – CONTD..

After four days of curing, the foundation bolts shall be evenly torqued.

Alternatively whenever dry packing is not feasible and liquid grout is required, liquid grout having cement, sand, aggregations with required anti shrinkage compounds after conducting mock-up is also acceptable.

TYPICAL DRY PACK ARRANGEMENT



NOTE

1. EACH BASE PLATE TO BE GROUTED SHALL BE DEVIDED IN NUMBER OF COMPARTMENTS AS MAY BE REQUIRED.TO ENSURE DRY PACKING IN ACCORDANCE WITH THE PROCEDURE DESCRIBED SKETCH ABOVE SHOWS A TYPICAL ARRANGEMENT.
2. ALLDIMENSIONS ARE IN mm.

APPENDIX – C

APPLICABLE SPECIFICATION, STANDARD AND PUBLICATIONS

In the event that certain requirements of any publication which conflict with those of the NPCIL Specification, the governing requirements shall be as per this Specification. The standards and publications listed below shall, along with latest revisions and addenda be considered applicable unless otherwise specified and this shall be confirmed by the Contractor in his bid / offer.

PC-M-287	Seamless carbon steel pipes & Butt welding fittings for feeders.
PC-M-309	Austenitic Stainless Steel Pipe Fittings.
PC-M-308	Austenitic Stainless Steel Pipe.
PC-M-288	Carbon Steel Seamless Pipes, Pipe Fittings and Pipe Components for Primary System
PC-E-286	Reactor Header Assemblies.
PB-E-68	High Pressure Pipe Coupling for PHT Feeders.
PB-E-451	Procedure Specification for Fabrication and Installation of Headers Associated Pipe Work and Installation of Primary Heat- Transport System Main Circulating Pumps & Main Piping Connections to the Boiler for the Tarapur Atomic Power Project-3&4
PC-P-345	Cleaning Methods for piping.
PC-P-285	Field Welding of Piping for Nuclear Power Plants (PHWRs)
PC-E-401	Technical Specification for Penetration Bellows.
PB-E-528	Mechanical shock arrestors (snubbers)
PB-P-454	Primary System feeder pipe and supports installation instructions.
PP-M-107	SS Tubing
PB-P-460	Primary System feeder pipe to end fitting joint (Gray lock type) Installation instructions.
PC-E-274	Stainless steel compression type Ferrule (Flare less) Tube fittings
PP-E-1864	Norms for Piping Equipment Identification (Color Code)

APPENDIX – C – CONTD.....

PP-M-1219 Specification for Epoxy coating for RB internal structure & equipments.

PP-M-1729 Specification for Inorganic Zinc Silicate Primer

PP-E-984 Technical Specification for Thermal insulation.

PP-E-918 Mechanical Shock arrestors (Snubbers)

AMERICAN WATER WORKS ASSOCIATION(AWWA)

The latest issues of the following Publications are applicable:

AWWA-C203 Cold tar protective coating and lining for Steel Water pipe line – Enamel& tape-hot applied.

AWWA-C207 Specification for Steel Flange for Water works Service.

AMERICAN NATIONAL STANDARD INSTITUTION/ASME

The latest issues of the following Publications are applicable:

B 1.20.1 Pipe Threads-General Purpose

B 1.20.3 Taper Pipe Threads (Dry Seal Type)

B 16.5 Pipe Flanges and Flanged Fitting (NPS ½ through 24)

B 16.9 Factory made Wrought Steel Butt Welding Fittings

B 16.10 Face to face and end to end dimensions of Ferrous valve.

B 16.11 Forged Steel Fitting, Socket Welding and Threaded

B 16.20 Metallic Gaskets for Pipe Flanges-Ring joint, Spiral-Wound, and Jacketed

B 16.21 Non-Metallic Gaskets for Pipe Flanges

B 16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

B 16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings, Classes 150 and 300, 400, 600, 900, 1500&2500 lbs

B 16.34 Valves Flanged, threaded and Butt Welding end.

B 16.36 Steel Orifice Flanges.

B 16.39 Malleable Iron threaded union.

APPENDIX – C – CONTD.....

B	16.47	Large diameter steel flanges.
B	16.48	Steel line blanks.
B	18.2.1	Square and Hex Bolts and Screws (inch)
B	18.2.3.1M	Hex machine Bolts and Screws (metric)-Heads
B	18.2.3.6M	Hex machine Bolts and Screws (metric)-Other dimensions
B	18.2.4.2M	Hexagonal Nuts (metric)
B	36.10M	Welded and Seamless Wrought Steel Pipes
B	36.19M	Stainless Steel Pipe
B	16.25	Butt Welding Ends
B	16.28	Wrought Steel Butt Welding Short Radius Elbows and Returns
B	46.1	Surface Textures

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The latest issues of the following publications are applicable:

ASME Boiler and Pressure Vessel Code, Section II, III, V, VIII, IX, & XI
ASME B 31.1 Power Piping Code

MANUFACTURERS STANDARDIZATION SOCIETY

The issues of the following publications are applicable:

MSS - SP25 Standard marking system for valves, fittings, flanges & unions.
- SP50 Forged Steel Plugs and Bushings
- SP58 Material design and manufacture of pipe hanger and supports.
- SP61 Hydrostatic Testing of Steel Valves
- SP67 Butterfly Valves
- SP69 Selection & application of pipe hanger supports.
- SP79 Socket Welding Reducing Inserts.
- SP83 Steel pipe unions, Socket Welding & Threads.
- SP89 Fabrication & installation practices for pipe hanger & supports
- SP97 Integrally reinforced forged branch outlet fittings (weldolets, sockolets & threadolets).
- PFI ES-Engineering Standards

APPENDIX – C – CONTD.....

ASME II PART C / AMERICAN WELDING SOCIETY

The latest issues of the following publications are applicable::

ASME/AWS-SFA	5.1	Specification for Carbon Steel Electrodes for Shielded metal Arc welding
	5.2	Specification for carbon and low alloy steel rods for oxy fuel gas welding
	5.4	Specification for stainless steel electrodes for shielded metal arc welding
	5.5	Low Alloy Steel Electrodes for SMAW.
	5.8	Specification for filler metals for brazing and braze welding.
	5.9	Specification for bare stainless steel welding Electrodes and rods
	5.10	Specification for bare Aluminium and Aluminium Alloy Welding Electrodes and rods
	5.12	Specification for Tungsten and Tungesten Alloy Electrodes for arc welding and cutting
	5.14	Specification for Nickel and Nickel Alloy Bare Welding Electrodes and Rods
	5.28	Low Alloy Steel Electrodes and rods for gas shield Arc welding.
	5.30	Specification for Consumable Inserts
	5.01	Filler metal procurement Guidelines

AMERICAN SOCIETY FOR TESTING AND MATERIALS/ ASME – SECTION-II MATERIALS SPECIFICATION

The latest issues of following publications are applicable:

ASME / ASTM NO	TITLE
SA20/SA20M	Specification for General requirement for Steel Plates for Pressure Vessels
SA-36/SA36M	Specifications for Structural Steel
SA-53/ SA-53M	Specification for Pipe, Steel, Black and Hot Dipped, Zinc coated Welded & Seamless.
SA-105/ SA-105M	Specification for Carbon Steel Forgings for Piping Applications

APPENDIX – C – CONTD.....

SA-106	Specification for Seamless Carbon Steel Pipe for High Temperature Service
SA-181/ SA-181M	Specification for Carbon Steel Forgings for General Purpose Piping
SA-182/ SA-182M	Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings and Valves and Parts for High Temperature Service
SA-193 / SA-193 M	Specification for Alloy Steel and Stainless Steel Bolting Materials for High Temperature Service
SA-194 / SA-194 M	Specification for Carbon & Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
SA-216 / SA-216 M	Specification for Carbon Steel Castings, Suitable for Fusion Welding for High Temperature Service
SA-217 / SA-217 M	Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure Containing parts Suitable for High Temperature Service
SA-234 / SA-234 M	Specification for Piping Fittings of Wrought Carbon Steel & Alloy for Moderate and Elevated Temperature.
SA-240	Specification for Heat – Resisting Chromimum and chromimum - Nickel stainless steel plate, sheet and strip for pressure vessels.
SA-276	Specification for Stainless Steel Bars and shapes.
SA-283 / SA-283 M	Specification for Low and Intermediate Tensile Strength carbon Steel Plates
SA-285 / SA-285 M	Specification for Pressure Vessel Plates, Carbon Steel , Low-and Intermediate Tensile Strength
SA-307	Specification for Carbon Steel bolt and studs, 60,000 PSI Tensile strength
SA312 / SA312 M	Specification for Seamless & Welded Austenitic Stainless Steel Pipe
SA320 / SA320 M	Specification for Alloy Steel bolting material for low temperature service
SA333 / SA333 M	Specification for Seamless & Welded Steel Pipe for Low Temperature Service

APPENDIX – C – CONTD.....

SA335 / SA335 M	Specification for Seamless Ferritic Alloy –Steel Pipe for High temperature service
SA350 / SA350 M	Specification for Forgings, Carbon & Low alloy Steel requiring notch toughness testing for piping components
SA351 / SA351 M	Specification for Castings, Austenitic, Austenitic – Ferritic (Duplex) for pressure containing parts
SA352 / SA352 M	Specification for Steel Castings, Ferritic and Martensitic, for Pressure containing parts suitable for low temp. service
SA353 / A353M	Specification for Pressure Vessel Plates, Alloy Steel, Nine Percent Nickel, Double Normalized and Tempered
SA358 / SA358 M	Specification for Electric Fusion Welded Austenitic Chromium Nickel Alloy Steel Pipe for High Temp. Service
SA376 / SA376 M	Specification for Seamless Austenitic Steel Pipe for High Temperature Central Station Service
SA387 / SA387 M	Specification for Pressure vessel Plates, Alloy Steel, Chromium-Molybdenum
SA388 / SA388 M	Specification for Ultrasonic Examination of Heavy Steel Forgings
SA403 / SA403M	Specification for Wrought Austenitic Steel Piping Fittings
SA420 / SA420 M	Specification for Piping Fittings or Wrought Carbon & Alloy Steel for Low Temp. Service
SA450 / SA450 M	Specification for General Requirement for Carbon Ferritic Alloy & Austenitic Alloy Steel Tubes.
SA515/A515M	Specification for Pressure Vessel plates, Carbon Steel, for Intermediate and Higher Temp. Service
SA516/A516M	Specification for Pressure vessels plates, carbon steel, for inte3rmediate and high temp. service
SA530 / SA530 M	Specification for General requirements for specialized carbon and alloy steel pipe.
SA672	Specification for Electric Fusion Welded Steel Pipe for High Pressure Service at Moderate Temperatures.

APPENDIX – C – CONTD.....

SA691	Specification for Carbon and Alloy Steel Pipe, Electric –Fusion - Welded for High Pressure Service at High Temperatures.
B32	Specification for Solder Metal
SB61	Specification for Steam or Valve Bronze Castings
SB62	Specification for Composition Bronze or Ounce Metal Castings
SB166	Specification for Nickel-Chromium-Iron Alloy AND Nickel – chromium – cobalt – molybdenum alloys Rod, Bar and wire
SB167	Specification for Nickel-Chromium-Iron Alloys, Seamless Pipe & Tubes
SB241 / SB241 M	Specification for Aluminium and Aluminium Alloy Seamless Pipe & Seamless Extruded Tube
SB247	Specification for Aluminium Alloy Die and Hand Forgings
E23	Test methods for notched bar impact testing of metallic materials
E94	Guide for radiographic testing
E709	Guide for magnetic particle examination
E94	Standard guide for radiographic examination
E165	Test method for liquid penetrant examination
E208	Test method for conducting drop weight test to determine nil-ductility transition temperature of ferritic steel
SA370	Standard test methods and definitions

INDIAN STANDARDS

The latest issues of the following publications are applicable:

IS : 210	Specification for Gray Iron Casting
IS : 554	Dimensions for Pipe Threads where Pressure Tight Joints are Required on the Threads
IS : 1239 (part I)	Specification for Mild Steel Tubes, tubular and other wrought steel fittings
IS : 1239 (part II)	Specification for Mild Steel Tubulars and other Wrought Steel Pipe Fittings

APPENDIX – C – CONTD.....

IS : 1363 (Part 1,2 3)	Specification for Hexagon Bolts, Nuts and Lock Nuts of product grade 'C' (size range M5 to M36)
IS : 1364 (6Parts)	Hexagon head Bolts, Screws and Nuts of Product Grades A&B
IS : 1367 (Part 1 to 18)	Technical Supply Conditions for Threaded Steel Fasteners
IS : 1520	Specification for horizontal centrifugal pumps for clear and cold water
IS : 1538	Specification for Cast Iron Fittings for Pressure Pipes for Water, Gas and Sewage
IS : 1747	Specification for Nitrogen
IS : 1875	Specification for Carbon Steel Billets, Blooms, Slabs & Bars for Forgings
IS : 1879	Malleable Cast Iron Pipe Fittings
IS : 1978	Specification for line pipe
IS : 2002	Specification for steel plates for pressure vessels for intermediate and high temperature service including boilers
IS : 2016	Specification for Plain Washers
IS : 2062	Hot Rolled Low, Medium and High Tensile Structural Steel
IS : 2712	Gaskets and Packings - Compressed Asbestos Fibre Jointing - Specification
IS : 3038	Martensetic stainless steel and Alloy Steel Castings for intermediate and high temperature service including boilers
IS : 3224	Valve Fittings for Compressed Gas Cylinders Excluding Liquefied Petroleum Gas (LPG) Cylinders - Specification
IS : 3589	Specification for Steel Pipes for Water& Sewage (168.3 to 2540 mm Outside diameter)
IS : 4072	Specification for Steel for Spring Washers
IS : 4218	ISO Metric Screw Threads Parts I, II, III, IV, V, VI
IS : 4682	Code of practice for lining of vessels and equipment for chemical processes
IS : 5120	Specification for Roto dynamic pump
IS : 5372	Taper washers for channels (ISMC)
IS : 7719	Metallic spiral wound gaskets

APPENDIX – C – CONTD.....

BRITISH STANDARD

The latest issues of following Publications are applicable:

BS 21	Specification for Pipe Threads for tubes and fittings where pressure tight joints are made on the threads
BS 1868	Specification for Steel Check Valves(flanged and butt weld ends) for Petroleum ,Petrochemical and Allied industries
BS 1873	Specification for Cast Steel Globe Valves
BS 3496	Specification for E Glass Fibre Chopped Strand Mat for the Reinforcement of Polyester and other liquid laminating System
BS 3532	Method of specifying Unsaturated Polyester Resin System
BS 3749	Specification for E Glass Fibre woven rovings fabrics for the Reinforcement of Polyester and epoxy resin system
BS 3799	Socket Welding pipe fittings of nominal size 15 mm to 50 mm (inclusive)
BS 4504	Dimension for large diameter flanges.
BS 5155	Specification for Butterfly Valves
BS 5166	Specification for Diaphragm Valves
BS 5352	Specification for steel wedge gate, globe and check valves 50 mm and smaller for petroleum ,petrochemical and allied industries
BS 5353	Specification for Steel plug Valves
BS 6755	Standard for testing of Valves

API STANDARD

The latest issues of following Publications are applicable

API 5 L	Specification for Line pipe
API 590	Spectacle Flanges
API 598	Specification for Valve Inspection &test
API 5 99	Specification for Steel &Ductile Iron Plug Valves
API 600	Specification for Steel Gate Valve, flanged or butt welding end.
API 602	Specification for Compact Carbon Steel Gate Valves
API 610	Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services

APPENDIX – C – CONTD.....

SAE STANDARD

The latest issues of following Publications are applicable

SAE J 517 Hydraulic Hose Specification

SAE 100 R Specification for R series Hoses

GUIDE / ACT /STANDARD /CATALOGOUE/NPCIL DATA SHEET

The latest issues of following Publications are applicable

AERB/SG/IS-1 Safety guide for Works Contract

Indian Boiler Regulation Act (Latest Edition)

Expansion Joint Manufacturers Association (EJMA)

Integrally reinforced branched outlet fittings

Pipe grooved Couplings

Quick Connect Couplings

APPENDIX – D

INSTALLATION OF CONCRETE EXPANSION FASTENERS

Concrete expansion fasteners are used in the reactor building, turbine building, service building and other plant buildings to support pipes, ducts and various other equipments. There are various types of concrete expansion fasteners being manufactured in India. Approved types of concrete expansion fasteners and the limitations on their uses depending on the areas are detailed below

Inner Containment Wall and Containment slab in the Reactor Building

Normally no expansion fasteners shall be installed on the Inner Containment Wall (ICW) and on the Inner Containment Dome in the reactor building. Wherever such expansion fasteners are unavoidable to be installed in the ICW or in the Inner Containment Dome, specific approval shall be obtained from the Engineer-in-charge. For making holes in the inner Containment wall/ Containment Dome, portable electric rotary drilling machine with carbide tipped drill bits shall be used. Before drilling, it shall be made sure that no re-bars/iron beams are cut / drilled in this operation unless specifically cleared by Engineer-in-charge on case to case basis.

Other areas of the Reactor Building, Turbine Building, Service Building and other Plant Buildings:

The following types of expansion fasteners can be used in the above areas:

a) Anchor fastness for the safety related / seismic buildings / structural / systems

	Type	Size in mm
Maxi bolt anchor	*	upto 25 mm
Hilti India	HDA*	upto 25 mm
Hilti India	HST	upto 25 mm
Fisher Anchor	FZA*	upto 25 mm
Fisher Anchor	FZA*	upto 25 mm

* These anchor fasteners have provision to get an under cut in concrete and may be used for Rotary equipments / Heavy process loads. Manufacturer's instructions with respect to installation and safe working loads shall be followed.

APPENDIX – D– CONTD.....

b) Anchor fastness for non- safety related / nonseismic buildings / structures / systems

Type	Size in m.m.(inches)
'Anchor Fasteners' (Hilti bolts make or equivalent)	6(1/4") to 25(1")

For making holes in the concrete "Hilti Machine" or Kango Rotary Hammer or equivalent with approval of Engineer-in-charge can be used. The maximum size of concrete expansion fasteners that can be used is limited to 25 mm.

General

1. The distance of concrete fastener from free edges of the structure in which fastener is installed shall be as per the fastener manufacturer recommendation.

2. The effective distance between two expansion fasteners should not be less than the sum of effective depth of installation of two fasteners.

3. In no case the hole sizes and depth of holes should be more than that recommended by manufacturers.

4. Caulking compound wherever required shall be applied to the satisfaction of Engineer-in-charge. 'Araldite' which is available in two packs can be used.

5. The detailed procedures for installation of the concrete expansion fasteners should be as per the manufacturer's catalogue.

6. The supply and installation of concrete expansion fasteners as detailed above would fall under the scope of piping contractor's supply and installation of the piping hanger and supports.

7. In certain situations where heavy loads are to be supported and EPs are not existing. suitable size of maxi-bolts or its equivalent shall be used with the approval of Engineer-in-charge. However, maxi-bolts or its equivalent shall not be used on containment dome i.e. ICW and OCW.

APPENDIX – E

SYSTEM TEST PRESSURE REQUIREMENTS

The hydro test pressure shall be reconfirmed from Engineer just prior to the hydro test.

USI No.	Circuit - Description	Air hold Test Pressure in $Kg/cm^2(g)$	Helium Leak Test Pressure in $Kg/cm^2(g)$	Integrity Test Hydrostatic / Pneumatic Test Pressure in $Kg/cm^2(g)$	Remarks
System : Reactivity Devices Process System					
32700	SDS#2 Main circuit	7.0	1.05 (50% Helium & 50% air) **	137.5	Permissible helium leak rate = 10^{-6} Std.cc/ Sec. or less (Weld joints) 10^{-4} Std.cc/ Sec(Mech joints)
	Auxiliary circuit	1.4	1.05	6.25	-do-
39000	Liquid Zone Control System Helium circuit	1.4	1.05 (50% Helium & 50% air) **	17.5	-do-
	Liquid Zone Control System Water circuit	1.4	1.05 (50% Helium & 50% air) **	17.5	-do-
System : Moderator System					
32110	a) Main moderator circulating system (with isolation of calandria & D_2O storage tank)	1.4	1.05 (50% Helium & 50% air) **	15.0	
	b) Interconnection between D_2O storage tank and purification system (with isolation of D_2O storage tank)	1.4	1.05 (50% Helium & 50% air) **	15.0	
32210	Moderator purification circuit	1.4	-do- **	15.0	
32310	Moderator cover gas system with isolation of calandria	1.4	1.05 (50% Helium & 50% air)	2.5	
32400	Adjuster rod cooling system	1.4	-do- **	15.0	
32510	Moderator leakage collection system (pump discharge side)	1.4	-do- **	15.0	
32510	Lines / tubings from various leak off points including LIGs and leakage collectors TK2, TK3 & TK4	1.4	-do- **	1.25	
32510	Leakage collection system (pump suction side)	1.4	-do- **	2.5	

APPENDIX – E CONTD....

USI No.	Circuit - Description	Air hold Test Pressure in $Kg/cm^2(g)$	Helium Leak Test Pressure in $Kg/cm^2(g)$	Integrity Test Hydrostatic / Pneumatic Test Pressure in $Kg/cm^2(g)$	Remarks
System : Moderator System CONTD...					
34520	Resin deuteration system with isolation of drums	1.4	-do- **	7.5	
34520	Resin de-deuteration and disposal system	1.4	-do- **	2.5	
34810	Moderator Liquid Poison Addition system	1.4	1.05 (50% Helium & 50% air) **	15.0	
34910	Vault leakage collection system (with isolation of 3491-TK-4)	1.4	1.05 (50% Helium & 50% air) **	15	
34910	Vault leakage collection (lines from drain hub to first isolation valve)	NIL	NIL	Water fill test	
34920	D_2O Evaporation and Cleanup system	1.4	NIL	15.0	Vacuum hold test at 50 mm of Hg (Absolute) for Heavy water lines.
34930	Heavy water Upgrading Plant	1.4	NIL	15.0	-do-
34940	D_2O sampling system	1.4	1.05 (50% helium, 50% air)**	15.0	
34950	Helium sampling system	7.0	1.0	NIL	
34960	D_2O addition and transfer system (with isolation of 3496-TK1)	1.4	1.05 (50% helium, 50% air)**	15.0	
	Tanks 3200-TK2	1.4	-do- **	2.5	
	3496-TK1	1.4	-do- **	2.5	
34980	Vacuum Mopping system	1.4	NIL	2.5	
34990	Downgraded D_2O Storage and Transfer System(Except Tank)	1.4	NIL	12.5	
System : PHT System					
33110	PHT Main Circuit	7	1.05 (50% helium, 50% air)**	157.5	During Hydrotest , steam generator metal temp. in pressure side shall be equal to or above 50^0C.
33116	Feeder	-do-	1.05	-do-	
33117	Header	-do-	1.05	-do-	

APPENDIX – E CONTD....

System : PHT System CONTD...

USI No.	Circuit - Description	Air hold Test Pressure in $Kg/cm^2(g)$	Helium Leak Test Pressure in $Kg/cm^2(g)$	Integrity Test Hydrostatic / Pneumatic Test Pressure in $Kg/cm^2(g)$	Remarks
33210	PHT purification system	2.0	1.05 **	18.75	
33230	D_2O Sampling system	2.0	1.05 (50% helium, 50% air)**	a)157.5 b)18.75	a) From SG inlet/ PCP discharge lines upto 3323-HX1 & HX2 b) Remaining lines inside RB & RAB
33310	Main feed pump discharge and feed circuit	7.0	1.05 (50% helium, 50% air)**	a)243.75 b)187.5	a) PPP discharge check valve upto 3331-V9, 3331-V14 on reflux cooler inlet, spray lines upto 3331-V40 b) Lines down-stream of 3331-V9 upto 3331-HX1, line after 3331-V14 upto reflux cooler and spray line after 3331-V40. From 3331-HX1 line no. 3331-6&7 including line no. 3331-9 from reflux cooler upto headers
33320	Bleed circuit upto bleed condenser level control valve	7.0	-do- **	157.5	
33330	D_2O Storage system	2.0	-do- **	6.25	
33330	Lines from various floor drain points including piping upto Valve no. 3333-AV-55 to AV-60 (IARS)	NIL	NIL	Pressure due to water column (water fill test)	
	Suction lines from MVs to pump suction flange including Inventory recovery tank (IARS)	1.0	NIL	6.25	
	Discharge lines from pump discharge flange upto 3333-V-47 including tube side of IARS HX-1	2.0	NIL	25	

APPENDIX – E CONTD....

System : PHT System CONTD...					
USI No.	**Circuit - Description**	**Air hold Test Pressure in Kg/cm^2(g)**	**Helium Leak Test Pressure in Kg/cm^2(g)**	**Integrity Test Hydrostatic / Pneumatic Test Pressure in Kg/cm^2(g)**	**Remarks**
33340	Gland supply and return circuit (part)	7.0 / 2.0	1.05 (50% helium, 50% air)**	a) 243.75 b) 187.5 c) 18.75	a)Gland supply line from PPP discharge check valve upto3334-CV38 b)From CV38 to PCPs, gland return lines from PCP up to isolation valve . c) Gland return lines from isolation valves to purification inlet (line no. 3332-7/3321-1)
33410	Shutdown cooling system	7.0	-do-	157.5	
33350	Emergency Core Cooling System	7.0 / 2.0	-do-	a) 157.5 b)68.75 c)25.0 d)6.25	a)ECCS injection lines from check valves 3335-V21,22,23&24 up to headers. b)From ECCS accumulator up to check valves 3335-V21 to 24, also pressurizing circuit & venting circuit of accumulator c) ECCS pump discharge lines up to check valve 3335-V 125,126,225&226 and pump recirculation line d) ECCS pump suction lines from ECCS sump;
33350	ECCS lines between F/M Vault, F/M Service Area & ECCS Sump	NIL	NIL	Water fill test	These lines are open to RB atmosphere

APPENDIX – E CONTD....

System : PHT System CONTD...

USI No.	Circuit - Description	Air hold Test Pressure in $Kg/cm^2(g)$	Helium Leak Test Pressure in $Kg/cm^2(g)$	Integrity Test Hydrostatic / Pneumatic Test Pressure in $Kg/cm^2(g)$	Remarks
33360	Pressurizer System	7.0	1.05 (50% helium, 50% air)**	157.5	
33370	Fuelling Machine D_2O Supply Circuit	7.0 / 2.0	-do-	a)243.75 b)25.00 c) 6.25	a) F/M pump discharge to F/M valve station. b)F/M return circuit line no. 3337-14,13 (down stream of CV-21 to RV-23) & line no. 3337-18,19&20. c) F/M pump suction line & down stream of RV-23.
33510	N_2 addition to F/M pump discharge accumulator	NIL	NIL	243.75	From 3351-V24, to 3337-TK1, TK2
	N_2 addition to F/M pump suction accumulator	NIL	NIL	6.25	From 3351-V25 to 3333-TK1, TK2
	N_2 back-up to PCP's seal	NIL	NIL	6.25	From 3351-V37 to back-up seal of PCP's.
	N_2 supply to PHT D_2O storage tank (3333-TK-1)	NIL	NIL	6.25	From 3351-V39 to 3351-AV2
	Hydrogen addition line to PHT	NIL	NIL	157.5	From 3351-V26 to 3331-V33
33610	Relief circuit	7.0 / 2.0	1.05 (50% helium, 50% air)**	157.5	
33710	Leakage collection system	2.0	NIL	a)31.25 b)6.25	a) L/C pump discharge lines. b) Remaining circuit.
33720	Service system (part)	2.0	1.05 (50% helium, 50% air)**	157.5	From SG drain valves to lock closed valve 3372-V30
33720	Service system (part)	2.0	NIL	6.25	From lock closed valve to service system recirculation tank 3372-TK2.
33820	PHT Resin Deuteration System	2.0	NIL	2.5	
33830	PHT D_2O Recovery System	2.0	NIL	2.5	

APPENDIX – E CONTD....

USI No.	Circuit - Description	Air hold Test Pressure in Kg/cm^2(g)	Helium Leak Test Pressure in Kg/cm^2(g)	Integrity Test Hydrostatic / Pneumatic Test Pressure in Kg/cm^2(g)	Remarks
System : PHT System CONTD...					
33840	PHT Resin De-deuteration System	2.0	NIL	2.5	
34330	ECCS Sump recirculation system	2.0	NIL	6.25	
36710	Emergency cooling System Fire Water Injection	7.0	NIL	68.75	
System : Secondary System (Inside R.B.)					
36110	Steam and level measurement piping around S.G.	7.0	NIL	68.75	
	Main Steam line from SG to MSIV	7.0	NIL	68.75	
36310	S.G. Blowdown system	7.0	NIL	68.75	
36600	Steam and water sampling system	7.0	NIL	68.75	
36710	Boiler emergency cooling system(from 3671-EV8.9 upto connection in ABFP line)	7.0	NIL	100.00	may be finalized after selection of ABFP.
	Boiler Emergency cooling System	2.0	NIL	12.5	From 3671- EV-8. 9. 10 to fire fighting headers
36730	PDHRS shell and connected pipings	1.0	NIL	3.75	
	Tube side including steam and condensate line	7.0	NIL	68.75	
43210	Main Feed Water System from SG to MFIV	7.0	NIL	68.75	
43210 (ABFP)	Auxiliary Feed Water System Pump discharge including recirculation line to main feed line inside RB	7.0	NIL	100.0*/68.75	1) Up to containment isolation valve. 2*) may be finalized after selection of ABFP. 3) From containment isolation valve up to feed water hook up point. the line may be tested along with feed water system.

APPENDIX – E CONTD....

System : Reactor Auxiliary System

USI No.	Circuit – Description	Air hold Test Pressure in Kg/cm^2(g)	Helium Leak Test Pressure in Kg/cm^2(g)	Integrity Test Hydrostatic / Pneumatic Test Pressure in Kg/cm^2(g)	Remarks
34110	End Shield cooling system	1.4	NIL	7.9	Expansion tank isolated
34160	Calandria vault water cooling system	NIL	NIL	6.25	Vault & expansion tank isolated
34200	Containment Spray System	1.4	NIL	22.5	
34710	Piping/tubing outside RB (from cylinders upto RV-114)	150	NIL	165	
	Circuit from RV-114 upto sub-header & header outside north & south F/M Vault	1.75	NIL	2.0	
	Complete circuit with tubing inside North & South F/M Vault	0.5	NIL	0.5	
34400	Spent fuel storage bay cooling and purification system	NIL	NIL	6.25	Bays isolated
71310	Active process water system	NIL	NIL	12.5	
71720	Active drainage system (Gravity Lines)	NIL	NIL	Fill Test	
	Active drainage system (Pumped Lines)	NIL	NIL	7.5	
73120	Condensate collection system	0.50	NIL	0.6	Air hold Test for 24hrs
71810	Service water system	NIL	NIL	9.4	

System : Fuel Handling Process System

Note : 1. DP = Design Pressure, indicated in remarks column
2. * = KAPP-3&4/USI No., # = KAPP-3/USI No.

USI No.	Circuit – Description	Air hold Test Pressure in Kg/cm^2(g)	Helium Leak Test Pressure in Kg/cm^2(g)	Integrity Test Hydrostatic/ Pneu Test Pressure in Kg/cm^2(g)	Remarks
35216	Fuel Transfer Oil Hydraulic System (RB)	NIL	NIL	1.5 x DP	DP=100, 10, 2kg/cm^2; For Boundaries refer */2001/FS Gross air leak check required before hydro test.
35216	Fuel Transfer Oil Hydraulic System (TLB)	NIL	NIL	1.5 x DP	DP=100, 10, 2kg/cm^2; For Boundaries refer */2002/FS. Gross air leak check required before hydro test.

APPENDIX – E CONTD....

System : System : Fuel Handling Process System contd..

USI No.	Circuit - Description	Air hold-up Test Pressure in $Kg/cm^2(g)$	Helium Leak Test Pressure in $Kg/cm^2(g)$	Integrity Test Hydrostatic / Pneumatic Test Pressure in $Kg/cm^2(g)$	Remarks
35217	Fuel Transfer Pneumatic System	1.25 x DP	NIL	NIL	DP=10kg/cm^2
35218	Fuel Transfer H_2O System	1.00	NIL	1.25 x DP	DP=20, 10, 3.5 & 1.0 kg/cm^2; For Boundaries referred in */2001/FS
35226	Fuelling Machine Oil Hydraulic System	NIL	NIL	1.5 x DP(Hydro test pressure to 210 $Kg/cm^2(g)$ only	DP=165,135,10.00& 2.00 Kg/cm^2 For Boundaries refer */2001/FS & */2002/FS Gross air Leak Check required before hydro test
35227	F/M Pneumatic System	1.25 x DP	NIL	NIL	DP=10 kg/cm^2
35228	Fuelling Machine D_2O System	7.00 (for DP 195, 140 & 20) 1.00 (for DP 3.5)	1.00	1.25 x DP	DP=195, 140, 20 & 3.5 kg/cm2; For Boundaries refer */2001/FS
35234	Rehearsal Tube Facility D_2O System	7.00(for DP 195&126) 1.00(for DP 3.5)	1.00	1.25 x DP	DP=195, 126 & 3.5 kg/cm^2 Boundaries refer */2001/FS
62136	Fuel Handling Auxiliary System-Oil Hydraulic System	Not Required	NIL	1.5 x DP	DP=100,10,2 kg/cm^2; For Boundaries refer */2001/FS, */2002/FS, Gross air leak check required before hydro test
62137	Fuel Handling Auxiliary System-Pneumatic System	1.25 x DP	NIL	NIL	DP=10 kg/cm^2 For Boundaries refer */2001/FS, */2002/FS

APPENDIX – E CONTD....

USI No.	Circuit - Description	Air hold Test Pressure in $Kg/cm^2(g)$	Helium Leak Test Pressure in $Kg/cm^2(g)$	Integrity Test Hydrostatic / Pneumatic Test Pressure in $Kg/cm^2(g)$	Remarks
System : Common Service					
53530	Fuel Oil Storage & Transfer System	NIL	NIL	9.4	
71120	Plant Water System	NIL	NIL	7.5	
71130	Chlorination System	NIL	NIL	15	
71200	CCW System	NIL	NIL	7.5	
71350	Aux Cooling Water System	NIL	NIL	15	
71400	Fire Water System	NIL	NIL	22.5	
71500	Domestic Water System	NIL	NIL	a)15.0 b)7.5	a)Piping from filteration plant to O/H tank-15.0 $Kg/cm^2(g)$ b) Lines from O/H tank to distribution point-7.5 $Kg/cm^2(g)$
71600	Demineralised Water System	NIL	NIL	11.25	
71710	Non-Active Drainage System	NIL	NIL	a)7.5 b)Fill Test	a)Pumped Lines-7.5 $Kg/cm^2(g)$ b)Gravity Lines –Fill test
71850	Aux- Service Water System	NIL	NIL	7.5	
71900	Chilled Water System	NIL	NIL	15.0	
75110	Compressed Air System	10.5	NIL	11.0	Air hold Test for 24hrs
75120	Instrument Air System	10.5	NIL	11.0	-do-
75130	Mask Air System	10.5	NIL	11.0	-do-
System : Waste Management Plant System					
79210	Liquid Effluent Segregation System (LESS)	NIL	NIL	15.0@	Pumps and Tanks shall be isolated, clean domestic water shall be used for hydro test
79220	Storage Treatment and Disposal System	NIL	NIL	15.0@	--do--
79220	Resin Transfer and Fixation System	NIL	NIL	15.0@	--do--
79220	Active Drainage System (Including Laundry Area of RAB#4) of WMP (Except Laundry Waste Transfer line from RAB#4 to Tk -1107/Tk-1108)	NIL	NIL	Gravity Drain line-2 $Kg/cm^2(g)$/@ Pumped line-15 $Kg/cm^2(g)$@	--do--

APPENDIX – E CONTD....

USI No.	Circuit - Description	Air hold Test Pressure in Kg/cm^2(g)	Helium Leak Test Pressure in Kg/cm^2(g)	Integrity Test Hydrostatic / Pneumatic Test Pressure in Kg/cm^2(g)	Remarks
System : Waste Management Plant System contd...					
79220	Laundry Waste Transfer line from Laundry Area of RAB#4 to dyke area Tk -1107/Tk-1108	NIL	NIL	15.0@	--do--
79220	Evaporation System	NIL	NIL	15.0@	--do--
79220	Vaporized liquid waste line from Evaporators of WMP to Evaporation chamber and all other associated lines of Evaporators.	NIL	NIL	5.4	
79220	Sampling System	NIL	NIL	15.0@	--do--
36900	Main Steam Line from grid F of PC bay of Control Building to the down stream isolation valve of PRV (44 to 7 Kg/cm^2(g))	NIL	NIL	68.75	--do--
36900	Main Steam Line from down stream isolation valve of PRV 44 to 7 Kg/cm^2(g)Located at WMP roof – to down stream isolation valve of PRV (7 to 3 Kg/cm^2(g))	NIL	NIL	12.60	--do--
36900	Steam Line from down stream isolation valve of PRV (7 to 3 Kg/cm^2(g)) to steam chamber of decontamination system	NIL	NIL	5.4	--do--
36900 & 42000	Main Steam Line from down stream isolation valve of PRV (44 to 7 Kg/cm^2(g)- located at WMP roof – to Evaporator of WMP Evaporation System and Condensate line from Evaporator of Evaporation System to Condensate Storage tank of Upgrading Plant	NIL	NIL	12.60	--do--
@ Hydro test Pressure may be revised after finalization of Piping GA					

** Refer Table – 1 in Page 51 of 64

NOTES

1.0 (a) Hydrostatic testing of all systems in Reactor Building (including first isolations outside Reactor Building) is to be done using demineralized water.

APPENDIX – E – CONTD....

(b) Hydrostatic testing of all systems outside Reactor Building is to be done using ordinary clean and filtered water. (Maximum halogen content expressed as chlorine and sulphur in the water shall be 25ppm).

(c) The chemistry of test fluid would require control as directed by the Engineer/Station Chemist.

(d) It is recommended that the hydrotest to be made at a temperature that will minimize the possibility of brittle fracture and hence the test temperature shall not be less than the lowest service temperature. The test pressure shall not be applied until the system, its component and the pressurizing medium are at approximately at the same temperature. The lowest service temp. for PHT system excluding steam generator and pressurizer inside R.B. is considered as +18°C. For Steam Generator and pressurizer it is 50°C.

For the system outside R.B., before applying hydrotest pressure test medium temp shall be checked with the component lowest service temp for the system designed as per ASME Section III.
All the spring support hangers shall be kept in locked condition during hydrostatic testing .The steam lines shall be provided with temporary supports as required.

(e) **Filling & Venting** : For hydrostatic test, filling shall be gradually done from lower most point normally in such a way that no air remains entrapped in any branch line / piping loop. For this purpose venting shall be done at all high points and complete venting shall be ensured by crack opening terminal valves, loosening the flanges/ screwed joints etc. Vents shall be kept open till the testing fluid comes out without any bubbles.

(f) **Method of Pressurisation** : The pressure in the system shall be gradually increased to not more than half of test pressure after which, in steps of approximately one tenth of test pressure until the required test pressure has been achieved.

2.0 The hydrostatic test pressure shall be maintained for a minimum of 10 minutes prior to conducting the examination for leakage. When testing pumps and valves, the pressure shall be maintained a minimum of 6 minutes for each centimeter of design minimum wall thickness but not less than 10 minutes. Following the application of the hydrostatic test pressure for specified period, examination for leakage shall be made of all joints. Except in case of pumps and valves, which shall be examined while at a test pressure, this examination shall be made at a pressure equal to the greater of the design pressure or three fourths of this test pressure. No leakage indications and distortion are permissible.

3.0 During hydrostatic testing of Reactor Auxiliary System, minimum holding time at test pressure is to be one hour with less than 1% pressure drop per hour.

APPENDIX – E – CONTD....

4.0 During air hold up test, all joints (mechanical and welded) including valve glands, are to be bubble tested. Pressure is to be held for minimum 15 minutes before starting bubble examination. No leakage indications are permissible.
The pressure drop during air hold test of 24 hours shall not be more than 4% of test pressure or that which would result from maximum permissible (as per MSS-SP-61/ individual specification sheet) seat leakages through terminal valves of the circuit being tested. The maximum permissible pressure drop rate, along with individual circuit testing procedure shall be subjected to the approval of the Engineer-in-charge.

5.0 Maximum permissible leak rates for helium leak testing are:

a. Welded joints 10^{-6} std cm^3/Sec
b. Mechanical joints (ie. threaded, flanged, packed glands etc.) 10^{-4} std. cm^3/Sec.

TABLE – 1

Sl. No.	Type of the Joint	Scope of HELIUM Leak Test (HLT) in				Remarks
		Inaccessible Areas	Accessible Areas			
		Design Class NB/NC/ND	NB	NC	ND	
1.	Butt Welded / Nozzle Joints	All Joints	No	No	No	
2	Socket / Fillet Weld Joints	All Joints	Yes	No	No	
3	Thread & Seal Welded Joints	All Joints	Yes	Yes	To be decided on case to case basis *	*HLT not required for D_2O sampling system, leakage collection system, Vacuum Mopping System, PHT service system, Downgraded D_2O system, D_2O addition & transfer system, Resin deuteration & de-deuteration system, etc.
4	Mechanical Joints Viz. threaded, flanged, grayloc, Hansen, Victaulic, Swagelok, etc.	All Joints	Yes	Yes	Yes	

Notes :

i) Any system specific requirement will over-ride the general guidelines given above by suitable justification.
ii) Inaccessible areas – Calandria Vault, calandria top hatch, Feeder and Header insulation cabinet.

APPENDIX – E – CONTD....

iii) Fuel handling Heavy Water systems are required to be Helium leak tested irrespective of type of joint.

6.0 Certain additional areas i.e. weld seam of longitudinal welded elbow as specified by the Engineer-in-charge shall also be inspected during hydro, pneumatic and helium leak testing.

7.0 All leakages beyond acceptable limit shall be repaired and areas of repair shall be retested using original procedure.

8.0 (a) Pressure test gauges used in pressure testing shall be indicating pressure gauges and shall be connected directly to the component. If the indicating gauge is not readily visible to the operator controlling the pressure applied, an additional indicating gauge will be provided which will be visible to the operator through out the duration of the test. For systems with a large volumetric content, it is recommended that a recording gauge be used in addition to the indicating gauges.

(b) Analog type indicating pressure gauges used in testing shall be graduated over a range not less than 1½ times nor more than 4 times the test pressure.

(c) Digital type pressure gauges may be used without range restriction provided the combined error due to calibration and readability does not exceed 1% of the test pressure.

9.0 Care shall be taken to see that no component especially in line expansion joints are over pressurized during integrity testing. During hydrostatic testing the expansion joints shall be kept in locked condition.

10.0 Care should be taken that no muck and other extraneous matter may get lodged inside the equipment during hydrostatic testing. Such a problem may exist in case of pumps especially at the mechanical seals, tube bend region of small diameter U tube type of heat exchangers, ion exchangers, filters, etc. In case of mechanical seals, pump internals should be removed and the casing be blanked during hydrostatic testing if the seals cannot withstand the test pressure. Separately flush the mechanical seals and internals after hydrotest if they were included for the test. (Note that these areas are not to be flushed alongwith main piping) wherever possible, pneumatic integrity test can be substituted for hydrostatic integrity test at the discretion of the Engineer.

APPENDIX – E – CONTD....

11.0 While pressurizing on shell side of a heat exchanger during integrity testing, if the design permits, tube side will be kept empty and vice-versa. This is necessary to check the integrity of the joints between the tubes and the shell. However, to dampen the flow induced vibration in the tubes, the tube side will remain filled when the shell side medium is flowing as during flushing and vice-versa.

12.0 Regarding instrumentation connections to piping, all welds and mechanical joints on pressure boundaries shall remain integral and leak tested jointly .

13.0 No working on pressurized system shall be permitted

14.0 Except the terminal points, it shall be ensured that all inline valves are in open condition.

15.0 Control valves and butterfly valves shall not be used as an isolation valve during the testing.

16.0 The vents and drains of the equipments, tanks and the portion of piping which are isolated during the hydro test shall be kept open to avoid their in advertent over pressurization.

17.0 The orifices, system RVs, rupture discs, flow element, filter element, solenoid valves, strainer element, etc. shall be removed before hydrostatic test.

18.0 Solenoid valves shall be installed only after hydrostatic test.

19.0 The closing joints made after system testing shall be examined as follows :

a) Closing joints of the systems having general examination level as level-1 / Level-2 / Level-3, shall be examined as per requirement of Level-1 joints.

b) Closing joints of the systems having general examination level as Level-4 / Level-5, shall be examined as per requirement of Level-3 joints.

Weld joints, mechanical joints, screwed joints, swageloc joints, etc. which could not see the system testing, shall be inspected for any leakage, during commissioning, at operating pressure and report shall be issued.

20.0 After testing, the system shall be normalized and made as per design drawings.

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APPENDIX – F

A) TORQUE VALUES FOR MACHINE BOLTS AND COLD ROLLED STEEL STUDS BOLTS

Load in Kgs. on Bolts and Stud Bolts when Torque loads are applied

Nominal Diameter of Bolt mm (inches)	Pitch mm (Threads per inch)	Diameter of Root of threaded mm	Area at Root of Thread mm	Stress Developed in the Bolt Material					
				*5.274 Kg/ mm^2		*10.549 Kg/ mm^2		*21.098 Kg/ mm^2	
				Torque Kg.M	Compression Kg.	Torque Kg.M	Compression Kg.	Torque Kg.M	Compression Kg.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
6 (1/4)	1.270 (20)	4.669	17.42	0.138	92.1	0.277	183.8	0.553	367.5
8 (5/16)	1.411 (18)	6.096	29.03	0.277	153.4	0.553	306.3	1.106	612.5
10 (3/8)	1.587 (16)	7.468	43.87	0.415	231.4	0.830	462.0	1.660	925.6
11 (7/16)	1.814 (14)	8.763	60.00	0.691	316.7	1.383	632.9	2.766	1205.9
12 (1/2)	1.954 (13)	10.160	81.29	1.106	428.8	2.074	857.5	4.149	1715.1
14 (9/16)	2.117 (12)	11.531	104.51	1.660	551.3	3.181	1102.5	6.223	2205.1
16 (5/8)	2.309 (11)	12.876	130.32	2.074	687.4	4.149	1374.8	8.298	2749.5
20 (3/4)	2.540 (10)	15.748	194.83	3.457	1027.7	6.915	2055.4	13.829	4110.7
22 (7/8)	2.822 (9)	18.567	270.32	5.532	1426.0	11.063	2851.6	22.127	5703.3
24 (1)	3.175 (8)	21.285	355.48	8.574	1875.2	17.010	3750.0	33.882	7500.0
27 (1 1/8)	3.628 (7)	23.851	447.09	13.553	2354.8	26.967	4709.6	53.935	9419.2
30 (1 1/4)	3.628 (7)	27.026	574.19	18.946	3028.6	37.754	6067.2	75.370	12114.3
33 (1 3/8)	4.233 (6)	29.413	680.00	25.308	3586.7	50.477	7173.3	100.95	14346.6
36 (1 1/2)	4.233 (6)	32.588	834.83	30.286	4403.4	60.434	8806.7	121.01	17613.4
42 (1 5/8)	4.618(5 1/2)	35.280	977.42	41.488	5155.6	82.976	10310.8	165.95	20621.6
45 (1 3/4))	5.080 (5)	37.846	1125.16	53.935	5934.7	107.18	11869.3	214.36	23738.7
48 (1 7/8)	5.080 (5)	41.021	1321.93	72.604	6972.8	145.21	13945.1	290.42	27890.2
50 (2)	5.644(4 ½)	43.459	1483.87	77.860	7826.7	155.58	15653.4	311.16	31306.7

* The stress values are around 60% of the yield stress of the material of the bolt used.

APPENDIX – F – Contd.....

DATA FOR USE WITH MACHINE BOLTS AND COLD ROLLED STEEL STUDS BOLTS

Load in Kgs. on Bolts and Stud Bolts when Torque loads are applied

Nominal Diameter of Bolt mm (inches)	Pitch mm (Threads per inch)	Diameter of Root of threaded mm	Area at Root of Thread mm	Stress Developed in the Bolt Material					
				*21.098 Kg/ mm^2		*31.647 Kg/ mm^2		*42.196 Kg/ mm^2	
				Torque Kg.M	Compression Kg.	Torque Kg.M	Compression Kg.	Torque Kg.M	Compression Kg.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
6 (1/4)	1.270 (20)	4.699	17.42	0.553	367.5	0.830	551.3	1.106	735.0
8 (5/16)	1.411 (18)	6.096	29.03	1.106	612.5	1.659	918.8	2.213	1225.0
10 (3/8)	1.587 (16)	7.468	43.87	1.659	925.6	2.489	1388.4	3.319	1851.2
11.1(7/16)	1.814 (14)	8.763	60.00	2.766	1265.9	4.149	1898.8	5.532	2531.8
12 (1/2)	1.954 (13)	10.160	81.29	4.149	1715.1	6.223	2572.6	8.298	3430.1
14 (9/16)	2.117 (12)	11.531	104.51	6.223	2205.1	9.404	3307.6	12.446	4410.2
16 (5/8)	2.309 (11)	12.878	130.32	8.298	2749.5	12.446	4124.3	16.595	5499.1
20 (3/4)	2.540 (10)	15.748	194.83	13.829	4110.7	20.744	6166.1	27.659	8221.4
22 (7/8)	2.822 (9)	18.567	270.32	22.127	5703.3	33.191	8554.9	44.254	11406.5
24 (1)	3.175 (8)	21.285	355.46	33.882	7500.0	50.892	11250.0	67.764	15000.0
27 (1 1/8)	3.175 (8)	24.460	469.67	49.094	9745.9	73.710	14863.9	98.189	19818.5
30 (1 1/4)	3.175 (8)	27.635	599.35	69.147	12645.2	103.72	18967.8	138.29	25290.4
33 (1 3/8)	3.175 (8)	30.810	745.16	94.040	15721.4	141.06	23582.1	188.08	31442.8
36 (1 1/2)	3.175 (8)	33.985	906.45	110.63	19124.3	165.95	28686.5	221.27	38248.6
42 (1 5/8)	3.175(8)	37.160	1083.87	152.12	22867.5	228.19	34301.3	304.25	45735.0
45 (1 ¾)	3.475 (8)	40.335	1277.42	207.44	26951.0	311.16	40426.5	414.88	53902.0
48 (1 7/8)	3.175 (8)	43.510	1486.45	276.59	31361.2	414.88	47041.7	553.18	62813.1
50 (2)	3.175 (8)	46.685	1710.96	304.25	36098.0	456.37	54147.0	608.49	72196.0
56 (2 ¼)	3.175 (8)	53.035.	2208.38	439.77	46592.6	659.66	69888.8	879.55	93185.1
64 (2 ½)	3.175 (8)	59.385	2769.02	608.49	58421.1	912.74	87631.6	1216.99	116842.1
72 (2 ¾)	3.175 (8)	65.735	3392.90	818.70	71583.5	1228.05	107375.2	1637.40	143167.0
76 (3)	3.175 (8)	72.085	4080.00	1067.63	86079.9	1601.44	129119.8	2135.26	172159.7

* The stress values are around 60% of the yield stress of the material of the bolt used.

APPENDIX – F – Contd.....

B) TORQUE VALUE FOR BOLTS OF PIPING SYSTEM FLANGE JOINTS USING SPIRAL WOUND GRAFOIL FILLED METALLIC GASKET

1) Pipe size range :- 15 NB to 600 NB

2) Flange :- 150 Class SORF as per ANSI B-16.5

3) Gasket :- Type – Spiral Wound Grafoil Filled Metallic Gasket, m = 2.5, y = 7.03 Kg-f/mm^2

4) Internal Test Pressure (P) :- 0.22 Kgs/mm^2(g)

5) Bolt Material :- SA 193 Gr. B-7 [Yield point 860 Mpa (86 Kgf/mm^2)]

1	2	3	4	5		6
Size of Flange Inch (mm)	ID of Gasket Inch	OD of Gasket Inch	No. of Bolts Nos.	Nominal Size of Bolts in mm x pitch		Torque of Bolt Kg-m
				Inch	Metric	
½" (15 NB)	0.84	1.88	4	½"	M-12 x 1.75	1.50
¾" (20 NB)	1.06	2.25	4	½"	M-12 x 1.75	2.2
1" (25 NB)	1.31	2.62	4	½"	M-12 x 1.75	3
1¼" (32 NB)	1.66	3.0	4	½"	M-12 x 1.75	4
1½" (40 NB)	1.91	3.38	4	½"	M-12 x 1.75	6
2" (50 NB)	2.38	4.12	4	5/8"	M-16 x 2	12
2½" (65 NB)	2.88	4.88	4	5/8"	M-16 x 2	14
3" (80 NB)	3.5	5.38	4	5/8"	M-16 x 2	17
3½" (90 NB)	4	6.38	8	5/8"	M-16 x 2	10
4" (100 NB)	4.5	6.88	8	5/8"	M-16 x 2	12
5" (125 NB)	5.56	7.75	8	¾"	M-20 x 2.5	17
6" (150 NB)	6.62	8.75	8	¾"	M-20 x 2.5	20
8" (200 NB)	8.62	11.0	8	¾"	M-20 x 2.5	26
10" (250 NB)	10.75	13.38	12	7/8"	M-20 x 2.5	22
12" (300 NB)	12.75	16.12	12	7/8"	M-20 x 2.5	27
14" (350 NB)	14.0	17.75	12	1"	M-24 x 3	36
16" (400 NB)	16.0	20.25	16	1"	M-24 x 3	33
18" (450 NB)	18.0	21.62	16	1 1/8"	M-24 x 3	38
20" (500 NB)	20.0	23.88	20	1 1/8"	M-24 x 3	34
24" (600 NB)	24.0	28.25	20	1 ¼ "	M-30 x 3.5	53

NOTES :

1) These values shall be used where torque values are not specifically indicated in the drawings / piping material specification.

2) For important equipment (heat exchangers, flange joints, etc.) the torque values shall be obtained from manufacturer drawing / designer.

3) Flanges shall meet the alignment requirements as specified in relevant piping specification.

APPENDIX – F – Contd.....

C) TYPICAL TORQUE VALUE OF EPDM (WITH PTFE FILM) GASKET FLANGED BOLTS OF PIPING SYSTEM

1) Pipe size range :- 15 NB to 250 NB
   Gasket :- Type –EPDM with PTFE film, Thickness = 1.5 mm
2) Pipe size range :- Above 350 NB
   Gasket :- Type – EPDM with PTFE film, Thickness = 3.18 mm
3) Flange :- 150 Class SORF as per ANSI B-16.5.
4) Internal Test Pressure (P) :- 0.20 Kgs/mm^2(g) (2.5 Kgs/cm^2(g)) max.

1	2	3	4	5		6
Size of Flange Inch (mm)	ID of Gasket Inch	OD of Gasket Inch	No. of Bolts Nos.	Nominal Size of Bolts in mm x pitch		Torque of Bolt Kg-m
				Inch	Metric	
½" (15 NB)	0.71	1.88	4	½"	M-12 x 1.75	0.25
¾" (20 NB)	0.87	2.25	4	½"	M-12 x 1.75	0.54
1" (25 NB)	1.18	2.62	4	½"	M-12 x 1.75	0.72
1¼" (32 NB)	1.46	3.0	4	½"	M-12 x 1.75	0.95
1½" (40 NB)	1.69	3.38	4	½"	M-12 x 1.75	1.21
2" (50 NB)	2.13	4.12	4	5/8"	M-16 x 2	2.15
2½" (65 NB)	2.72	4.88	4	5/8"	M-16 x 2	3.10
3" (80 NB)	3.15	5.38	4	5/8"	M-16 x 2	3.70
4" (100 NB)	4.05	6.88	8	5/8"	M-16 x 2	3.70
5" (125 NB)	5.00	7.75	8	¾"	M-20 x 2.5	5.10
6" (150 NB)	6.00	8.75	8	¾"	M-20 x 2.5	6.30
8" (200 NB)	7.80	11.0	8	¾"	M-20 x 2.5	9.80
10" (250 NB)	9.80	13.38	12	7/8"	M-20 x 2.5	11.1
12" (300 NB)	12.00	16.12	12	7/8"	M-20 x 2.5	16.2

NOTES :

1) These are indicative values. Actual values shall be as per gasket supplier's recommendation/ piping material specification.

2) For important equipment / heat exchangers, flange joints, etc. the torque values shall be obtained from the designer.

3) Flanges shall meet the alignment requirements as specified in relevant piping specification.

APPENDIX – F – Contd.....

D) TORQUE VALUES FOR EQUIPMENT FOUNDATION BOLTS

TABLE – 1

BOLTING MATERIAL : (1) IS-1367. CLASS-4.6. (2) IS:2062

UTS – 410 N/mm^2

S. No.	Nominal Major Dia. – D (mm)	Pitch (Coarse) P mm	Torque N.m
1	8	1.25	11
2	10	1.5	22
3	12	1.75	40
4	14	2.0	60
5	16	2.0	95
6	20	2.5	180
7	24	3.0	315
8	30	3.5	615
9	36	4.0	1100
10	42	4.5	1750
11	48	5.0	2600

TABLE – 2

BOLTING MATERIAL : ASTM-A-193. GRADE : B7

UTS – 860 N/mm^2

S. No.	Nominal Major Dia. – D (mm)	Pitch (Coarse) P mm	Torque N.m
1	5	0.8	5
2	6	1.0	9
3	8	1.25	23
4	10	1.5	45
5	12	1.75	80
6	14	2.0	125
7	16	2.0	195
8	20	2.5	375
9	24	3.0	655
10	30	3.5	1300

NOTE :

1. Above shall be used when the torque values are not indicated in original design / piping material specification.
2. These values are not applicable for bolts at floating end of the equipment / floating equipment.
3. Torquing shall be done sequentially. Release of preload due to torquing of near by bolts shall be checked.
4. Bolting material shall be free from burrs, dents and shall be in clean condition.
5. Nut shall move freely on the bolt.
6. There shall be no external loading / equipment load etc. in the bolts during tightening.
7. Calibrated torque wrenches shall be used.
8. For bolt sizes M-14 and below for IS:1367 Class 4.6, & for bolt sizes M-12 and below for ASTM-A-193 Gr. B-7 bolts, torque required is generally lower than that can be applied by hand tightening using standard spanner. Therefore, due care shall be taken during tightening of these bolts to avoid over tightening of the bolts.

APPENDIX:-G

Guidelines for Testing of Instrument Tubing Installations (Along with the Instruments)

1.0 **Scope**

These guidelines cover the requirements of air hold test, helium leak test and pneumatic/hydro test of instrument tubing of various systems, in Nuclear Power Plant, after erection by the contractor

2.0 **Categorization of tubing circuit**

2.1 Tubing with D_2O as medium and Critical H_2O, SG steam and Nitrogen Circuits

Under this category, impulse tubing (SS 304L) of various sub-systems of PHT and moderator, light water circuits of LZC and tubing of steam, feed water and nitrogen circuits are covered.

2.2 Tubing with helium as medium and AGMS

Under this category, impulse and purge tubing (SS 304L) of moderator cover gas, SDS#2 and tubing of AGMS are covered.

2.3 Tubing with instrument air as medium and CO_2 circuits other than AGMS & tubing of tritium in air monitoring system

Under this category, copper tubing from instrument air header manifolds to various instruments/equipment and signal/impulse tubing of various systems and SS 304L impulse tubing used in pneumatic systems and copper tubing of tritium in air monitoring system are covered.

2.4 Tubing with water as medium

Under this category, all common services systems with SS-304L impulse tubing and sampling tubing of tritium in water monitoring system are covered.

2.5 Tubing with oil as medium

Under this category, tubing of oil hydraulic systems are covered.

APPENDIX:-G :Contd.....

3.0 Pre-requisites

3.1 It is desirable that all the tubing covered in clause no. 2.1& 2.2 shall be tested along with their respective process piping circuits. The exceptions, if any shall be recorded in DCR.

(a) For the integrity (hydrostatic / pneumatic) test of these tubing circuits, all the instruments shall be checked for its pressure rating and if the test pressure exceeds the upper range limit of any instrument, the same shall be removed and tubing end shall be plugged.

(b) To ensure the testing integral with process piping, it is to be ensured that erection of instrumentation shall be completed along with the respective process piping circuit.

(c) These instrumentation shall be tested for integrity (hydrostatic / pneumatic) and helium tests as per the requirement given in Appendix- E of this specification for moderator, PHT and LZC systems.

[Whenever integrity (hydrostatic / pneumatic) test of tubing is not possible along with respective process piping, the same shall be arranged separately at test pressures requirement given in this specification. In this case the pressurizing point remains untested, which shall be checked for no external leakage at operating pressure].

(d) It is desirable that tubing covered under Clause 2.3 and 2.4, shall be tested along with the process piping as per respective process erection piping specification. When tested separately, tubing circuits under category 2.3 shall be tested at 1.15 times the design pressure (to be adjusted by PRV) or maximum available air header manifold pressure whichever is lower. The exceptions, if any shall be recorded in DCR.

(e) For the tubing of the oil hydraulic systems (under clause 2.5) hydro-test shall be carried out at the test pressure mentioned in the respective drawings. The exceptions, if any shall be recorded in DCR.

4.0 Testing Guidelines

4.1 When instrument tubings are tested in isolation to process piping, air hold test (which is carried out for determining the leak rate) cannot be carried out because of low volume and for such cases, only integrated test and leak test may be carried out & be recorded in DCR.

APPENDIX:-G :Contd.....

4.2 All the impulse/signal tubings which are required to be tested shall be marked in instrument schematic / PIS indicating test pressure, and wherever applicable the details of instrument isolation.

4.3 For the D_2O / Helium circuits and H_2O circuit of LZC. testing shall be carried out as per the requirement spelt out in this piping specification and site procedure, as issued by field engineering.

4.4 For tubing with air as medium, only pneumatic test is applicable. It is desirable that, the testing of these tubings shall be carried out along with the respective process piping, following respective erection specification of piping. The following steps shall be followed for the testing.

a) Instrument tubing and terminations shall be completed with check list signed by site QA, erection engineers.

b) Respective needle valves of air header manifold shall be opened to charge the instrument tubing with the test pressure.

c) After charging leak search shall be carried out by applying soap solution at all potential leak points i.e. at various joints, valve glands, etc.

d) Leakages found by above test, are to be arrested and leak search is to be carried out until leak tightness is ensured.

e) Steps (a) to (d) shall also be followed for the tubings tested separately.

f) After competition of the test, the soap solution should cleaned properly.

4.5 For sample tubing of tritium in air monitoring system the integrity test (pneumatic test) has to be carried out at maximum available air header manifold pressure. Following steps are to be followed.

a) Sample tubing termination shall be completed with check list signed by Site QA and Erection Engineer.

b) Respective isolation valves at sample take off point end and tritium in air mounting panel shall be closed.

c) Sample tube shall be pressurized with nearest charged air header manifold pressure from the test point of each sample tubing.

d) Leak search shall be carried out applying soap solutions at all potential leak points.

APPENDIX:-G :Contd.....

e) Leakages found during above tests have to be arrested and leak search has to be carried out until leak tightness is ensured.

4.6 For tubing with light water as medium pneumatic test is not required. It is desirable that the testing of these tubings shall be carried out along with the respective process piping.

a) Instrument tubing and terminations shall be completed with the checklist signed by site QA and erection engineers.

b) Root valves of the respective impulse tubing shall be closed and shall be pressurized (preferably from instrumentation side) at system hydrotest pressure with water, or by nitrogen cylinder.

c) Leak search is to be carried out at all potential leak points (i.e. joints, valve glands, etc.).

d) If any traces of water are found in any joints they are to be arrested and the testing is to be repeated till no leakages are observed.

e) Testing /Acceptance Criteria: Testing /Acceptance Criteria: Test pressure . holding time and acceptance criteria shall be same as per Appendix –E.

4.7 For tubing with the oil as medium, hydro test shall be carried out, for which following steps shall be followed.

a) All the tubings and terminations shall be completed with checklist signed by site and erection agency.

b) Oil hydraulic power pack shall be used for pressurizing at the test pressure.

c) Test pressure shall be held for about 10 minutes.

d) If pressure falls, leak search is to be carried out at all potential leak points.

e) Leakages are to be arrested and testing is to be repeated till no leakages are observed.

g) Testing /Acceptance Criteria: Test pressure, holding time and acceptance criteria shall be same as per Appendix –E.

APPENDIX:-G :Contd.....

4.8 Certain instrumentation installations i.e. instruments directly mounted on root valves and instrument installations where it is not feasible to carry out the integrity test are to be referred to NPCIL.

5.0 Test Report

A test report in the given format shall be generated after performing the test as per guidelines which shall be jointly signed by Erection, QA, and FE groups.

PNEUMATIC / HYDROSTATIC TEST REPORT

1.	INSTRUMENTATION AND CONTROL LOOP NO. AND TEST SCHEME	:	_____
2.	DRAWING NO.	:	_____
3.	JOINT NOS./WIR NO./SIR NO. ETC.	:	_____
4.	TERMINAL POINTS WITH BLANKING DETAILS	:	_____
5.	SAFETY RELIEF VALVE	:	_____
	a) No.(S) : _____, (b) LOCATION : _____		(c) SET PRESSURE __ $KG/CM^2_{(g)}$
6.	TEST MEDIUM	:	_____
7.	SPECIFIED TEST PRESSURE	:	_____
8.	RELEASE FOR TESTING	:	
	ERECTION ENGR.		FE ENGR.
9.	PREVIOUS TEST REPORTS (IF ANY)	:	_____
10.	INSPECTION RECORDS VERIFIED NPC(QA)	:	_____
11.	PRESSURE GAUGE (a) SR. NO. _____, (b) RANGE _____, (c) LEAST COUNT ____, (d) CALIBRATION DETAILS _____		
12.	PRELIMINARY GROSS AIR LEAK TEST PRESSURE	:	_____ KG/CM^2
13.	TEST PRESSURE OBSERVED : _____ KG/CM^2, MAINTAINED FOR _____ (TIME)		
14.	PRESSURE DROP : OBSERVED : _____ KG/CM^2 IN _____ HRS.		
15.	TEST RESULT (DETAILS OF LEAKAGE FOUND IN EACH TEST)	:	_____

APPENDIX:-G

16.	NO. OF TIMES SYSTEM WAS SUBJECTED TO FULL PRESSURE	:	
17.	REMARKS	:	
18.	TEST CONDUCTED BY	:	(CONTRACTOR)
19.	TEST WITNESSED BY	:	(Erection Engineer) (NPC-QA)
20.	TEST EVALUATION/ACCEPTANCE STATUS	:	

(CONTRACTOR) NPCIL (ERECTION ENGR.) NPCIL (QA ENGR.)

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13-9-11 PC-P-345

NUCLEAR POWER CORPORATION OF INDIA LTD.
(A Government of India Enterprise)

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TECHNICAL SPECIFICATION

FOR

CLEANING METHODS OF PIPING

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Name Signature Date

(For Revisions see Revision Control Sheet)

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DOCUMENT TYPE: TECHNICAL SPECIFICATION

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CLEANING METHODS FOR PIPING

REV. NO. & DATE	DESCRIPTION OF REVISION	PREPARED BY	CHECKED BY	REVIEWED BY	APPROVED BY

1.0 SCOPE

1.1 This specification describes cleaning methods which shall be used for cleaning of pipes, fittings and small components during the construction of the forthcoming NPP's (PHWRs). The extent and methods of cleaning concerning all systems of the Project are tabulated in Appendix – A.

2.0 CONTENT

The specification requirements are presented under the following headings:

		Section
Scope	:	1.0
Contents	:	2.0
Pickling	:	3.0
Metal Brush and Compressed Air	:	4.0
Detergent washing of CS/LAS/SS pipe & fittings	:	5.0
Cleaning of Special Components, Valves and Flanges	:	6.0
Degalvanization of G.I. Pipe Ends	:	7.0
Cleanliness in Work Areas	:	8.0
Halide and Sulphur Contamination	:	9.0
Appendices		
Extent and Methods of Cleaning	:	APPENDIX-A
Blind Flanges and Caps	:	APPENDIX-B
Guide to Pickling of Carbon Steel	:	APPENDIX-C
Degalvanization of G.I. Pipe Ends	:	APPENDIX-D
Check for Chloride and Iron contamination	:	APPENDIX-E

3.0 PICKLING

The purpose of pickling carbon steel / alloy steel pipes and fittings is to remove mill scale from the surface of the components. Abrasive blasting is an acceptable alternative method for removing the scale on large diameter pipes such as steam lines but shall not be used on components of the Primary Heat Transport System because subsequent removal of abrasive particles could be a problem.

Materials supplied in pickled condition need not be re-pickled by the Contractor at site. Appendix – A indicates the extent of pickling for system components prior to installation and the condition in which these systems components will be

the supplier of pickled components or have failed to prevent rusting, these components are to be cleaned by quick acid wash or by passing a wire brush followed by sustained blast of oil free compressed air.

The pickling procedure shall be submitted for the approval of the Engineer-in-Charge and shall be completed with respect to the equipment, acid concentration, temperature, inhibitors and quality control to prevent over-pickling etc. in accordance to the guide to pickling procedure given in Appendix – C.

When pickled pipes / fittings are supplied with protective coating, the coating shall be removed completely using suitable approved solvents. In case kerosene is used for the purpose, adequate fire protection measures shall be taken and cleaned pipes / fittings shall be detergent washed. So that any residual kerosene is fully removed.

4.0 METAL BRUSH AND COMPRESSED AIR

Metal brush cleaning shall be done on all carbon steel materials, stated in Appendix – A and also in case described here under:

Power driven brushes will be satisfactory for the type of cleaning intended and shall be suitable to take the attachment of different sizes of metal brushes and be driven by flexible shafts where ever necessary. Oversize brushes (i.e. I.D. of pipe +6 mm to 12 mm) shall be either carbon steel or stainless steel. Manual cleaning is also acceptable if approved by the Engineer-in-Charge. The cleaning operation shall consist of passing a rotary brush through the pipe followed by a blast of compressed air and repeating the same if required. The purpose is to remove any loosely adhering matter.

In the event that loosely adhering matter has to be removed from stainless steel materials, nylon brushes shall be used in order not to destroy the passivated surface.

The compressed air shall be oil free whenever subsequent washing operation is not specified. When washing with detergent follows metal brush cleaning, oil free compressed air is still preferable.

Fittings and large diameter pipes will be cleaned with hand brush.

Bodies of strainers shall be cleaned in the same way as fittings/ by rotary power brush.

Carbon steel fittings as supplied are frequently painted with protective coatings which shall be removed prior to installation. This coating can be removed by dipping them in caustic soda solution or by suitable means as approved by Engineer-in-Charge followed by adequate water rinse. It should be noted that initial brush cleaning shall be done on all carbon steel pipes and fittings as stated in Appendix-A irrespective of whether or not loose material is evident on visual inspection.

in Appendix-A irrespective of whether or not loose material is evident on visual inspection.

Galvanized and copper pipes and fittings if properly stored should not require any cleaning. However if storage or handling resulted in contamination, the Engineer-in-Charge will decide on suitable cleaning depending on the nature of the contamination. In any case all the pipes and fittings should be cleaned by oil free compressed air prior to fabrication and installation.

All pipes and fittings being assembled for pre-fabrication and or installation shall be in clean conditions as specified. In addition, at fabrication stage sub-assemblies shall be cleaned of weld spatter, slag, oxide films (such as occurring in brazing) and any other foreign matter.

Just prior to field erection of fabricated sub-assembly, its inside surface shall be subjected to wire brushing and oil free compressed air cleaning.

In cases where the carbon steel / alloy steel pipes are rusted / pitted, the metal brush cleaning may not be sufficient, in such cases the pipes shall be cleaned by pickling additionally with the concurrence of Engineer-in-charge.

PVC / CPVC pipes may be cleaned by using nylon brush followed by flushing with compressed air. Subsequently, the pipe & pipe fittings shall be washed / rinsed in water and dried.

5.0 DETERGENT WASHING OF CS/LAS/ SS PIPE & FITTINGS

The purpose of washing the pipes and fittings with detergent is to remove dirt grease, foreign matter and halides contamination and the extent of requirement is tabulated in Appendix-A. DM water rinse is mandatory on all systems containing heavy water or cover gas and for other systems clear, filtered water can be used.

The following equipment accessories will be required for washing operations:

a) **Enclosure and handling equipments**

This shall be adequate to accommodate all cleaning equipment. It shall be properly illuminated, be equipped with drainage facilities, and must be of the type which when closed would protect the equipment being cleaned from dust in the atmosphere. Handling facilities, monorails or other shall be as required.

b) **Tanks**

At least four tanks will be required as follows:

Wash tank for carbon steel materials

Wash tank for stainless steel materials

Each wash tank to have its corresponding rinse tank

Adequate working area must be available around each tank, and the tanks shall be suitably designed.

Minimum inside dimensions of the tanks shall be 7.8 to 9 meter long, 1 meter deep and 1.4 meter wide. Tanks for washing carbon steel can be of carbon steel material but tanks for washing stainless steel must have at least lining of stainless steel. The design of tanks shall be subjected to approval of Engineer-in-Charge.

c) **Heaters**

All tanks shall be equipped with heaters capable to maintain the temperature as required for detergent wash. The water in the rinse tanks shall be in continuous overflow or with feed and bleed, system the set rate of which will depend upon size of the equipment.

d) **Brushes**

Nylon brushes shall be used to ensure adequate cleaning of the surfaces and to speed up the cleaning operations. Flat brushes can be used on the flat surfaces or on the small components, circular brushes mounted on the rod shall be used for scrubbing inner surface of pipes. Similarly as in the case of metal brush cleaning described in Section 4, a slightly over size brush shall be used for a particular pipe diameter. Brushes will be classified in sets, all are to be suitably tagged to provide instant identification with respect to pipe / fitting material being used i.e. carbon steel, stainless steel, copper, etc. They shall be continuously in good condition and shall be examined before during and after the cleaning operations. Brushes showing any signs of disintegration shall be replaced. If any damage is noticed, the disintegrated part/s of the brush shall be removed from the pipe.

e) **Detergent**

Any suitable detergent complying with the following specifications can be used.

1) 25 ppm maximum free halogen expressed as Chlorine in solution at strength for use.

2) 25 ppm maximum sulphur in solution at strength for use.

However, selected detergent shall be submitted for the approval of the Engineer-in-Charge as follows:

I) The supplier of the selected detergent must clearly indicate in writing the Halogen and sulphur contents of his product and that it is free of any other contamination and does not contain secret additives and is exactly that represented by its chemical formula.

II) Subject to satisfactory certification by the supplier, the Engineer-in-Charge may request a sample of each batch of the detergent for chemical examination. The approval, if granted shall be restricted to this batch.

f) **De-mineralized Water**

Filters and Ion exchange equipment shall be supplied & erected for the production of clean de-mineralized water. The DM water shall be piped to the cleaning area in plastic, stainless steel, or aluminium piping. This pipe shall feed the tanks as and when required. A spare connection shall be provided for rinsing purposes.

De-mineralized water shall comply with the following specifications.

1) Specific resistance – Min. 500,000 ohms-cm.

2) pH value shall be between 6.5 to 8.

3) The suspended solids in the treated water shall be less than 0.2 ppm when retained on a +0.45 micron filter.

g) **Oil Free Compressed Air**

A compressor having graphite or Teflon ring, receiver, separator, dryer, filter etc. shall be supplied for the production of oil free compressed air. The air pipe to the cleaning area shall be plastic, aluminum, stainless steel or galvanized iron materials.

h) **Washing**

The preparation of washing solutions as regards concentration and temperature will be as recommended by the Supplier of the detergent and there will be no addition of any other chemical or ingredients.

An item to be washed shall be immersed in the solution, allowed to soak in the solution for 5 – 10 minutes, then its surfaces shall be brushed inch by inch. When lifted from the solution the item will be allowed to be completely drained. It will then be retained in a position, just on the outside of the wash tank where it will be adequately rinsed with de-mineralized water.

Subsequently, the item will be placed to soak in the rinse tank in which de-mineralized water is continuously overflowing. When lifted from the rinse

tank it shall receive from the hose a final rinse with excessive amount of de-mineralized water. It will then be allowed to drain and will be dried with oil free compressed air.

When inspected and approved, the open ends will be closed with the protective devices of the type shown in Appendix – B before the item leaves the washing area. NPCIL, QS shall be available at all time in the area when cleaning operations are in progress.

Any piece of equipment, pipe or fitting shall not be moved into the installation area without prior approval from the NPCIL, QS that a particular item has passed cleanliness inspection and is adequately protected from further contamination.

The "metal brushing" and "washing" operations should not develop into voluminous production for stock piling reasons and must be planned as required. Detergent and de-mineralized water bath shall be drained and fresh bath shall be prepared when they fail to do the cleaning function intended or the bath are dirty / have been kept for a long duration as and when directed by Engineer-in-Charge. The Contractor is responsible for final cleaning of the installed system prior to handing over to Engineer-in-Charge. The internal surfaces shall be cleaned with oil free compressed air and the external surfaces shall be cleaned of any dirt, paint marks, etc by thorough mopping with de-mineralized water.

i) **Blind Flanges and Caps**

Upon completion of cleaning operation, blind flanges or caps shall be installed on pipes or equipment approved specimens of these are shown in Appendix–B

6.0 CLEANING OF SPECIAL COMPONENTS, VALVES AND FLANGES

Special Components, Valves and Flanges will require cleaning by solvent or detergent wash including in presence of protective coating / compound, grease which is normally applied for transit protection purposes. Any solvent used and the procedure for such pre-cleaning shall be approved by the Engineer-in-Charge. This pre-cleaning shall be followed by adequate rinse with water except for the system containing heavy water or cover gas where washing with detergent followed by de-mineralized water rinse is mandatory. All these items after washing shall be dried by oil free compressed air.

All flanges and other machined surfaces shall not be brushed on gasket seat / sealing faces.

Suitable Ultra Sound cleaning methods may be employed with the concurrence of Engineer–in- charge.

7.0 DEGALVANIZING OF G.I. PIPE ENDS

Where Removal of Zinc coating from G.I. Pipe ends is required (e.g. for welding of G.I. pipes) the procedure for de-galvanizing which is to be adopted is described in Appendix – D of this specification.

8.0 CLEANING IN WORK AREA

All areas of installations shall be kept dust the free condition and the dust removal will be done by means of vacuum cleaners and wet mops. The cleaning operations may create dusty conditions / atmosphere in a particular area. The contractor shall identify such areas in advance and coordinate to take appropriate actions. For the duration of such operations pipe fitting shall not be permitted in that area. All installed piping and equipment shall be regularly cleaned by means of vacuum cleaner and wet mopping so as to be free of dust. The equipment and pipe lines (whether washed or cleaned by other methods) shall be closed at all times with the devices of the type shown in Appendix – B except during the actual performance of the work on the joint in question.

9.0 PREVENTION OF WET SURFACE PERIODS

All the materials/equipment taken-up for cleaning shall be processed in expeditious manner and at no stage these components be subjected to idle periods with wet surface.

10.0 HALIDE AND SULPHUR CONTAMINATION

The contamination of austenitic stainless steel, zirconium and high nickel alloys with halides and sulphur may affect their corrosion resistance and mechanical properties. Therefore, the specification as a rule prohibits the use of solvents, cleaning agents tapes, paints etc. containing free halides and sulphur in any other piping / equipment of the project. This is required to eliminate the possibility of their inadvertent use on stainless steel, zirconium and high nickel materials or materials which may come in contact with them.

Further more, where approved tapes/soap solution/lubricants are used for testing etc. in the project, these along with residue must be completely removed by washing because of possibility of breakdown of residue under radiation and formation of organic acids.

11.0 IRON AND CHLORIDE CONTAMINATION ON S.S. MATERIAL

All piping inside Calandria Vault shall be checked for these Contaminations. SS pipes to be used outside the vault for moderator and other system will be checked for these Contaminations on sample basis as and when asked by the Engineer-in-Charge. Contamination test may be carried out as per Appendix-E or any other suitable methods approved by the Engineer-in-Charge.

APPENDIX – A

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
OPRD PIPINGS	31280	SS	HELIUM	NA	A	
REACTIVITY DEVICES	32700	SS	D_2O/HELIUM	NA	A	
PROCESS SYSTEMS	39000	SS	H_2O/HELIUM	NA	A	
MODERATOR SYSTEM	32000	SS	D_2O/HELIUM	NA	A	
	32110	SS	D_2O/HELIUM	NA	A	
	32210	SS	D_2O/HELIUM	NA	A	
	32310	SS	HELIUM	NA	A	
	32400	SS	D_2O/HELIUM	NA	A	
	32510	SS	D_2O/HELIUM	NA	A	
	34510	SS	D_2O	NA	A	
	34520	SS	D_2O/HELIUM	NA	A	
	34540	SS	D_2O/HELIUM	NA	A	
	34810	SS	D_2O	NA	A	
	34910	SS	D_2O	NA	A	
	34920	SS CS	D_2O	NA A	A NA	
	34940	SS	D_2O	NA	A	
	34960	SS	D_2O/HELIUM	NA	A	
	34980	SS	D_2O/AIR	NA	A	
	34990	SS CS	D_2O/AIR	NA A	A NA	
D2O UPGRADING PLANT	34930	SS CS	D_2O	NA A	A NA	
PRIMARY HEAT TRANSPORT SYSTEM	33110	CS	D_2O	A	NA	
	33116	CS	D_2O	A	NA	SURFACE OF SS MATERIAL & FEEDER PIPES & FITTINGS UNDER 33116 TO BE WASHED
	33210	CS	D_2O	A	NA	
	33230	CS SS	D_2O	A NA	NA A	
	33310	CS	D_2O	A	NA	

APPENDIX – A - CONTD...

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
PRIMARY HEAT TRANSPORT SYSTEM - CONTD...	33320	CS SS	D_2O	A NA	NA A	
	33330	SS	D_2O	NA	A	
	33340	CS SS	D_2O/AIR	A NA	NA A	
	33350	CS SS	D_2O/H_2O	A NA	NA A	
	33360	CS SS	D_2O/H_2O	A NA	NA A	
	33370	CS SS	D_2O	A NA	NA A	
	33410	CS	D_2O	A	NA	
	33510	SS	N_2/H_2	NA	A	
	33610	CS SS	D_2O	A NA	NA A	
	33710	SS	D_2O	NA	A	
	33720	CS SS	D_2O	A NA	NA A	
	33820	SS	D_2O/H_2O	NA	A	
	33830	SS	D_2O/AIR	NA	A	
	33840	SS	D_2O/H_2O	NA	A	
	34330	SS	D_2O/H_2O	NA	A	
	36110	CS	H_2O	A	NA	
	36710	CS	H_2O	A	NA	
	36730	CS	H_2O	A	NA	
	36600	SS	H_2O	NA	A	
REACTOR AUXILIARY SYSTEM	34110	CS SS	DM WATER	A NA	NA A	
	34160	SS	DM WATER	NA	A	
	34200	CS SS	DM WATER	A NA	NA A	
	71810	CS SS	H_2O	A NA	NA A	
	34410	SS	DM WATER	NA	A	
	34710	SS	CO_2	NA	A	
	71310	CS	DM WATER	A	NA	
	71720	CS SS	D_2O/H_2O	A NA	NA A	
	73120	SS	D_2O	NA	A	

APPENDIX – A - CONTD...

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
SECONDARY SYSTEM	36110	CS SS	STEAM	A NA	NA A	
	36120	CS	STEAM	A	NA	
	36310	CS/LAS SS	H_2O	A NA	NA A	
	36510	CS	H_2O	A	NA	
	36600	CS	STEAM/ H_2O	A	NA	
	41120	CS	H_2O	A	NA	
	41130	CS	H_2O	A	NA	
	43110	CS/LAS	STEAM	A	NA	
	43130	CS/LAS	H_2O	A	NA	
	43140	CS/LAS	STEAM	A	NA	
	43210	CS/LAS	H_2O	A	NA	
	43310	CS/LAS	H_2O	A	NA	
	45110	SS	STEAM/ H_2O	NA	A	
	45210	CS/LAS SS	H_2O	A NA	NA A	
COMMON SERVICE INSIDE REACTOR BUILDING AND RAB	71120	CS	H_2O	NA	NA	Brush &Air cleaning
	71130	CPVC /PVC	H_2O	NA	NA	-DO-
	71200	CS	H_2O	NA	NA	-DO-
	71350	CS	DM WATER	NA	NA	-DO-
	71400	CS	H_2O	NA	NA	-DO-
	71710	CS	H_2O	NA	NA	-DO-
	71850	CS	H_2O	NA	NA	-DO-
	71500	CS	H_2O	NA	NA	-DO-
	71600	SS	DM WATER	NA	NA	-DO-
	71900	CS	H_2O	NA	NA	-DO-
	75100 75110 75120	CS SS	AIR	A NA	NA A	
	75130	SS	AIR	NA	A	
DG FUEL OIL SYSTEM	53530	CS	DG FUEL OIL	A	NA	

APPENDIX – A - CONTD...

EXTENT AND METHOD OF CLEANING

SYSTEM	USI NO.	MATE-RIAL	SYSTEM FLUID	PICKLING	WASHING WITH DETERGENT	REMARKS
FUEL HANDLING PROCESS SYSTEM	35216	SS	D_2O/H_2O/ OIL/ AIR	NA	A	
	35217	SS	-DO-	NA	A	
	35218	SS	-DO-	NA	A	
	35226	SS	-DO-	NA	A	
	35227	SS	-DO-	NA	A	
	35228	SS	-DO-	NA	A	
	35234	SS	-DO-	NA	A	
	62136	SS	-DO-	NA	A	
	62137	SS	-DO-	NA	A	
WASTE MANAGEME NT SYSTEM	79210	CS	H_2O	A	NA	
	79210	SS	H_2O	NA	A	
	79220	CS	H_2O	A	NA	
	79220	SS	D_2O/H_2O/ Resins	NA	A	

NOTES :

1) CS : Carbon Steel
   PVC : Polyvinylchloride
   CPVC : Chlorinated Polyvinylchloride
   GI : Galvanized Iron
   SS : Stainless Steel
   DM : De-mineralized
   LAS : Low Alloy Steel
   A : Applicable
   NA : Not applicable

2) If the entire process of pickling is completed by adequate rinse with DM water, further washing with detergent is not required.

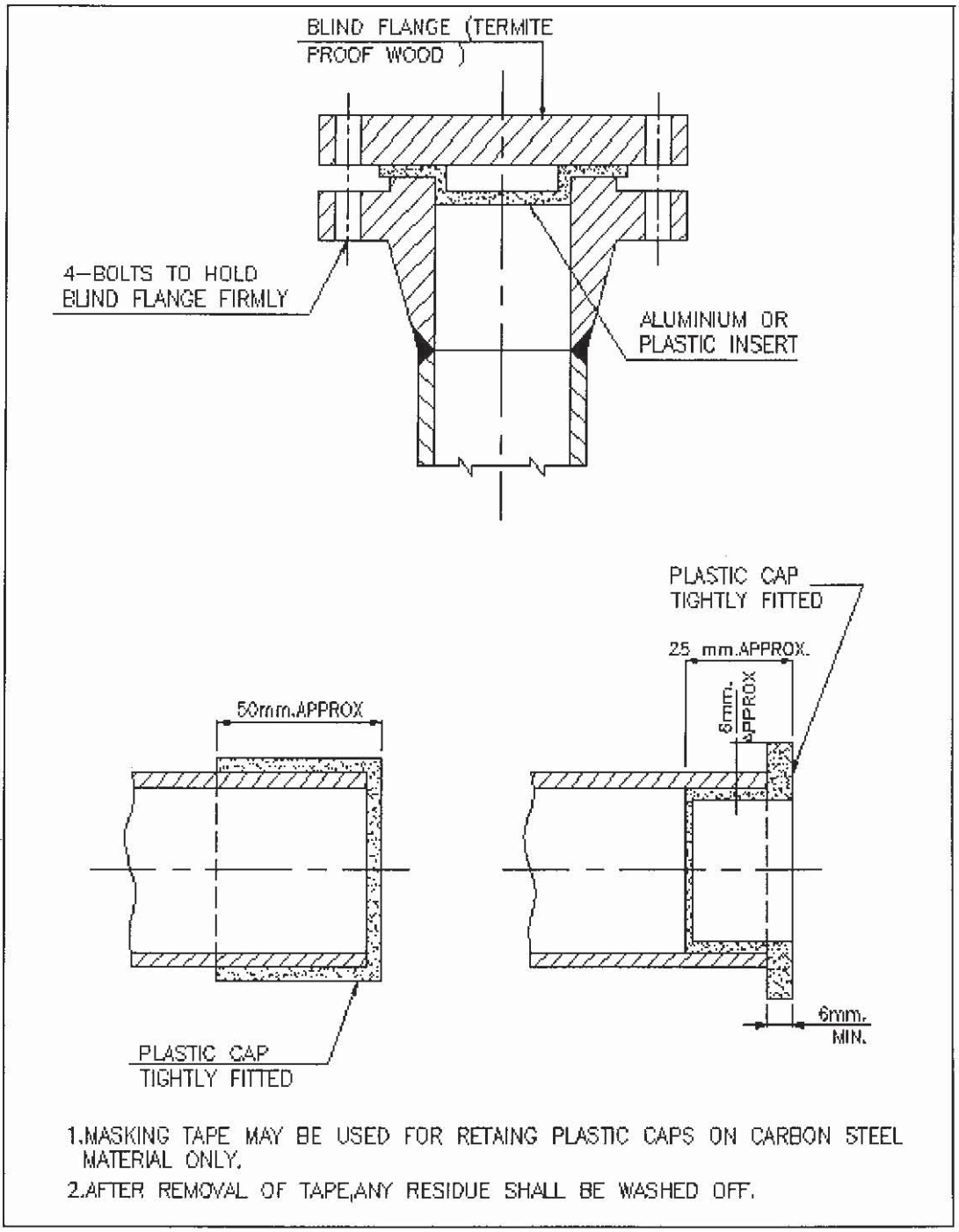
3) Feeder pipe and fittings under USI 33116 are bought in pickled condition. Normal degreasing method indicated at para 5 is considered adequate. However, depending on the surface condition, degreasing using step 1 to 4 and 10 of Appendix-C at the discretion of the Engineer-in-Charge will be used.

4) All CS Pipes and Fittings except as mentioned in (3) are bought in un-pickled condition.

5) For cleaning of GI and Copper materials refer para 4 of this specification.

6) In any case all the pipes and fittings should be cleaned by oil free compressed air prior to fabrication and installation.

APPENDIX – B : BLIND FLANGE AND CAPS



APPENDIX – C

GUIDE TO PICKLING OF CARBON STEEL PIPES

Pickling of Carbon Steel Pipes will be done in water solution of H_2SO_4. The concentration of acid will be approximately 15% by weight of H_2SO_4 and 0.1% inhibitor Corobit 1001. With the temperature of pickling at 50^0C to 55^0C by means of electric heaters, and depending on surface conditions of the pipe, the removal of mill scale should be achieved within 10 to 15 minutes. Brushing or air agitation will assist the process. When concentration of solids, i.e. iron sulphate in the pickling bath is excessive (i.e. approx. 12 to 15%) the solution will be changed. The pickling will follow the steps outlined:

1) Select batches of pipes with similar surface conditions, i.e. mill scale or rust.

2) Brush pipes to remove loosely adhering scale or dirt.

3) Degrease and clean in a bath of cold solution of 8% Caustic soda. Depending on contamination, the soaking time will be 5 to 10 minutes assisted by brushing or air agitation. Acid, NaOH and D.M. Water rinsing baths shall be changed when they fail to degrease / pickle / neutralize / rinse effectively as and when directed by Engineer-in-Charge.

4) Rinse with water and allow to drain.

5) Pickle in approx. 15% H_2SO_4 plus 0.1% of Corobit 1001 at 50^0C to 55^0C

6) The bath shall be changed when iron concentration in the bath reaches to13% by weight.

7) After pickling, place pipes in a tank with water and brush the pipes to remove any loosely adhering matter.

8) Rinse with fresh water from a hose and transfer into neutralizing tank.

9) Neutralize with 2% Caustic Solution. Pipes are to be soaked for 5 to 10 minutes in this solution which is to be agitated with compressed air.

10) Remove from neutralizing bath and rinse adequately with water. DM water should be used for rinsing pipes for D_2O and cover gas system.

11) Litmus paper shall be used to check for complete removal of acid / alkali.

12) Allow to drain, dry with oil free compressed air and cap it as required.

APPENDIX – C - CONTD...

GUIDE TO PICKLING OF CARBON STEEL PIPES

13) The bright shined surface shall indicate the appropriateness of the pickling process employed. The surface should not appear dull/ rough which is indicative of under pickling /over pickling respectively .

14) After cleaning, the overall thickness of pipe (in finally installed condition) shall not be less than permitted by applicable standard for pipes i.e. 90% of nominal wall thickness welded pipes (as per IS 1239) and 87.5% nominal wall thickness for seamless pipes.

The following laboratory checks shall be made:

a) Acid Concentration
b) Iron Sulphate concentration
c) Percentage loss of weight of a pipe sample for each batch.

NOTES:

i) The pickling procedure shall be subject to the approval of the Engineer-in-Charge before the pickling operation.

ii) Piping sub-assembly shall be pickled at such a stage that its interior is completely accessible for brushing and inspection.

iii) The Contractor shall provide all necessary tanks, electric heater and chemicals for the above cleaning.

APPENDIX – D

DEGALVANIZING OF GI PIPE ENDS

The pickling of GI pipe ends will be done in water solution of H_2SO_4. The concentration of acid should be approx. 8% by weight of H_2SO_4, and 0.10% of inhibitor Corobit 1001. The ends of pipes (recommended length from where zinc is to be removed for welding = 80 mm) shall be dipped in the acid bath for about 45-50 minutes or for just sufficient time to remove the zinc coating. The level of the acid shall be maintained in such a way that removal of coating takes place on required length of pipe from ends. Clearance shall be keep so as to maintain the same chemical conditions for outside and inside surface of the pipes.

The pipes being de-galvanized should be held vertically throughout the operation so as to avoid non-uniformity of the surface and attach of acid / NaOH on the area which is not be de-galvanized.

After de-galvanizing the ends of the pipes shall be adequately rinsed in clean over flowing water. After washing the pipe ends, they shall be dipped in neutralizing bath containing 2%. NaOH for enough time (recommended time 5 – 10 minutes). After neutralizing the pipe ends shall be adequately rinsed in clean over flowing water, followed by draining, drying with oil free compressed air and proper capping. Litmus paper shall be used to check for the complete removal of acid / NaOH. After washing, the ends shall be dried by blast of air which shall be followed by proper capping.

Tests :

The following tests shall be made after getting the approval of test procedure from Engineer-in-Charge :

1) Acid Concentration

2) NaOH concentration

3) The difference in pipe thickness before and after pickling.

APPENDIX – D - CONTD...

DEGALVANIZING OF GI PIPE ENDS

NOTES :

1) After cleaning, overall thickness of pipe (in finally installed condition) shall not be less than permitted by applicable standard for pipes i.e. 90% of nominal wall thickness for welded pipes (as per IS 1239) and 87.5% nominal wall thickness for seamless pipes.

2) The de-galvanizing procedure shall be subject to the approval of the Engineer-in-Charge before the de-galvanizing operation.

3) Acid and NaOH baths shall be changed everyday or when they fail to remove the zinc coating and complete neutralization respectively, which ever is earlier. Acid bath should be completely neutralized before draining.

4) All the pipes shall be visually inspected after de-galvanization and cleared by Engineer-in-Charge. Some of the de-galvanized pipes will be checked by using $CuSO_4$ solution for complete removal of Zinc.

5) Line numbers shall be marked on all the pipes before de-galvanizing.

APPENDIX – E

CHECK FOR CHLORIDE CONTAMINATION

The Spot-check for Chloride Contamination of SS surfaces shall consist of

1) Dropping 5 ml of 10% HNO_3 into a clean surgical swab.

2) Scouring a 100 cm^2 area of the surface to be tested with the acid-laden swab.

3) Reabsorbing the free liquid with the swab and dropping it into a glass test tube containing 5 ml. of de-mineralized water.

4) Preparing a control specimen – a clean acid laden swab dropped into a 5 ml. of de-mineralized water as per (3) above.

5) Picking out each swab and draining it back into its test tube.

6) Adding two drop of 1N $AgNO_3$ solution to each test tube.

7) Comparing the turbidity of the spot-check test solution with that of the control sample solution.

If the turbidity of the spot-check test solution visibly exceeds that of the control solution, the surface shall be deemed contaminated. In such event the surrounding contaminated areas shall be checked to establish the extent of the contaminated areas. These shall be cleaned by repeated swabbing with 10% HNO_3 and rinsing with warm demineralised water and re-checked to ensure effective removal of contamination.

APPENDIX – E - CONTD...

CHECK FOR CHLORIDE CONTAMINATION

Note :

Care shall be taken to prevent spurious indications through prior contamination of test tube, solutions and swabs. These shall be handled with rubber gloves and/or suitable tweezers.

CHECK FOR IRON CONTAMINATION

The check for this shall consist of

1) The surface to be inspected shall be Scoured with clean surgical swab using $CuSO_4$ solution (4g $CuSO_4$, 1 ml H_2SO_4, sp Gr 1.84) in 250 ml DM water.

2) The surface shall be kept wet with solution for 6 minutes min.

3) The surface shall be rinsed and dried.
4) Any copper deposit on the surface shall indicate presence of free iron and deemed to be contaminated.
5) In such event the surrounding areas shall be checked to establish the extent of contaminated areas.

6) The affected area should be cleaned by repeated swabbing with 10% HNO_3 solution and rinsing with warm de-mineralized water. In case the iron particles are found to be deeply embedded, the surface may be ground. In such case care shall be taken for the minimum thickness of the pipe.

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GHAVP-1&2/40000/PROCUREMENT SPECIFICATION/MS-1

REVISION No. – R0, AUGUST-2018

VOLUME-II –
Section-C
PART-2

C-2: SPECIFIC TECHNICAL REQUIREMENTS

C-2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

NUCLEAR POWER CORPORATION OF INDIA LIMITED

(A Government of India Enterprises)

PROCUREMENT SPECIFICATION NUMBER : GHAVP- 1&2/40000/ PROCUREMENT SPECIFICATION/ MS-1
PROCUREMENT SPECIFICATION
FOR
TURBINE ISLAND PACKAGE

SECTION C -2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

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REVISION CONTROL SHEET

PROCUREMENT SPECIFICATION NUMBER : GHAVP- 1&2/40000/ PROCUREMENT SPECIFICATION/ MS-1

PROCUREMENT SPECIFICATION FOR TURBINE ISLAND

SECTION C -2-1: SPECIFIC TECHNICAL REQUIREMENTS OF CIVIL STRUCTURES

REV. NO. / DATE	DESCRIPTION	PREPARED BY	CHECKED BY	REVIEWED BY	APPROVED BY

1. GENERAL

1.0.1 PROJECT

The proposed project of GHAVP-1&2 consists of two units of 700 MWe PHWR type Nuclear Reactors.

1.0.2 LOCATION

The site is situated on the left bank of the Fatehabad Branch of Bhakra canal, near running distance (RD) of 48159 m (158000 ft.), in Fatehabad District of Haryana State. The nearest village to the site is Gorakhpur.

1.0.3 ACCESSIBILITY

Chandigarh, the State capital is about 218 km away from the site by road. The site can be accessed by following ways:

By Road

National Highway No. 10 passes about 6 km away from site. The project site can be approached from NH-10 by turning-off at village Kharakheri, via. the Kharakheri-Gorakhpur road. From Delhi the road to site via NH-10 passes through Rohtak, Hansi and Hisar. The entire route from Delhi to Hissar and further upto Kharakheri is a black-topped national highway.

By Rail

The nearest rail head is Adampur at a distance of 22 km south-western of the site. Adampur station is on the Hisar-Sirsa Borad-Gauge section of Northern Railway. Jakhal Junction is located on the Delhi-Bhatinda sections of the Northern Railway. The road from Adampur station to the site is a good road. Narwana or Jakhal junction / railway station can be used by personnel coming from places like Mumbai, by train.

By Air

The nearest major airport is at Delhi (about 208 kms from project site).

1.1 GEOLOGY OF THE SITE

The site area lies on the western part of Indogangetic alluvial plain on the Punjab side, adjoining the Rajasthan shelf, separated underneath by the alluvium, by the NW-SE trending Lahore-Saharsa Ridge. The site is located on alluvial soil made up of both older and newer alluvium with a thickness estimated to be of the order of about 320 m, below which hard rock formation of the Lahore-Sahara Ridge is reported to occur.

Preliminary investigations at site indicate that the substrata consist of alternate layers of sandy silt/silty sand and silty clay/sandy clay (each layer being of approx. 4m thickness) upto approximate 110 M depth from EGL.

The water table is varying between 0-3 m below the existing ground level. It is likely that the water table may rise to a higher level during rainy seasons. Ground water variation is reported to be quite minimal thereby causing water saturation and water logging in the region during monsoon times.

The existing ground level of the site in the area around TI package is varying from RL 213.5 m to 215.0 m.

1.2 METEOROLOGICAL DATA

The maximum and mean wind speed observed at Hisar during the period 1969-2013 was 48km/hr and 3.6 km/hr respectively.

The other meteorological parameters at Hisar are as follows:

		Max.	Min.
1.	Air temperature (1969-2013)	48.8	-1.5
2.	Average annual Wet Bulb Temperature ^{o}C (1969-2013)	21.4	17.3

The annual average rainfall is about 450 mm with maximum of 793.6 mm (1976) and minimum of 145.2 mm (2000). Relative humidity of maximum 100 % & minimum 5 % has been observed.

Occasionally dust storms are experienced during summer months and hail storms during Feb-April. Fog and dew prevail generally during Dec-Jan. Thunder storm also occurs during post monsoon season and summer months.

1.3 SEISMOLOGY

The site falls under zone III as per the seismic zoning map of India (IS: 1893-Part-1).

1.4 SITE INSPECTION

Intending bidders should visit the site to familiarize themselves thoroughly with the site conditions before submitting their tender. Non-familiarity with site conditions will not be considered a reason either for extra claims or for not carrying out the work in strict conformity with the drawings, time schedule and specifications. For any information on site visit, the bidders may contact NPCIL site office, Village-Gorakhpur, District-Fatehabad, Haryana.

1.5 SITE CONDITIONS

The bore hole location drawing (Drawing No. GHAVP-1&2/10120/2001/DD) is enclosed along with the tender document. Typical details of a relevant Bore log data are given at the end of this section in Annexure-1 for general guidance to the Bidders. Seven Boreholes BH103, RBH-104,RBH-109, BH-110, RBH-111, BH-115 and BH-116 were drilled covering Turbine Building-1. Seven Boreholes BH105, RBH-112,BH-113, BH-106, RBH-114, BH-117 and RBH-118 were drilled covering Turbine Building-2. The bore hole no RBH107 & RBH108 covers the transformer yard area of unit 1 & 2 respectively.

The bidders are advised to study the bore log data for information. The details of other bore log data in balance area of plant is available in the office of the Engineer for reference of the bidders, if needed.

The finished grade level of EL 99.7m corresponds to RL 219.300m.

For detailed geology around Turbine Building & other structures, para 2.1.1 may be referred.

1.6 BUILDING DESCRIPTION

Description of Main structures covered in the scope of this tender are as follows:

1.6.1 TURBINE BUILDING :

The Turbine buildings are located to the East of Control building. The Structure of the Turbine building shall be of reinforced concrete and shall be supported on Raft Foundation. Wherever required, piles shall also be provided under the raft foundation. For wall/cladding , Concrete Block Masonry is to be provided unless approved otherwise by the engineer. The roof shall be made without any internal support, in order to avoid any interference in work being carried below the roof. The roof shall be provided with water proofing with thermal insulation as per specifications. All the fire rating & other technical requirements shall be considered while selection of material & sizing of the members. Each turbine building shall be accommodated within the allocated maximum plan size as shown in the main plant layout drawing. The location of buildings in the main plant lay out is shown in Drg No. GHAVP 1&2/10000/5001/GA enclosed along with the tender. A portion below condenser shall be lowered appropriately for cooling water inlet and outlet pipes.

The turbine building shall have floors and mezzanine floors at various elevations, housing the turbo generator and other components like HP Turbine, LP Turbine, Generator, Moisture Separator & Reheater, Deaerator, HP and LP feed water heaters, Condensate Extraction Pumps, Boiler Feed Pumps, Storage tanks, Vacuum pumps, Generator Circuit Breaker, Bus Ducts etc. The description given above is brief only . For detailed description relevant chapters of the tender may be followed.

For industrial & fire safety requirements relevant AERB & other statutory guidelines

as applicable shall be strictly adhered.(Refer C-1-3)

The Turbine Generator(TG) shall be supported on a separate RCC pedestal and Reinforcing Concrete Raft foundation. Wherever required, piles shall also be provided below TG raft. The TG foundation shall be isolated from the main turbine building, so as to avoid transmission of vibrations or any other kind of forces to the main building.

Inside the building, EOT cranes with suitable crane girders shall be provided, to handle the heaviest load within the building for maintenance & erection of Turbo Generator & other equipments except Turbo Generator Stator. During maintenance provision to facilitate the removal of Turbo Generator Stator , proper removable leak-tight opening shall be made in the roof of Turbine Building. The building shall have necessary cable & Pipe trenches / tunnels, racks, pipes, hangers & anchor supports. The lifts as well as stair cases shall be provided to access from one floor to another floor of the building.

The access to Turbine building from Control Building at various floors shall also be provided through proper connecting walkways, landing, Staircase etc. Floor levels & entry location from control building are enclosed in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, along with this tender. ***The connecting structure (Access Bridge) shall be planned & designed in such a way that it does not transfer any load to control building as the same is not considered in the design of control building.***

In addition to above, condensate storage area & ventilation buildings, are to be provided by the side of Turbine buildings as indicated in the Drawing No. GHAVP 1&2/10000/5001/GA enclosed along-with the tender.

Annex Buildings are located by the side of both the Turbine Buildings. One of the Annex Building houses the Workshop alongwith other facilities, whereas other Annex Building houses the Laboratory with other facilities. For details of various facilities in the Annex Buildings Chapter C-1-3 of the Tender may be referred. The Annex building may be designed by the bidder as standalone structure or could be a part of the Turbine Building.

The construction of a local Control center inside turbine building with noise barrier/acoustic insulation as specified is also included in the scope of bidder, The detailed requirements of same which are indicated C&I specifications in chapter C-2-4 are also to be met .

1.6.2 **Pipe Cable Bridge (PCB):**

The Pipe and Cable Bridge (PCB) connecting Control building to Turbine Building shall have RCC Structure with suitable foundation and the same is included in the scope of this tender . The intermediate floors & roof of PCB shall be of RCC. The roof shall be provided with water proofing with insulation as per specifications.. ***The structure of PCB shall be planned in such a manner that it does not interfere with***

the vehicular and equipment movement on 10 m wide (7m carriage bay and 1.5m wide shoulder on either side of road) road , as well as tunnels & trenches laid under the road. The tunnel & trenches in this area are indicated in drawing no GHAVP-1&2-29700-5002-GA.The PCB foundations should not transfer any load on tunnels & trenches.

The floor elevations of Turbine Building shall preferably match with Control building floor levels. (Floor levels of control building are enclosed in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, along with this tender). The width of PCB shall match with the PCB opening at control building end as shown in above mentioned drawings ,however the length of PCB will depend on the size of Turbine building as finalized by the bidder and approved by the purchaser. ***The PCB structure shall be planned & designed in such a way that it does not transfer any load to control building.***

1.6.3 **Electrical Bays:**

The electrical bays shall be provided adjoining to main turbine buildings. The electrical bay houses switchgears and Motor Control Centers. The size , layout & equipment arrangement of electrical bay shall be as specified in section C-2-3 of the Tender. The Structure of the Electrical bay shall be of RCC with raft foundation. Piles shall also be provided, wherever required. The roof shall be provided with water proofing with thermal insulation as per specifications. All the fire rating & other technical requirements shall be considered while selection of material & sizing of the members. ***The engineering of the Electrical Bay shall be carried out on the basis of equipment layout and other input as finalized by the Purchaser & given in the electrical specifications in section C-2-3.***

The present layout of Electrical bays is finalized based on the structural configuration and sizing of various columns, beams etc. as per drawings attached in section C-2-3. It is expected that bidder shall maintain the same while design of Electrical Bay Buildings . In case, it is found to be essential to change the given dimension and same is approved by Engineer, the Purchaser may modify the equipment layout, opening arrangement etc, to meet the design, construction and maintenance requirements. In such situation, Bidder shall carry out the necessary design changes based on modified layout by the purchaser without any extra cost to Purchaser.

1.6.4 **Access Bridge:**

The Access bridge for both the units needs to be provided to connect the turbine building from control building from each floor of Control building. This structure shall have landing at each floor of Turbine Building connected to nearest available Control building floor. It shall also have provision of lift, to access the Turbine Building & control building. The floor elevations of Control building at which turbine building to be connected with control building are given in drawing Nos. GHAVP 1&2/24200/ 2011 TO 2018/ GA, attached with this tender. The Access Bridge structure shall be RCC. The roof shall be provided with water proofing with insulation as per specifications. Lift shall open at all floor levels of CB & TB.

1.6.5 **CCW Inlet & Outlet Pipes / Conduit**

The detailed requirement for CCW Inlet & Outlet Pipes/ Conduits given in Section C-2-5 shall be met. Suitable arrangement viz. culvert etc. shall be made to ensure that no loads are transferred by other Structures & Systems under this package on CCW Pipes/ Conduits.

1.6.6 **Transformer Yard:**

All the civil works for transformer yard (adjoining to turbine buildings & electrical bay) to accommodate SUT, UT, GT, Oil Separation Pit, Bus Duct, Rail Track (including rails) for maintenance upto Turbine building, spare GT area, fire barrier walls etc. are included in the scope of the bidder as shown in the relevant tender drawing. **The supply and erection of rail on road towards western side of grid X-2 is also included in the scope of bidder**. For detailed scope Section C-2-3 shall be referred. The transformer yard is open to sky. An area reserved for Transformer Yard is shown in main plant layout drawing attached with the tender. ***The engineering of this area shall be done on the basis of input data and equipment layout provided by the Purchaser as given in the electrical specifications in Section C-2-3.The foundation for all the equipment & structures shall be Raft or Pile- Raft foundation, unless approved otherwise by the Purchaser. The founding level for SUTs, UTs, GTs, Burnt Oil Pit and Fire wall etc. shall be kept at EL 95.4m or lower as required (unless specifically approved by the engineer).*** The equipment foundations shall be structurally isolated from the grade slab to avoid any transfer of load.

1.6.7 **Tunnels & Trenches around Turbine Building & Transformer Yard (Other than CCW Pipes/conduits) & other area:**

The engineering & construction of all the tunnel trenches within the road edges between grid (8&9), Grid (26-27), grid (r2- q2) & grid (x2-y2)is included in the scope of bidder. The terminal points are specified in Sketch No.GHAVP-1&2/29700/2001/SK. The end of the RCC tunnels shall be provided with proper construction joint & dowels of adequate length which can be used by other agency for further construction. (The load being transferred, if any, at terminal point and is to be accounted for during design by TI package contractor to be specified.) The tunnels / trenches shall be aligned & engineered properly considering the road crossing etc, if any as per overall layout of the plant. The Tunnel trenches included in the scope are:

- PTL 26, 33(upto terminal point),53,96,97
- PTR 26A , 26B & 68
- CTR 72,74, 74A,75, 77,78,79, 80
- CTL 73, 73A(upto terminal point), 73B, 94 (upto terminal point), 95, 95A
- ASW tunnels upto terminal points in East & West direction.
- Any additional tunnel / trenches / pipes required within the terminal points as given in above para. are also included in the scope of bidder. The portion of the tunnels/

trenches which is excluded from the scope of this package are specifically mentioned in the Sketch No . GHAVP-1&2/29700/2001/SK given with the tender.

- Tentative layout of Surface drain is given in Drawing No GHAVP-1&2/15300/5001/GA. Design and construction of down comer pipes & additional internal drains connecting to the Surface drains shown in above drawing is in the scope of bidder. Construction of Surface drains between nodes A26 to A29, A29 to A30, A30 to A45, A39 to A45, B2 to B5, B5 to B6 and B1to B6 are in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant.
- Tentative layout of Plant drain is given in Drawing No. GHAVP-1&2/15200/5101/GA. Design and construction of additional internal plant drains connecting to the nearest available plant drains shown in above drawing is in the scope of bidder. Design & Construction of plant drains from building to the terminal point (PDC-22, PDC-23, PDC-30, PDC-31, PDC-32, PDC-33 and PDC-34) are in the scope of the bidder. Construction of Plant drains between M62 to M67, PDC-31 to M67, M43 to M46 and PDC-33 to M46 is in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the boundary limit.
- Tentative layout of Roof drain is given in Drawing No. GHAVP-1&2/15200/5001/GA and Drawing No. GHAVP-1&2/15200/5002/GA. Design & Construction of roof down comers to the terminal points (RWE-16 to RWE-23, RM-18 and RM-19) are in the scope of the bidder. Construction of Roof drains between RWE-16 to RWE-23 and RM-18 to RM-19 is in the scope of bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the battery limit.
- The tentative layout of sewer lines is given in Drawing No GHAVP-1&2/15200/5201/SK. Design & construction of sewer line from building to the nearest manhole is in the scope of bidder. The construction of Manhole no MH 338 to MH 340 and connecting sewer lines to these manhole as shown in the above drawing is in the scope of the bidder. The relevant sectional details & Layout, given in construction *drawings supplied by the Purchaser (at a later stage)* shall be followed, in order to meet the continuity of flow as these are part of overall drain network of plant. In case the manholes for above services are not available, close to terminal boundaries, then these lines are to be connected by the bidder at his own cost to the nearby Man Hole/ nearest connecting point at the boundary limit.
- The construction of 10 m wide road between grid 17- 18 within terminal point is excluded from the scope of the bidder. However the bidder shall fill the area up to subgrade i.e. EL 98.0m , with soil cement mix as per the specification. The typical cross section to be followed for the road is given in Sketch No. GHAVP

1&2/15600/5001/SK attached with the tender .

1.6.8 The Hard Stand "C" is excluded from the scope of this tender. However, the area below the Hard stand within terminal point shall be graded upto EL 98.00 with soil cement mix as per detailed technical specifications.

1.6.9 **Area grading within the terminal points:**

The area grading within the terminal point within the road edges between grid (8-9), Grid (26-27), grid (r2- q2) & grid (x2-y2) , upto EL 99.7M (RL 219.3M) is within the scope of bidder. For area grading backfilling upto EL 98.7M shall be done using soil cement mix as per the specifications, unless specified in the approved drawing otherwise . The portion above EL 98.7M shall be backfilled using compacted soil as per technical specifications provided.

1.7 SCOPE OF CIVIL WORK

1.7.1 **General:**

The works proposed to be performed under this contract are for Engineering, procurement, fabrication, construction, commissioning and handover of two 700 MWe units of Gorakhpur Haryana Anu Vidhyut Pariyojana - 1&2 (GHAVP- 1&2) and shall include all the facilities required for power production utilizing the steam produced in secondary cycle. ***The facilities shall be established within the allocated area satisfying all the statutory, technical and performance requirements specified in the tender*.** The work shall generally include but not limited to following:

Finalization of equipment layout, general arrangement, loading, analysis , design , drawings, procurement, fabrication, construction & commissioning of :

- Turbine Building including BFP, CEP and Vaccum Pumps.
- Turbo Generator Foundations
- Foundation of all other equipments
- Annex Building ,Turbine Oil storage tank
- Condensate storage tank and its storage area
- Pipe and Cable Bridge (PCB) structure connecting Control building to Turbine Building
- Electrical bay (The engineering of the building is to be carried out on the basis of equipment layout and other input finalized by the Purchaser or his consultant as given in the Electrical Specification.).
- All other Tunnels , Trenches & pipes within the terminal points except those are specifically mentioned as excluded in the sketch No. GHAVP-1&2/29700/2001/SK.
- Transformer yard accommodating SUT, UT, GT, Oil Separation Pit, Bus Duct, Rail yard for maintenance upto Turbine building including rails in transformer yard to & within the turbine building unloading bay, spare GT area . The supply and erection of rail on road towards western side of grid X-2 is also included in the scope of bidder.
- Embedded parts / Penetrations,
- Access bridge to connect the turbine building from control building from each floor

of Control building (The floor elevations of Control building at which turbine building to be connected with control building are given in drawing Nos GHAVP 1&2/24200/ 2011 TO 2018/ GA, attached with this tender) .

- Surface drains, Plant drains, Roof drains and Sewer lines (Based on the engineering input provided by the purchaser)within the terminal point as specified in Para 1.6.7.
- Internal & External Finishes, cladding , plastering , flooring & painting etc.
- Fabrication & erection of all structural steel works like trusses , crane girders etc.
- Area Grading & temporary access roads within the terminal point
- All the civil, structural & architectural works as necessary for completion of the system.

1.7.2 **Detailed:**

The scope of work shall include engineering, procurement, supply & construction necessary for functional requirements. The work shall generally include but not limited to the following :

(a) Based on the geotechnical study carried out at site, the soil is found to be susceptible to liquefaction in varying depth. In order to mitigate the possibility of liquefaction the soil is to be treated up to a depth susceptible for liquefaction, by mixing the soil (at OMC) with 5% cement (by weight of dry soil) and compacting the same in a specific manner. The area within the battery limits of TI package shall be treated by the Purchaser up to the various levels specified in the attached Drawing GHAVP-1&2/16000/2003 &2004/DD. However, as per the layout and structural arrangement opted by the bidder or system requirements , if the founding levels are fixed at a higher elevation than the levels indicated in Drawing no GHAVP-1&2/16000/2003&2004/DD, the area shall be raised by treating it using soil cement mix (cement content 5% by weight of dry soil) by the bidder at his own cost, as specified in the relevant part of technical specifications. The area may also be raised by filling PCC, only if approved by the Engineer . ***It is preferred to take up the foundation of various structures from the level up to which Ground Improvement is carried out by the Purchaser and as indicated in the Drawing No*** GHAVP-1&2/16000/2003& 2004/DD**.** Wherever, the founding levels are lower than the levels specified in above drawing the ground shall be lowered by bidder at his own cost using appropriate cutting tool like chisel etc. which does not disturb and damage the improved soil below founding level. The damaged improved ground, if any, shall be made good by the bidder at his own cost. Additional excavation or backfilling, wherever required shall be carried out by bidder on priority avoiding any adverse effect on the existing works or the works being executed by other contractors in adjoining areas. Schedule of the additional excavation and backfilling shall be finalized in consultation with PURCHASER. Bidder must schedule his excavation and other activities considering the status of construction & schedule of construction of adjoining structure.

(b) Analysis ,Design and Detailed Engineering of all the structures i.e. covered in the scope of this tender and as detailed above.

(c) Preparation of Design Basis Reports (DBR), Static and dynamic analysis reports and other design reports as applicable and suggested by the engineer.

(d) Preparation of general arrangement, loading, Architectural , concrete forming, EP location, EP fabrication and Reinforcement drawings etc. The reinforcement detailing has to be as per Indian Standards/ ACI/ AERB code as directed by the engineer

(e) Complete analysis , design, procurement ,fabrication and erection of structural /Miscellaneous Steel works & EP including preparation of all necessary drawings within the terminal points &within the scope of this tender.

(f) Preparation of composite drawings including details of Civil, Electrical, Mechanical, Instrumentation etc.

(g) Preparation of Bar bending schedule and Bill of materials.

(h) Design , fabrication and erection of formwork and supporting system required for concreting of the various elements of the structure.

(i) All Reinforced concrete work in pile, raft, isolated footings, columns, equipment foundations, slabs, beams, underground tunnels/trenches, sumps, basement structures, ducts, precast covers and allied structures etc

(j) All RCC work required for equipment machinery, tanks, tunnels , trenches etc, supply & installation of EPs.

(k) Supplying and Fixing water stops, expansion joint.

(l) Supplying & Construction of brick, concrete block walls along with plastering , glazed walls, Metal sheet cladding & roofing as per the drawings .

(m) Providing & fixing the Metal Doors/ Fire proof doors, Windows, Ventilators & Louvers with glass & glazing along with all the necessary fixtures wherever required or as specified by the Purchaser. Wherever required, suitable sound insulation measures shall be provided.

(n) Providing and laying of plant drain, storm water drains, sewer lines, roof drains, UPVC pipe down comers and different pipes and other plumbing and sanitary works and connecting the sewer lines to nearest manhole outside the area within this contract or as required.

(o) F3 & U3 finishes to the concrete.

(p) Hardonate flooring by vacuum de-watering method and other types of flooring as specified in the specifications, including specific requirements given in other sections of the tender.

(q) Painting over concrete , structural steel , wall, ceiling, Doors , Windows & Ventilators etc. wherever required as specified in the tender or else as directed by

Purchaser.

(r) Water proofing work in basement, sump, wall and roof etc as specified in the tender specifications or approved by the Purchaser.

(s) Providing facilities throughout the contract period for sampling and testing of various construction materials as specified and as directed by Purchaser.

(t) Providing proper storage facilities for construction materials such as cement, steel, aggregate, admixture, Structural Steel, water stop, paints etc.

(u) Construction of temporary Access Roads & storm water drains within the terminal points .

(v) General area grading and drainage within the terminal points upto EL 99.7M unless specified otherwise, with proper retaining walls / sheet piles (wherever required) .

(w)Finishing works for above mentioned structures, partition walls. plastering, flooring, painting, false ceiling wherever specified & approved in the drawings, erection of doors, windows & rolling shutters, P.H. Works, waterproofing, construction joints, fire proofing, painting of equipment, structures and piping etc.

(x) Preparation of quality assurance plan, quality assurance manual, testing methodologies Inspection and testing plan, and acceptance criteria for material qualification.

(y) Preparation of construction methodology, safety manual, job hazard analysis, work procedures, etc.

(z) Submission & obtaining the purchaser approval on Construction Completion Certificate & system transfer docket containing necessary documents like Test Certificates, Pour Cards, As Built Drawings & Inspection reports etc.

(aa) Attending meetings with purchaser, AERB, wherever & whenever required, at own cost.

1.8 MATERIAL AND SERVICES BY NPC

Land, water and power etc. will be given by NPCIL on chargeable basis on conditions mentioned elsewhere in the relevant documents.

The supply of all the materials , required to execute the work covered under this contract, is in the scope of contractor.

1.9 DRAWINGS

Drawings being issued with bid are for ***guidance*** only. All the construction/ as-built drawings are to be prepared by bidder on suitable integrated engineering environment or AutoCAD (latest version) as per relevant standards and as specified by purchaser .

Drawings in Compatible AutoCAD version shall also be provided to the purchaser. Contractor should have adequate knowledge of prevailing codes and practices for reinforcement detailing .

3 number of prints (full scale) of each drawing shall be submitted to Purchaser for every revision/correction. Drawings /Documents preparation, checking and Approval of drawings shall be done by the EPC contractor as well as design consultant (if appointed) and same shall also be approved by Proof consultant. Before submission to Purchaser all documents should bear the signatures and names of persons preparing, checking and approving the documents/drawings as well as of Proof consultant .After the approval from Proof consultant the Drawings /Documents shall be submitted for final acceptance of Purchaser. Purchaser comments if any shall be incorporated in the relevant final drawings/ documents prior to execution.

Supporting design calculations (wherever applicable) shall also be submitted by EPC contractor prior to submission of related drawings. Two copies of the approved prints and one set soft copy shall be submitted to the Purchaser. The final soft copy of all the documents and drawings will be registered in Purchaser's document management system (PLM) in the format attached with the tender, progressively with the work progress. Execution shall be done only after proper registration of the documents/ drawings.

Submission of DVD/ CDs (2 copies) of all approved drawings, DBR, Mathematical model, software input and output files, post processors , static and dynamic analysis reports, Design Manual etc , along with soft copy of executable file of programme, excel sheets used in the process of analysis and design are also included in the scope of bidder.

The documents/drawings furnished by Purchaser and/or generated by the EPC contractor shall not be used by the contractor anywhere else without prior written approval of the purchaser. All the generated documents/ drawings will be property of the purchaser.

The bidder has to prepare the following drawings:

(a) General arrangement, loading, Architectural , Concrete forming, EP location, EP fabrication, Reinforcement drawings etc for all the structure covered in the scope of this contract. The reinforcement detailing has to be carried out as per Indian Standards/ ACI code as directed by the purchaser .

(b) Design of Joints, preparation & issue of fabrication drawings for Structural Steel works& other Miscellaneous Steel Structures.

(c) Preparation of Bar bending schedule and Bill of materials (BOQ).

(d) Preparation of composite drawings including details of Civil, Electrical, Mechanical, Instrumentation etc.

(e) Preparation of EP list

The bidder has to prepare all the drawings/ Report as per the approved format of the Purchaser. A period of minimum 15 working days shall be considered for obtaining the Purchaser's comments after submission of drawing / Document by the Contractor.

1.10 SPECIFICATIONS

The specifications given in this document cover the general description, quality and workmanship of materials and finished work. They are not intended to cover minute details. The work shall be executed in accordance with best modern practices.

For all the Civil works these specifications shall have precedence in case anything contrary to this is stated anywhere in the contract document, unless specifically mentioned in this document or approved by the engineer. The Purchaser's decision shall be final, on any issue arising out of such discrepancies.

1.11 PARTICULARS OF THE MATERIALS TO BE USED BY THE BIDDER:

The bidder has to use the following materials for civil construction unless otherwise specified /approved by the Engineer in writing

- **Backfilling:**

A) AREA GRADING:

i) Upto EL 98.70m : Using soil (at OMC) with 5% cement (by weight of dry soil) and compacting the same as per relevant specifications for Backfilling /ground improvement unless approved otherwise. PCC may be used , only if specifically approved by the engineer without financial implication.

ii) Above EL 98.70m: Soil suitable for land escaping/ Soil Cement mix as approved by the Engineer.

B) Within Foot Print of structure/ equipment Foundation:

PCC shall be used, unless specifically approved by the Engineer. The properties of the back fill material used shall be suitably accounted in the design.

- **CONCRETE : M 35 Grade**

- **PCC: M15 Grade**

- **STRUCTURE-**

Foundation Type : RCC Raft or RCC Raft with Piles

Structure above Raft: Reinforced Cement Concrete (RCC), unless approved otherwise by the Purchaser. *RCC slabs and roofs shall be constructed using Galvanized deck sheets as left in shuttering*, unless specifically approved otherwise.

- **WALLS :**All external walls shall be of Concrete Block Masonry, unless approved otherwise by the Engineer . Wherever required, proper glass partitions shall also be provided.

- **ROOFING :**

  The roof of Turbine buildings shall be cast in situ RCC (with water proofing and required thermal insulation as per specifications) over Steel Deck Span Sheets, unless specifically approved by the Engineer. The roof of Turbine Buildings shall be laid over steel roof trusses and purlins. The roof shall be made without any internal support from slab below in order to avoid any interference in work being carried below the roof.

  The floors & roofs for Electrical Bay, Annex Portion of Turbine Building, PCB and AB shall be cast in situ RCC (with water proofing and required thermal insulation on roofs) .

- **PLASTERING : On masonry works**

  A)EXTERNAL: 20 mm thick rough cast plaster / sand faced plaster wherever masonry is used for cladding and as approved by purchaser.
  B) INTERNAL: 15 mm thick cement mortar

- **FLOORING :**

  40 mm thick Hardonate flooring in cement concrete 1: 1.5: 3 or alternative flooring or as functionally required & approved by the purchaser.

  The areas used for handling the chemicals and battery rooms shall be provided with acid & alkali resistant lining .

  In case, if specific flooring requirements are specified in other sections of the tender the same shall be followed unless otherwise agreed by the engineer.

- **WATER STOP :**

  PVC type as required & approved by the purchaser.

- **WATER PROOFING:**

  FOR ROOF :

  Spray Applied 2 component Polyurethene Membrane as per specifications on all RCC roofs . Wherever required, proper thermal insulation shall also be provided .

  FOR BASMENT / TUNNELS/ TRENCHES /SUMPS:.

PVC Membrane as per the technical specifications. PVC membrane shall also be provided all around CEP foundation external surfaces.

❖ **PAINTING**

A) INSIDE SURFACE :
On masanory walls upto 2 m height 250 micron thick epoxy paint & for balance height acrylic emulsion paint of shade to be approved by purchaser.

B) OUTSIDE SURFACE:
Anti-Carbonation, Anti-Corrosive and Waterproof Coating on plastered/ concrete surface of shade as approved by the purchaser.

C) STEEL STRUCTURE:
Epoxy paint as specified in clause 19.18.5.5, unless specified otherwise.

D) FLOOR :
1200micron thick Self-Leveling Epoxy coating on Turbine operating floor. On all other floors except for Turbine operating floor, 500 micron thick epoxy paint shall be used.

In areas where any other specific type of flooring like Acid Alkali Resistant Lining etc (other than Hardonate flooring) is specified, epoxy coating need not be provided.

E) FIRE PROOFING OF STEEL STRUCTURE:
Using Intumescent Paint for desired fire rating or encasing in concrete as specified in the drawing and approved by the Engineer.

❖ **DOORS/ WINDOWS :**

Anodised aluminum doors / steel rolling shutters and anodised aluminum windows as approved by the purchaser .Wherever required, fireproof doors shall also be provided of adequate fire rating.

❖ The false ceiling shall be provided, wherever specified in the tender (inclusive of other sections).

1.12 GENERAL & ARCHITECTURAL REQUIREMENTS

1.12.1 *Grade of concrete*

All the cement concrete works involved in the Turbine Building& other associated structures shall meet the requirements for relevant IS standards.

Grade of concrete shall be M35 for sub-structure and for super-structure. The RCPT value of the concrete used for the construction shall not be more than 2000 columbs at 56 days.

1.12.2 *Types of cement*

The cement shall be OPC 43 grade confirming to IS 8112 or OPC 53grade confirming to IS 12269 as well as the additional requirements of technical specifications . To meet the durability requirement, mineral admixture like flyash may be used with proper mix proportioning . The quality of fly ash shall meet the relevant technical specifications.

1.12.3 *Reinforcement*

The reinforcement shall be HYSD TMT bars of grade Fe 500 as well as the additional requirements of relevant technical specifications shall be used.

1.12.4 *General Architectural Requirements*

Powder coated aluminum panel of minimum 0.5mm thick lined ceiling (closed type pattern) fixed to R.C. beams shall be provided for all air-conditioned areas. The illumination and duct grills in these areas shall match the overall aesthetics.

All the buildings shall be provided with minimum 1.0m wide concrete paving all round as plinth protection. Paving shall be slopped outward to provide a rapid run off rainwater away from building.

Doors, windows and rolling shutters on external walls of buildings shall be provided with sunshade with side projections .Sunshade from walls shall be minimum 750 mm over windows & doors and 1500 mm over rolling shutters.

All stairs shall have a maximum riser height of 175mm and a minimum thread width of 250mm with Aluminum nosing. Minimum width of stairs of in all building shall be 1200mm.

Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 3.0m and number of riser shall not exceed 12 for a single flight.

Hand railing minimum 1100mm high shall be provided around all floors/roof openings, projections, balconies, walkways, platforms, etc. ***All hand rails, toe guard, balustrades, vertical posts& horizontal rails of RCC staircases connecting the floors& railings around openings in RCC floors shall be of Stainless steel*** . Other hand rails shall be 32mm nominal bores MS medium quality pipes and shall be coated with 2 coats of high build epoxy paints with suitable primer. Vertical spacing of landings shall not exceed 1.5m center to center. Minimum 2 numbers 32NB GI pipe shall be provided for horizontal rails and toe guard shall be provided. All rungs for ladder shall also be coated with 2 coats of high build epoxy paints with suitable primer as per specifications.

All steel platforms above grade shall be constructed with 150 wide kick plates at edge of platform to prevent tools or materials from falling off platform.

Doors shall be provided at appropriate location to prevent dust ingress from outside.

Rolling shutter size and its operating system shall be decided based on the equipment handling for erection and maintenance with a side clearance.

All windows/louvers shall be of anodized aluminum .

External cage ladder shall be provided for access to Turbine building roof. Internal cage ladder 2 nos. shall be provided to access crane walkway .

All the edge protection angles shall be coated with 2 coats of high build epoxy paints with suitable primer.

1.12.5 *Glazing*

Glazing partition wall shall be provided in areas wherever required and as approved by the Engineer.

Glazing shall be in double toughened glass with glass of minimum 6mm thickness for effective thermal insulation. Vision panel shall be minimum 4mm thick.

Windows & ventilators located on external walls above operating floors levels and those located in fire prone areas shall be provided with wired glass of minimum 6mm thickness. Windows in other areas shall be finished with 6mm thick clear glass.

1.12.6 *Flooring*

The nominal total thickness of floor finish shall be 40mm. The areas used for handing of chemicals shall be provided with Acid & Alkali resistant Lining. Wherever, special type of flooring is required due to functional requirements or mentioned in other sections, the same shall be provided.

Skirting shall match with floor finish.

1.12.7 *Roof Drainage System*

A system shall be provided for removal of water from roof surface to avoid damage to the roof structure of all buildings and shall consist of the following:

Roof Drain Heads
Rainwater down comers
Fixtures

IS:1742 code of practice for buildings drainage shall be followed for this purpose.

Multiple drains (min.2nos.) shall be provided for all roof areas. System will be designed to handle rainfall at a rate of 125mm per hour and in accordance with

stipulations of IS:1742

Roof drains will be connected to main roof drain arrangement as given in Drawing No. GHAVP-1&2/15200/5001/GA and Drawing No. GHAVP-1&2/15200/5002/GA.

1.12.8 ***Plant Drain, Surface Drain & Sewer Line:***

Construction shall be done as per the system engineered by Purchaser as specified in clause 1.6.7 above . Wherever additional lines are to be laid to connect the system engineered by Purchaser, shall be designed and constructed by Bidder.

1.12.9 ***External Painting***

The building shall be provided with paint on external surface matching with the plant aesthetics as specified in clause 1.11 above.

1.13 LAYOUT

Only two main centre lines and one permanent bench mark would be furnished and all other lay out, fixing levels etc. shall be done by the Contractor at his own cost. The Contractor shall protect and maintain, during the course of execution of the work, the main centre lines and bench marks, so that they are left undisturbed even after completion of his work.

1.14 ACTIVITY SCHEDULE

The successful bidder has to prepare the detailed schedule and construction procedures for all major activities and submit the same for approval before commencement of work.

The work shall commence and completed in accordance with the Construction Schedule specified elsewhere. The various phases of work shall be completed within the periods as specified in the approved construction schedule, to be submitted by the bidder. The total completion period for this contract will be as given in the tender notice attached with this tender document.

2. DESIGN SPECIFICATIONS

2.1 PROJECT SITE FEATURES

2.1.1. LOCAL GEOLOGY

Seven Boreholes BH103, RBH-104,RBH-109, BH-110, RBH-111, BH-115 and BH-116 were drilled covering Turbine Building-1.

Seven Boreholes BH105, RBH-112, BH-113, BH-106, RBH-114, BH-117 and RBH-118 were drilled covering Turbine Building-2.

Boreholes RBH-107 & RBH -108 covers Transformer Yard of both the units.

The soil samples from these boreholes have been tested . The location of bore holes & relevant data are enclosed in Annexure-1.

Subsurface profile at Turbine building -1 & 2 areas generally consists of alluvial deposits for full depth of exploration. Alluvium soils, consisting mostly of clayey silt and silty sand, were encountered from the ground surface in the boreholes. Based on Standard Penetration Tests (SPT) conducted in this layer, consistencies of the cohesive soil (clayey silt) ranged between medium stiff to hard Clay Silt, while relative densities of the granular soil (silty sand) derived from SPT values, ranged between Medium dense to Dense silty sand. Boreholes were terminated in this layer at depths between 51.6m and 54.0m below existing ground surface and details are given in the Annexure - 1.Groundwater level was observed at depths between 2.3 m and 3.0 m below existing ground surface in the boreholes.

2.1.2. SITE GRADING

The site selected for general layout of Turbine Building and other associated structure are located in a relatively flat terrain. This area will be excavated and ground improvement will be carried out by the Purchaser up to the levels as indicated in drawing No GHAVP 1&2-/16000/2003 &2004 /DD. However, on completion of construction, this area will have to be graded to Finished Grade Level of RL 219.3 m. i.e. EL 99.7 M and the same is included within the scope of this tender.

The finished floor level of all the structures is fixed at EL 100 000 i.e RL 219.6 M . The site will be graded to EL 99700.

2.1.3. SEISMIC, SAFETY, QUALITY & DESIGN CLASSIFICATION

The site lies in Zone-III, as per the zoning map of India [IS-1893-2002, Part-1]. The structures within the scope of this tender are seismically classified category 3, safety class NINS (Not important from Nuclear Safety) & Design Class DC-4(Non Safety class structure.

2.1.4. METEOROLOGICAL CONDITIONS

Following meteorological data should be considered for design.

a) Annual average Rainfall: 450 mm
Maximum Intensity /Hr for 1 Hr duration: 125 mm/hr
(for design of roof drainage)

b) Wind pressures : Following wind speed shall be followed in the design.

Height	V_b	k_1 values for	Values of	3-sec averaged extreme wind

(m)	(m/s)	different return periods						speed for different return periods			
		50	100	1000	10000	k_2	k_3	50	100	1000	10000
10	47	1.00	1.07	1.35	1.63	0.99	1.00	46.5	49.8	62.8	75.8
20	47	1.00	1.07	1.35	1.63	1.06	1.00	49.8	53.3	67.3	81.2
30	47	1.00	1.07	1.35	1.63	1.09	1.00	51.2	54.8	69.2	83.5
40	47	1.00	1.07	1.35	1.63	1.12	1.00	52.6	56.3	71.1	85.8
50	47	1.00	1.07	1.35	1.63	1.14	1.00	53.6	57.3	72.3	87.3
60	47	1.00	1.07	1.35	1.63	1.15	1.00	54.1	57.8	73.0	88.1
70	47	1.00	1.07	1.35	1.63	1.16	1.00	54.5	58.3	73.6	88.9
80	47	1.00	1.07	1.35	1.63	1.18	1.00	55.5	59.3	74.9	90.4
90	47	1.00	1.07	1.35	1.63	1.19	1.00	55.9	59.8	75.5	91.2
100	47	1.00	1.07	1.35	1.63	1.20	1.00	56.4	60.3	76.1	91.9
Note: (i) Design wind speed obtained by multiplying basic wind speed by different factors of k_1, k_2 and k_3; and (ii) Values of k_2 at different heights are computed under assumption of terrain category 1, Class C											

c) Max Dry Bulb Temp : 50.8 ^{0} C (1000 year return period)
d) minimum Dry Bulb temp : -6.9 ^{0} C (1000 year return period)
e) Relative Humidity
i) Max. during monsoon : 100%
ii) Min. during Dec to Jan : 5%

2.2 DESIGN

The design of the structures (unless specified otherwise) given in clause 1.6 &1.7 is in the scope of the Bidder. The design of the structures shall be done by the Bidder or his design consultant as approved by the purchaser .**The designer should have experience to design of similar structures i.e minimum one Turbine Building with Turbo generator Foundation of a power plant of minimum 500 MWe capacity of any Nuclear or Thermal Power Plant in soil sites**. ***The designer shall be acceptable & approved by the purchaser. The credentials of Designer shall also be provided along with technical bid.***

The bidder has to follow the procedure for preparation and approval of design documents given in flow chart as Annexure-2 of this tender.

2.2.1 PROOF CONSULTANT

The successful bidder shall appoint a proof consultant(s) with the approval of the purchaser for independent checking of the analysis, design and drawing works carried out by the bidder or his design consultant. The bidder shall provide the names of his prospective design consultants (if appointed) and proof consultants along with his bid.

It is preferred that proof checking consultants are from institutions like IIT's or

any other premier organizations / experienced professionals. The proof consultant shall have experience of analysis & design of machine foundation & framed structures. The proof consultant shall be acceptable & approved by the purchaser. The credentials of Consultant (if appointed) & Proof consultant shall also be provided along with technical bid.

All design related deliverables by bidder shall bear the certification by proof check consultant regarding conformance to codal provisions and technical specifications.

2.2.2 GUARANTEE FOR DESIGN

The bidder shall furnish guarantee against fault in the design (even though it might have been accepted by the Purchaser)of the structures covered under his scope of work. Further he shall also carry out at his cost all necessary rectification/improvements in the design of structures covered under the contract so as to make good any inadequacy arising out of above factors. The approval of Purchaser does not absolve the bidder from the overall responsibility of satisfactory performance of design & construction of the works within his scope.

2.3 DESIGN PARAMETERS AND METHODOLOGY

The following design parameters and methodology shall be followed for structural/civil engineering design of Turbine building and other structures within this contract. ***The fundamental principle controlling the design and construction of all the structures is to ensure that functional performance is maintained at all times upto earthquake level of zone III of IS 1893 and structural integrity against collapse is also to be maintained under the extreme loading including Safe Shutdown Earthquake condition*** to ensure safety of the adjacent safety related buildings viz. Control Building, SAB etc.
In principle this shall be achieved through a combination of using the best quality control standards for material and workmanship during construction and designing for all severe load combinations, whilst imparting a high level of redundancy within the structural system.

2.3.1 DESIGN PARAMETERS

2.3.1.1 SAFE BEARING CAPACITY, FOUNDING LEVEL & OTHER GEOTECHNICAL PARAMETERS:

The safe bearing capacity at founding level of any structure shall be computed based on standard codal approach/ practices considering the geotechnical parameters of the influence zone, based on dimension of structure and maximum intensity of pressure. For finalization of influence zone, the soil profile up to a depth, where net increase in vertical pressure becomes less than 10% of the initial overburden pressure from founding level of the structure shall be considered in the analysis.

The various geotechnical parameters to be considered for evaluation of engineering parameters are given in Annexure 1.

The geotechnical parameters given in Annexure-1, are evaluated based on bore hole data obtained on original ground prior to excavation. Subsequently, the ground improvement is carried out to mitigate liquefaction, in varying depth below the founding level using Soil Cement mix. Therefore the properties of the improved soil as given Annexure-1A shall be considered instead of soil properties for the relevant improved portion of ground.

The foundation of all major equipments of transformer yard (SUT, UT, GT etc.) & oil separation pit, CCW Inlet & hot water tunnel, PCB & Electrical bay, Turbine Building and Turbo-generator etc. shall be taken from EL 95.4 or below, unless required otherwise functionally or approved by the engineer. All other tunnel / trenches may be engineered & founded on PCC / Soil Cement mix, unless approved otherwise and as accepted by the Engineer.

2.3.1.2 MODULUS OF SUBGRADE REACTION :

The value of subgrade reaction for both static and dynamic analysis shall be worked out as per detailed soil structure analysis using ABAQUS or equivalent software. The detailed approach for the same is given in clause 2.4 below.

2.3.1.3 GROUND WATER

From the recording of ground water table observed in various bore holes during site investigation, it has been established that the bore holes and trial pit water level variation within the main plant area is quite erratic. The ground water table varies from 0m to 3m from the existing ground level. The Coefficient of permeability based on pump-out test is 1.2 x 10-5 m/sec. This value is recommended for the design of dewatering system in this area. The design, operation & maintinance of dewatering system for the TI package area is in the scope of NPCIL. The details of the same will be provided to the successful bidder. The bidder has to schedule his work plan in coordination with dewatering contractor engaged by NPCIL. However, if any water accumulates within the building same shall be dewatered by the bidder at his own cost.

As the foundations are below the ground water table, de-watering will be required during construction. Suitable de-watering system will be adopted during construction stage to maintain the water level 1 m below the founding level. All the foundations, retaining walls etc. will be designed taking into account worst conditions of ground water hydrostatic pressure. As per the current practice for design and stability check purpose, ground water level will be taken upto finished grade level/EL 95.4M as approved by the engineer. The structural integrity of the basement raft and walls shall be ensured by designing them for full hydrostatic head upto ground level/ EL 95.4M as approved by the engineer.

2.3.1.4 EARTHQUAKE INDUCED LIQUEFACTION

The phenomena of Landslides, Collapse, Subsidence and Liquefaction depend on the nature of ground and prevailing sub-soil water conditions. The soil is found to be susceptible for Liquefaction and same is being treated upto the expected founding level of structures as indicated in the Drawing No GHAVP-1&2/16000/2003 &2004/DD by the purchaser.

2.3.1.5 LOADS & LOAD COMBINATIONS

The following loads shall be considered in their worse combinations as appropriate for the design of the Turbine Buildings, Ventilation Buildings, Electrical Bay, Pipe & Cable Bridge , Transformer Yard area& CCW Tunnels etc

a) Dead Loads (D)

Dead loads comprise of the self-weight of all permanent construction, including walls, floors, roofs, ceilings, columns, stairways, cable shafts and fixed service equipments. While estimating dead loads for the purpose of design, the unit weight specified in IS: 875 Part-1 shall be used.

b) Equipment Loads (EL)

The buildings shall house a number of equipment on various floors. The loads from these equipments shall be specified as per vendor details.

c) Live Loads (L)

Live loads on floors shall be considered as per the following sub-sections:

d) Uniformly distributed loads

The uniformly distributed live loads assumed shall be the highest values likely to be produced. The uniformly distributed loads are static loads on the plan area and provide for normal effects of impact but do not take into consideration special concentrated loads, which are been dealt below.

e) Concentrated loads

Except for offices, toilet blocks etc. all floor slabs, secondary beams and girders etc. (other than the operating platforms near the equipments) shall be designed for a concentrated load of 10000 N acting simultaneously with the uniform live load as given in (i) to take care of any unforeseen exigent loads. This load shall be assumed to act at points so as to result in maximum moment and/or maximum shear. However, this load shall not be considered concurrently along with any actual concentrated load given to be carried over to the main beams, columns and foundations. For floor slabs, unless otherwise specified, this load shall be assumed to act as distributed uniformly over an area of 750mm square and shall be located so as to produce the maximum

stress condition in the floor slab.

f) Live load on roof (LR)

Live load on roof shall be considered, as the roof is provided with access. The following provisions as per BIS 875 Part-2 shall be followed. The minimum live load on roof that shall be considered for design is 1500 N/sq m. but not less than 3750N uniformly distributed over any span of one meter width of roof slab or 9000N uniformly distributed over the span in the case of beams or truss or wall.

g) Loads on purlins supporting the RCC roof

Every purlin shall be designed to carry the more severe of the two loads indicated below:

- The loads transmitted to the member RCC roof in accordance with (f) and
- An incidental concentrated load of 10000N placed at the most unfavorable position on the member.

h) Loading on handrails, parapets etc

Stairway railings, hand rails, parapets and balustrades, both exterior and interior shall be designed to resist horizontal thrust of 750 N/m applied at the top of the railing.

i) Loads due to impact and vibration

Structures carrying live loads, which induce impact or vibration, shall be designed for increased live load as follows:

Structures	**Min. Impact Factor**	**R e f e r e n c e**
a) For light machinery, shaft or motor units.	20%	BIS:875
b) For reciprocating machinery or power units.	50%	BIS:875
c)Transformer roller loads	10%	Assumed
d)Truck wheel load	30%	Assumed

Impact and vibration load for gantry girders, monorails etc

For crane gantry girders and supporting columns, the following allowances shall be deemed to cover all forces set up by vibration, shock from slipping of slings, kinetic action of acceleration and retardation and impact of wheel loads –

Type of load	Additional load
a) Vertical loads for electrical overhead crane (EOT)/monorails	25% of maximum static wheel loads.
b) Vertical loads for hand operated cranes/monorails (HOT)	10% of maximum wheel loads.
c) Horizontal forces transverse to the rails for electric overhead cranes.	5% of weight of the crab and the weight lifted on the crane.
d) Horizontal forces along the rails for EOT cranes.	5% of the static wheel loads.

The horizontal forces specified in (c) & (d) shall be considered as acting at the rail level.

For monorails no horizontal surge shall be considered.

j) Construction Live Load (CL)

These are the superimposed loads, which may come on a member during construction or after construction as erection loads.

k) Soil/Earth Pressure (Sp)

Turbine building with C.W. Pit basement walls shall be subjected to lateral earth pressure for the portion where sides of the wall are back-filled. The walls shall be subjected to earth pressure at rest derived as per standard formulae.

l) Hydrostatic Pressure (F2)

The basement walls shall be designed considering the subsurface water pressure rising up to finished grade level/ El 95.4m, as approved by the engineer , under normal and severe environmental load combinations including Earthquake. Computation shall be based on the buoyant unit weight of the soil plus full hydrostatic pressure. The value of δ shall be taken as half the value of δ for dry backfill. The full upward pressure of water below basement floors shall be taken over the entire area.

m) Rain Loads (RL)

Design maximum intensity of rainfall for the roof is 125 mm/hr. The flat roofs shall be designed to sustain the load of rainwater that could accumulate on it during any unlikely event of roof drain blockage. The maximum accumulated height of water shall be assumed as 300mm over roof drain and 150mm over roof slab. Rain load and live load on roof shall not be considered to act simultaneously and more critical of the two shall be adopted in the design.

n) Wind Loads (WC)

The design wind speed (Vz) shall be computed in accordance with BIS:875 (Part-3).

The relevant normal loadings to be considered in combination with wind load as stated above shall comprise of the full dead load and the reduced percentage of live loads as applicable, together with live loads on roof. For structural design 100 year return period of wind shall be considered.

o) Seismic Loads (EO/ES)

Since no safety related systems are located in turbine building and other associated structures, but due to provision of MSIV on PCB, the seismic classification has been kept as NINS and structure design is to be done as per codal provisions of IS 1893.However, the structural integrity against collapse is also to be maintained for all the structures under the extreme loading (SSE) condition to ensure safety of the adjacent safety related buildings viz. Control Building, SAB etc.

The elements of the structures shall be checked considering the SRSS values of responses due to all the three ground motions acting concurrently.

At GHAVP- 1&2 site, in SSE condition the digital value of Response spectra is given in Annexure-3 corresponds to the peak free field ground acceleration .

The relevant normal loadings to be considered in combination with seismic load (SSE) shall comprise of the full dead load and the following percentages of live loads:

Load Class	Percentage of Design Live Load
Staircase & balconies	25%
Uniformly distributed live loads 4000 N/sq.m. and above	50%

Under earthquake conditions the structure shall be assumed as loaded with the above-reduced percentages of live loads and the roof with no live load . Self wt. of EOT cranes shall be considered without any lift load.

Active earth pressure distribution due to submerged backfill on the basement walls during an earthquake shall be as per the provisions of BIS:1893. Also active pressure due to uniform surcharge over backfill behind basement walls shall be obtained as per BIS:1893. For saturated earthfill, the saturated unit weight of the backfilled soil shall be adopted. For submerged earthfill, the dynamic increment in active earth pressure during earthquakes shall be found using Mononobe-Okabe formulae which has been furnished in of BIS:1893and also recommended in ASCE 4-16.

p) Crane Load:

The maximum load while lifting the test load shall be considered . However this shall

not be considered during the seismic condition.

q) Surcharge:

A suitable surcharge (Minimum 2 T/SQM) shall be considered in the design on account of movement of equipment, traffic, stacking of material , crane etc on the ground adjacent to structures .

r) Internal Pressure (In case of Pressure Tunnels)

The internal water pressure in the tunnels including the surge & shut off condition shall be considered in the design appropriately as specified in Section C-2-5.

s) **Any Other Load:**

As applicable the load due to temperature, creep, shrinkage etc shall be considered in the design following the relevant codal provisions.

t) Combination Of Loads

The turbine buildings and other structures shall be designed for worst combination of the loads specified above and any other loads as applicable. The suitability of the design shall be checked for load combinations to satisfy the Limit state of serviceability & Limit state of strength / Collapse as defined below:

i) Limit state of Serviceability :

Load combinations under this category are unfactored (or as given in Table-18 , BIS:456 for Limit State of Serviceability) and shall be used to ensure the requirements of limit state of serviceability of the structure. For CCW Tunnels relevant requirements specified in the AWWA standards and requirements specified in C-2-5 shall be met.

ii) Limit State of strength/ Collapse:

Load combinations for design under this category are factored and shall be used to ensure that no applicable limit state of failure is exceeded and stresses in the structure are well within its permissible limits . The structural elements to grouped into a number of groups and the basic loading combinations applicable to each of these groups shall be applied . The load factors applicable for the various load combinations shall be based on the combination philosophy of BIS:456, except for the Extreme Environmental load combination. No load factors of the extreme environmental load (SSE) combination has to be considered.

All loads with appropriate load combinations shall be considered to act with the corresponding load factor. The most unfavorable effect on the structural element shall be considered for design. In the load combinations, under Severe Environmental and

Extreme Environmental condition, the earthquake and the wind loads are considered not to act concurrently. Moving loads such as those of monorail hoists, EOT crane together with the loads lifted are considered only for normal load combinations. In other combinations their static load effects without the loads being lifted are to be considered. Loading effects due to truck or transformer movement are to be considered under normal load combination. Construction load shall be combined with dead load only.

For CCW Tunnels relevant requirements specified in the AWWA standards and requirements specified in C-2-5 shall be met.

2.4 Submission of design report

The analysis shall be carried out using NISA, ANSYS, ABAQUS, SAP which has been validated. The bidder shall make copies of all the analysis & design documents available to the owner in required numbers as desired by the purchaser.

2.5 ANALYSIS AND DESIGN METHODOLOGY

Prior to carrying out actual analysis, the structural analysis software needs to be validated by solving some benchmark problems.

Suitable software like SASSI or equivalent shall be used to carry out analysis considering detailed soil structure interaction for frequency dependent springs.

2.5.1 Modeling of Soil Structure Interaction

2.5.1.1 Evaluation of Geotechnical Properties

Soil Structure Interaction shall be taken into account by providing suitable springs at the foundation nodes.

The following approach for soil springs calculation for raft foundation with/without pile shall be followed, unless approved otherwise by the engineer:

a. The soil profile in the site consists of two parts. The upper layer is known as improved soil consisting of soil-cement mix to mitigate the liquefaction potential. The layer below the improved layer is natural soil. The depth of excavation and soil improvement is shown in the Drawing No. GHAVP-1&2/16000/2003&2004/DD.

b. Design soil profile up to a depth where net increase in vertical pressure becomes less than 10% of the initial overburden pressure from founding level of the structure shall be considered in the analysis.
c. Geotechnical parameters of the Improved Soil and natural soil profile (below the improved soil) shall be considered are per its properties given in Annexure -1 &1A.
d. Wherever geotechnical data are not available up to required depth, worked out as per para (b) above, the geotechnical properties of the last available layer of soil shall be considered up to the required depth for which data are not available.

2.5.1.2 Evaluation of Soil Springs using above Geotechnical Properties

In case of structure supported on raft foundation or combined piled raft foundation (CPRF), evaluation of springs for soil/soil & pile shall be carried out as follows:

a. Detailed Soil –Structure-Interaction (SSI) analysis with appropriate simulation of soil-pile-structure interaction shall be carried out using ABAQUS or similar software to compute the stiffness of soil spring (i.e., for raft foundation system) and soil & pile spring (for CPRF) for both static and dynamic condition.
b. Validation report of the calculation of springs using above software shall be submitted.

Suggested approach for evaluation of static and dynamic spring by detailed Soil-Structure Interaction using ABAQUS or similar software:

I. Geometric modeling of layered soil strata shall be done, as 3D finite element of size 3LX3L where L is the longest dimension of raft/structure.
II. Boundary condition of soil layer element in lateral direction shall be considered as fixed and vertical direction free. And boundary condition of bottom elements of soil is fixed in all direction.
III. Geometric modelling of structure (including pile for CPRF) shall be carried out.
IV. Modelling of interface of soil – structure and soil-pile-structure shall be done, which requires computation of following interaction parameter:
    (a) Friction factor ($0.75\tan\phi$)
    (b) Critical/limiting shear stress $\{0.75x\ (Cu+\sigma\tan\phi)\}$
    (c) Elastic slip

V. Perform static analysis with static modulus of elasticity, E_{static} values of soil profile under sustained load, which includes dead load, equipment load and live load. The modulus of subgrade reaction value (Kz_{static}) is estimated by dividing the induced contact pressure at typical i_{th} node of the raft with displacement of that node. The modulus of subgrade reaction thus obtained is multiplied by the contributory nodal area of that node to obtain the vertical stiffness of soil and pile spring at typical i_{th} node.
VI. Similarly dynamic analysis shall be performed using dynamic modulus of elasticity, $E_{dynamic}$ (using correction factor of $G/G_{max} = 0.4$, where G_{max} corresponds to low strain shear modulus) under sustained load plus Earthquake loading to obtain dynamic springs as $Kx_{dynamic}$, $Ky_{dynamic}$ and $Kz_{dynamic}$. The stiffness at typical i_{th} node in lateral directions is computed by dividing the induced contact shear stress in that

direction with the lateral displacement along that direction and further multiplied this value by the contributory nodal area of that node.

VII. To obtain static spring stiffness in lateral direction (x &y direction) at typical i_{th} node, following equations may be followed

$Kx_{static}=Kx_{dynamic}$ x $(Kz_{static}/Kz_{dynamic})$

$Ky_{static}=Ky_{dynamic}$ x $(Kz_{static}/Kz_{dynamic})$

2.4.1.3 Using spring values calculated by above approach further structural analysis shall be carried out using any standard Finite Element software like NISA, ANSYS, ABAQUS, and SAP etc.

2.5.2 F.E. Modelling & Design of Turbine Building, Electrical Bay, PCB, Access Bridge &Transformer Yard

The structures should be idealised as a 3D framed system. Raft, Pile(if applicable) Columns, beams and slabs should be modeled using suitable finite elements available in the structural analysis software to be used. Commercially available software for structural analysis like NISA, ANSYS, ABAQUS, SAP etc.

3D static analysis has to be done to obtain the member forces due to the static load conditions.

To obtain the member forces due to earthquake, response spectrum analysis with 3-D model of the structure has to be performed using the response spectra as per IS 1893. For collapse study under SSE , the response spectra given in Annexure -3 shall be used **.**

2.5.3 TG BLOCK

The TG block consists of top deck, columns, intermediate platforms and TG mat. Top deck supports the turbine, generator and the exciter. The columns of TG pedestal, independent columns supporting the platforms, some internal columns and pit walls are supported on the TG mat.

The design of TG block shall be based on working stress method. The permissible stresses in concrete and reinforcement shall be based on IS: 456 and IS: 2974 (part-3). In addition to functional requirement mentioned above codal requirements of IS: 2974 (Part-3) shall be satisfied. Some of the important requirements are listed below:

- The base mat shall be so dimensioned that the resultant force due to weight of the machine, the top deck, intermediate floors/platforms, columns supporting the TG deck, equipments and supporting structures resting on mat, basement walls resting on the mat etc., shall not have eccentricity with respect to the centre of gravity of the base area more than 3% of the base dimensions in the direction of the eccentricity.
- Adequate haunches shall be provided at intersections of the beams and the columns to avoid large concentration of stresses and to increase general rigidity of the frame.

- Fundamental natural frequency of the TG block in horizontal direction shall be separated by a minimum of 20% of the operating speed and fundamental natural frequency in vertical direction shall be separated by 50%.
- Minimum reinforcement for the deck beams shall be 0.25% of the sectional area at top and bottom and 0.1% of sectional area at sides.
- Allowable bearing pressure on soil/rock shall be 80% of allowable safe bearing pressure on soil
- For grouting of machine bed plates and pockets for anchor bolts, non-shrink grout shall be used.
- TG block should have adequate strength to withstand the worst combination of static, dynamic and seismic loads.
- Raft should be rigid enough to ensure fixed end conditions for the columns and prevent non-uniform settlement. If required , the Piles shall be provided under the raft.
- The natural frequency of the machine foundation system to be such as to avoid resonance at operating speed of the turbo-generator and the amplitude of displacements or any other specific criterion specified by the Turbine / Equipment Manufacturer.

2.5.4 Tunnel Trenches

The Tunnels are to be designed for the worst combination of loads considering Internal water pressure , wherever applicable (Considering Surge both positive & negative pressure & Shutoff Pressure), Earth Pressure (considering fully saturated soil conditions) , Surcharge, Seismic Loads, Loads from vehicular movement over tunnels and any other additional loads etc as applicable. The support for tunnel shall be properly modeled considering the springs or any other elements as the case may be. The suitability of design shall be checked for completely filled as well as in its empty condition etc also.

The tunnels are to be designed meeting requirements specified in IS 3370

2.5.5 SPECIFIC REQUIREMENTS

2.5.5.1 FIRE RATING & CORROSION

The Turbine building& other associated structures in the scope of this tender will have to cater the fire rating specified in Section C-1-3, unless approved otherwise. The following minimum dimensions and clear covers shall be provided.

Element	Parameter	Minimum Dimension (mm) for Resistance Period			
		1 hour	2 hour	3 hour	4 hour
Column	Side	200	300	400	450
	Cover	25	35	35	35
Load	Thickness	125	150	200	250

bearing wall	Cover	15	25	25	25
Slab	Thickness	100	125	150	175
	Cover	15	25	35	45
Beam	Width	125	200	250	275
	Cover	30	60	70	80

Note: Covers indicated relate to main reinforcing bars. Floor finishes shall be taken as part of clear cover for top reinforcement in beams and slabs . Fire rating requirements will not govern for secondary structural elements like lintels, transoms, mullions and canopies. Weld mesh shall be provided wherever cover is more than 40 mm.

2.5.5.2 EMBEDDED PARTS (EP)

These shall be designed for maximum forces arising out of Operating condition and Earthquake (codal) condition**.** It may be noted that the usage of Cinch anchors for anchoring any equipment is prohibited unless specifically permitted by the engineer. Therefore the bidder should provide adequate number of EPs for fixing the equipments and services. However, anchors less than 6 mm dia may be used to provide electrical fixtures etc.

3. CLEARING AND EARTHWORK

3.1 EARTHWORK EXCAVATION

3.1.1. GENERAL

SCOPE OF WORK :

The major excavation of site will be carried out by the Purchaser. The area after excavation up to a depth susceptible for liquefaction is improved using compacted soil- cement mix to a level as indicated in the drawing no. **GHAVP-1&2/16000/2003& 2004/DD.**

It is preferred to take up the foundation of various structures from the levels indicated in above mentioned drawing. However as per layout and structural arrangement opted by the bidder or system requirements , if the founding levels are lower than the levels specified in Drawing no GHAVP-1&2/16000/2003& 2004/DD, the ground shall be lowered by bidder using appropriate cutting tool like chisel etc which does not disturb and damage the improved soil below founding level. In case of damage the same shall be corrected by the contractor without any extra cost to Purchaser.

The above work of excavation shall be carried out as per relevant technical specifications. The contractor has also to make necessary arrangements for side protection to avoid any slippage of soil etc. at his own cost. No extra payment will be

made to remove any of slipped earth etc in the excavated area**.** The contractor is also requested to visit the site prior to quoting & satisfy himself with the actual site conditions. In case further excavation is required, the same shall be carried out as per following specifications:

A) This section covers all the excavation works to be performed under this contract which shall consist of clearing of site and excavation of all existing material of whatever nature, to the lines and grades shown on the construction drawing or as otherwise directed by the engineer. The work shall also include chiseling, loading, hauling and disposal of materials in designated spoil, stockpile areas or directly as construction materials.

B) The contractor shall also be responsible for excavation which is not specifically required for the construction of permanent structures, but incidental to the installation of temporary facilities such as site roads, approach ramps etc.

C) Slope protection and stabilization measures, which may be needed in conjunction with surface excavation work, shall be carried out as defined in other sections of these specifications by the contractor at his own cost.

D) The approval given by the Engineer during the course of execution, to the contractor's methods and equipment shall not relieve the contractor of his full responsibility for the proper and safe execution of excavations, or of liability for injuries to, or death of persons, or any other obligations under this contract. It shall also not relieve his responsibilities for the accuracy or adequacy of the plan for obtaining the desired results in the stipulated time schedule.

3.2 SUBMITTALS

A) The contractor will be required to submit along with the bid, a detailed method statement, drawings and work programme for the excavation. The method statement has to give the details on the plant and equipment proposed to be used by the contractor for excavation and haulage, blasting methods, drainage and safety precautions, disposal of material, procedures for installation of soil supporting and stabilization works, and for construction of temporary site facilities such as roads, temporary drainage lines etc.

B) After the award of work and at least 15 days prior to commencement of the actual excavation, the contractor shall submit to the Engineer an updated method statement and programme for the activities set out in (A) above giving refined and full details of the proposed excavation methods in improved ground and sequences including necessary plans for site drainage and safety precaution. Any and all variations from the corresponding data submitted with the tender will be explained and justified in the updated document to the satisfaction of the Engineer. The data shall include the following:

i) Method for excavation of improved ground
ii) Method of mucking & disposal of excavated material.

iii) Details of the equipment to be deployed with proper justification.

C) Within 7 days of receipt of the above updated excavation method statement and programme, the Engineer will advice the contractor in writing, of his acceptance of, or comments on the submitted documents. The Engineer reserves the right to reject the proposed plan, if, in his opinion, undesirable damage to improved ground or existing structures would result from the proposed excavation method. If acceptance is withheld, a new plan in whole or in part shall be submitted. Excavation shall only be carried out in areas for which the Engineer has accepted the plan.

D) At least 15 days prior to dumping and stock piling any excavation material, the contractor shall submit the layout of spoil or stock pile areas which will be within the areas designated on the tender drawings or as approved by the Engineer. All pertinent data of working methods and provisions for stability and temporary and permanent drainage of the areas shall be included. Details of volume proposed to be stored, material types, heights of storage and grades shall be provided.

E) The Contractor shall submit and agree with the Engineer a monitoring plan for the progress of the excavation as well as to observe potential or actual movement of the slopes of the excavated pit. This plan shall also give details of the procedure and equipment to be employed by the contractor to stabilize or to protect as quickly as possible any areas in which untoward movement or slope deformation is likely to occur or has occurred.

3.3 CLEARING THE SITE (IF APPLICABLE)

All the areas upon which the construction is to be carried out and over which excavation is to be done and areas which are required by the Contractor for his construction facilities are to be cleared of all rubbish, and any other objectionable matter. All spoils and unserviceable materials and rubbish shall be disposed of at locations away from the work site in a manner directed by the Engineer. Care shall be taken to see that unsuitable waste materials are disposed off in such a manner that there is no likelihood of these getting mixed up with the materials meant for construction. Useful materials, saleable timber, firewood etc., shall be stacked properly at the work site in a manner directed by the Engineer and finally handed over to Purchaser.

3.4 LAYOUTS AND LEVELS

Under no circumstances shall the contractor remove or disturb any permanent benchmarks / reference pillars installed by Purchaser. The contractor shall carefully maintain and protect all benchmarks and reference pillars and shall layout all his works by accurate reference thereto. The layout and levels of all structures shall be made by the Contractor from the general grid of the plot and bench marks given by the Engineer. The Contractor shall make his own surveying arrangements for laying out and establishing the reduced levels based on two reference grid lines and one bench mark as furnished by the Engineer and shall be responsible for the accuracy of layout and levels.

The theodolite and leveling instruments to be used by the Contractor shall be of digital type (total station). He shall also render necessary assistance to the Engineer by way of surveying instruments, materials and men for checking the layout and levels.

The ground level shall generally be taken at spacing at a grid of 5m x 5m.Where local mounds or abrupt undulations are met with or when so directed by the Engineer, the grid spacing may be at closer interval not exceeding 2m. The ground levels shall be properly recorded and plotted on plans, which shall be signed by the Contractor and the Engineer before the earthwork actually commences.

3.5 EXTENT OF EXCAVATION, LINES AND GRADES

The contractor shall perform excavation in all types of soils, murrum, soft and hard improved cement-soil mix., etc. in foundation, over areas and in trenches to widths, lines, levels, grades and curves as shown in the drawing or to lesser widths, lines and levels as directed by the Engineer.

3.6 APPLICABLE CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

a) IS-3764 - Safety Code for Excavation Work.

b) IS:9758 - Guidelines for de-watering during construction.

c) IS:10379 - Code of practice for field control of moistures and compaction of soils

d) Indian Explosives Act 1940 (Latest Version)

e) IS-2720 - Part-II - Determination of water content.

Part-VII - Determination of water content. - Dry Density Relation Using Light Compaction.

Part-VIII - Determination of Moisture content - Dry Density Relation Using Heavy Compaction.

Part-XXVIII - Determination of Dry Density of Soils, In-place, by the Sand Replacement Method.

Part XXIX - Determination of Dry density of Soils, In place, by core cutter method.

f) IS-4081 - Safety Code for Blasting and Related Drilling Operation.

g) IS-1200 - Method of Measurement of Building Works.

3.7 EARTHWORK EXCAVATION -GENERAL

Excavation shall be done to lines and levels defined in the drawings or as directed by the Engineer. The earthwork shall also include, where required temporary sheet piling or sheeting, bracing and shoring, to maintain the excavated pits, without interruptions to service lines, cables, duct banks, etc., encountered within the area of excavation or within reasonable distance of excavation.

3.7.1 LIMITS OF EXCAVATION

All excavation shall be carried out very carefully using methods and techniques that will produce smooth and sound surfaces with minimum over-break beyond the lines and grades/ limit of excavation shown in the construction drawings and will preserve the structural integrity of the excavated area. The contractor shall take all precaution to preserve in the soundest possible and undisturbed condition all materials beyond the limits of excavation. Special care shall be exercised where vertical or near vertical faces are required. Any extra excavation beyond the specified limit shall be made good by the contractor at his own cost with the class of material proposed to be laid over it or any other material approved by the Engineer.

Soft pockets, if any, shall be removed even below the final level and extra excavation shall be filled up by material which is proposed to be laid over it or any other material approved by the Engineer.

3.7.2 CLASSIFICATION OF EARTH WORK

For purposes of work to be executed in accordance with this specification, the following classification shall apply.

A) All types of soils, murrum, loose boulders of size with volume up to 1 cum, intrusions and soft rock

The excavation work shall further be categorized in the following 3 categories:

A) Excavation in General Areas & grading work up to grade level.
B) Excavation for buildings /structures foundations below grade level.
C) Excavation for Tunnel & trenches etc., below grade level

3.7.3 EXCAVATION IN SOIL

This includes earth, murrum, top deposits of agricultural soil, reclaimed soil, clay, sand or any combination thereof, soft and hard murrum, shingle etc. which is loose enough to be removed with spades, shovel, pick axes, poclain & poclain mounted rippers.

When the bottom of the excavated pit as indicated in the construction drawing is disturbed or loosened by the excavation process, the contractor shall improve it at his

own cost with the class of material proposed to be laid over it or any other material approved by the Engineer.

3.7.4 EXCAVATION IN HARD CEMENT SOIL MIX:

This includes all improved soil other than materials mentioned above, , which shall be removed only by , chiseling and wedging etc. as approved by the engineer.

3.7.5 STRIPPING BLUFFS AND LOOSE SOIL

All loose soil, not directly in the excavation but close to the area to be excavated as to be liable, (in the opinion of the Engineer), to fall or otherwise endanger the workmen, equipment, or the work etc. shall be stripped off and removed away from the areas of excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion, which was originally sound and safe. Any materials not requiring removal as contemplated in the work, but which, in the opinion of the Engineer, is likely to later become loose or unstable shall also be promptly and satisfactorily removed as directed by the Engineer.

3.7.6 APPROACH RAMPS/ROADS

The contractor shall adopt method of mucking by clamshell, dragline or conveyors. However only under exceptional circumstances where ramps are unavoidable, the Contractor may provide the same with the prior approval of the Engineer. Berms, if required at intermediate levels may be provided beyond 6-m depth with the prior approval of the Engineer. Such ramps shall be excavated later and the excavation shall be finished to the lines and grades shown on the approved drawings and to the satisfaction of the Engineer. No extra payment shall be made for formation of such berms , ramps etc. The berms , ramps falling outside the line of excavation shall be made good after the completion of work as directed by the Engineer.

3.8 STABILITY OF EXCAVATION

The methods of excavation shall, in every case be subject to the approval of the Engineer. The Contractor shall ensure the stability and safety of the excavations, adjacent structures, services and the works. The Contractor shall ascertain himself the nature of materials to be excavated and difficulties likely to be encountered in executing the excavation. Coffer dams, sheeting and shoring, bracing and maintaining suitable slopes, draining etc. shall be provided and installed by the contractor. The contractor shall submit drawings to the Engineer showing the proposed arrangement with detailed design calculations and shall obtain written approval from the Engineer. Irrespective of the approval of the Engineer, the responsibility for adequacy of such measures shall rest fully with the contractor.

If any slip occurs, the Contractor shall remove all the slipped material from the excavated pit, at his own cost. Also, if any damage to the built up structure occurs because of the slip, the Contractor shall make good the same at his own cost & to the satisfaction of the Engineer.

3.8.1 TIMBER SHORING

Timber shoring shall be as specified in IS: 3764-Safety Code for Excavation Work. Wherever the shoring is required for deep excavations, the same shall be designed by the Contractor and got approved by the Engineer prior to its use in the work

Timber shoring shall be 'Close' or 'Open' type, depending on the nature of soil and the depth of pit or trench. The type of shoring shall be as approved by the Engineer.

3.8.2 OPEN TIMBERING

In the case of open timbering, the entire surfaces of the side of trench or pit are not required to be covered. The vertical boards of minimum 25 cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangements, sizes of the timber and the spacing shall be subject to the approval of the Engineer.

3.8.3 CLOSE TIMBERING

Wherever so directed by the Engineer the contractor shall provide close timbering

3.8.4 LEFT IN SHORING

If the Engineer directs any timbering to be left in for the safety of the structure or otherwise for reasons commensurate with the type of construction, necessitating such decision, the same shall be provided by the contractor.

3.8.5 REMOVAL OF SHORING

The removal of shoring timber shall be done very carefully to prevent the collapse of the pit or trench. It shall start at one end and proceed systematically to the other end. No part of the work should be damaged during the removal of the shoring. No claim shall be entertained for any shoring, which cannot be withdrawn and is lost and buried.

3.9 ACCEPTANCE OF EXCAVATED AREA

Excavated area shall be cleaned, trimmed to exact shape and size. All disturbed material and other debris shall be removed and the surface shall be thoroughly cleaned to the satisfaction of the Engineer. A joint survey of the excavated pit shall be carried out at various stages of excavation before acceptance of the excavated area. The joint survey report duly signed by NPCIL and the contractor. Before any further work with concrete or backfill is commenced, the Contractor shall inform the

Engineer and get the area approved by him.

3.10 DISPOSAL OF SURPLUS MATERIAL

All surplus materials shall be carried away from the site and disposed at dumping site/ stock piles, in separate heaps as per the utility of the material, as directed by the Engineer. The Engineer may ask the contractor to dump the excavated materials in low lying areas, regular heaps, bunds, blankets riprap with regular slopes and level so as to provide natural drainage. As a rule, all softer material shall be laid towards the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. All such works as mentioned above are deemed to have been taken into account while quoting .

All excavated material from the pits shall be the property of the Corporation and if the Contractor wants to use it, he shall have to obtain it from the Engineer at a rate fixed by the Purchaser, until unless specified otherwise.

In no case, the excavated soil shall be stacked within a distance of 1.5 m from the edge of the excavation or 1/3rd of the excavation depth, whichever is more.

3.11 PRECIOUS OBJECT, RELICS, OBJECTS OF ANTIQUITY ETC.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or on the site shall be the property of the Corporation and contractor shall duly preserve the same to the satisfaction of the Engineer and from time to time deliver the same to such person or persons as the Engineer may from time to time authorize or appoint to receive the same.

3.12 USE OF EXCAVATED MATERIAL:

The Contractor may note that useful material excavated from the structures shall be used for backfilling. All the material suitable for backfilling shall also be stacked suitably. The excavated material used for backfilling will be available free of charge, if required the contractor has to break the bigger sized available material to the suitable size as specified in the specification, for backfilling at his own cost .

4. BACKFILLING

4.0. GROUND IMPROVEMENT /BACKFILLING USING COMPACTED SOIL / SOIL-CEMENT MIX

4.1 OBJECTIVE

The objective of this document is to lay down the specifications for Ground improvement of GHAVP-1&2 site by replacement of in-situ soil from

existing/excavated level as per drawing by well compacted in-situ soil / in-situ soil cement mix.

The bidder shall study this specification along with the other documents and input data given by NPCIL and work out the detailed working methodology for the execution of the work.

4.2 SCOPE

As per the Liquefaction studies carried out at site, the soil is found to be susceptible for liquefaction in varying depth . Based on records of water table the ground upto EL 95.40M is only susceptible for Liquefaction. Based on Purchaser's experience from earlier projects and geotechnical studies , the Ground improvement upto the depth susceptible for Liquefaction, within the battery limits of this package is carried out by the Purchaser upto the top levels as indicated in Drawing No GHAVP-1&2/16000/2003 &2004/DD.

Any area which is to be raised (including after excavation) shall follow the requirements given in Clause 1.11. The specifications given below shall be followed for backfilling .

1. Improvement of soil characteristics by mixing cement in soil at Optimum Moisture Content (OMC) corresponding to modified Proctor density (Heavy compaction) test and application of suitable roller compaction to achieve the target maximum modified Proctor density at site.

2. Improvement of soil characteristics by suitable roller compaction of soil at OMC corresponding to modified Proctor density (Heavy compaction) to achieve the target maximum modified Proctor density at site, wherever specified or specifically approved by the Engineer.

This specification covers the following aspects:

(a) Study of trial report on Ground Improvements (Compacted soil/ soil- cement mix) and liquefaction analysis by USNRC guidelines.

(b) Collection of soil samples from site for carrying out laboratory tests.

(c) Conducting laboratory tests to arrive at optimum moisture content and modified proctor's density of soil and soil cement mix samples.

(d) Carrying out grain size analysis, moisture content (for soil) and unconfined compressive strength and stability for soil cement samples.

(e) Excavating and drying soil in drying beds, mixing/batching of soil/soil cement mix in suitable batching-mixing plant, laying and spreading of soil/ soil cement mix at OMC in layers and compacting each layer by suitable vibro rollers.

(f) Conducting field tests to find out moisture content, density & SPT values for compacted soil and soil - cement mix.

(g) Determining post improvement values of cohesion & angle of internal friction of soil.

(h) Carrying out liquefaction analysis as per USNRC guidelines using the above laboratory and field test values.

(i) Maintaining batching, mixing, compaction & testing records.

NOTE

Report on field mockup - report no. GHAVP-1&2/Civil-1/10120/Report/2017/02/R2 is provided for *broad information/ general understanding purpose*. The work shall be carried out in line with the recommendations of the trial mock up. Any modification suggested by the successful bidder for optimization purpose shall be demonstrated to yield desired results by conducting additional mock up by the bidder at his own cost.

4.3 REFERENCE CODES/ DOCUMENTS

- Trial mock up Report: Report no. GHAVP-1&2/Civil-1/10120/Report/2017/02/R1
- IS 2131: Method for Standard Penetration test of Soil.
- IS: 4332- Part-1: – Method of sampling and preparation of stabilized soils for testing.
- IS: 4332- Part-2: – Determination of moisture content of stabilized soil mixtures.
- IS: 4332- Part-3: – Test for determination of moisture content- dry density relation for stabilized soil mixtures.
- IS: 4332- Part-4: – Wetting and drying, and freezing and thawing tests for compacted soil-cement mixtures.
- IS: 4332- Part-5:– Determination of unconfined compressive strength of stabilized soils.
- IS: 4332- Part-7: – Determination of cement content of cement stabilized soils.
- IS: 2720- Part-4: – Methods of test for soils; Grain size analysis.
- IS: 2720- Part-5:– Method of test for soils; Determination of Liquid and Plastic limit.
- IS 2720- Part-7: Determination of Water Content-Dry Density relation using Light Compaction.
- IS 2720- Part-8: Determination of Water Content-Dry Density relation using Heavy Compaction.

- IS 2720- Part-28: Determination of dry density of Soils In-place, by the Sand Replacement Method.
- ASTM D5778-12: Standard Test method for electronic Friction Cone &Piezocone penetration testing of Soil.
- IS 12175: – Specification for rapid moisture meter for rapid determination of water content for soil.
- IS 3764: – Excavation work- Code of Safety.
- IS: 269: Specification for 'Ordinary Portland Cement'
- IS: 456: Specifications for 'Plain and Reinforced Concrete'
- IRC SP-89: Guidelines for Soil and Granular material stabilization using cement, lime and fly ash.
- Soil-Cement Inspector's Manual by Portland cement association.
- Specifications for road and bridge works, Indian roads congress, Ministry of shipping,
- road transport & highways.

4.4 MATERIALS

Following material shall be used for the work under this specification:

1. Soil excavated from Project area.
2. Ordinary Portland cement.
3. Water

4.5 INPUTS BY NPCIL

NPCIL will provide the following documents with regard to this work:

GHAVP-1&2/Civil-1/10120/Report/2017/02/R2: Report on Field Mock-up for Ground Improvement by Replacement of Liquefiable Strata by Compacted soil/Soil-Cement Mix.

4.6 DEWATERING: The dewatering for the area will be carried out by the Purchaser through some other agency. However, if any water accumulates within the building same shall be dewatered by the bidder at his own cost.

4.7 COLLECTION OF SOIL FROM PROJECT AREA

The excavated soil from the project area shall be used for preparation of soil/ soil-cement mix. Contractor shall prepare the drying beds for facilitating natural drying of the excavated soil. The excavated soil shall be spread in the drying beds for sufficient time before using the same for preparation of compacted soil/ soil-cement mix. Soil in

drying beds shall be protected against rains through provision of suitable sheds, bunds, cut-off trenches, diversion channels, etc. and also protected during subsequent stages, i.e. transportation to batching plant, transportation to site for placement and after placement & compaction. The size and number of such drying beds shall be planned so as to meet the overall construction schedule. All efforts shall be made to minimize dust pollution during handling/ transportation/ mixing of soil/ soil-cement in mixing/ batching plant etc.

4.8 PREPARATION OF COMPACTED SOIL/ SOIL-CEMENT MIX

The methods of ground improvement to be adopted for this work i.e.

1. Compacted soil-cement mix (with 5 % of cement) in consultation with the Engineer.
2. Compacted soil.

The dried soil shall be thoroughly pulverized and taken to batching-mixing plant for preparation of compacted soil/ soil-cement mix. Mixing of soil/ soil and cement with water, as the case may be, shall be done in a mechanical mixer/batching plant. The quantity of water to be added shall be such that optimum moisture content (OMC) is achieved at the time of compaction. The capacity of batching-mixing plant shall be commensurate with the construction schedule requirements.

Tolerance on water content shall be maintained within +0.5% & -2% of OMC. Layer displaying plastic behavior in the form of bumpiness during compaction shall not be accepted & removed.

4.9 MIXING, TRANSPORTATION, PLACEMENT & COMPACTION

Automated plant with weigh batching shall be used for mixing.

The mix shall be transported to site in tippers (covered, if necessary, depending on ambient atmospheric conditions) and placed in position by conveyor belt or other appropriate means. Transit time shall not be more than 30minutes for soil-cement mix. Suitable ramps shall be prepared for entry/exit to/from excavated pit. The mix shall be placed on dry sub-base and in no case pooling of water shall be allowed at any point of time. The compaction of soil/ soil-cement mix shall be done at OMC in layers of maximum compacted thickness of 200 mm each by adequate number of passes of suitable vibratory roller so as to achieve 95% of modified proctor's density for both soil and soil-cement mix. Moisture loss from soil cement shall be minimized by either laying of subsequent layer of soil cement or curing with damp burlap (in case of break in laying of subsequent layer). Interlayer gap for soil cement mix as adopted in mockup will be adhered to. For soil cement mock-up, compaction must be finished within the Initial Setting Time and next layer shall not be laid before the final setting time.

The work shall be carried out strictly as per the recommendations of the trial mock up. Any modification suggested by the successful bidder shall be demonstrated to yield desired results by conducting additional mock up by the bidder at his own cost, however the capacity, type of vibro-roller and number of passes in mutually perpendicular directions shall meet requirement of target dry density.

4.10 LABORATORY & FIELD TESTS ON SOIL SAMPLES

4.10.1 LABORATORY TEST

The following laboratory tests shall be conducted on the soil samples as per relevant IS.

1. Grain size analysis
2. Atterberg's Limits of Soil.
3. Bulk density and dry density of soil.
4. Natural moisture content.
5. Modified Proctor density to find out maximum dry density at OMC for soil/ soil cement mix.
6. Unconfined compressive strength, stability tests and cement content (through procedural means) on soil-cement samples.
7. Organic content of soil

4.10.2 FIELD TESTS

1. Measurement of ground water table.
2. Measurement of ground Levels.
3. Standard Penetration tests (SPT) on compacted soil and compacted soil-cement. After completion of SPTs the bore hole shall be grouted with cement sand in the proportion of 1:10.
4. Measurement of in-situ Moisture content.
5. In-situ density of the compacted backfill shall be determined by any of the following three methods:

- Nuclear Method
- Sand Cone method
- Rubber-Balloon method

The contractor shall develop laboratory facility at site to carry out day-to-day testing of soil and soil-cement mix. However, for any special/ non routine laboratory tests, testing may be carried out at NPCIL approved laboratory with prior permission of the Engineer.

4.11 INSPECTION AND TESTING PLAN

The following testing frequencies shall be adopted for the work:

The soil dried in the drying beds shall be tested for grain size analysis & moisture content before mixing. The testing frequency shall be 1 test per 1000 cum. & 200 cum. respectively.

All the cement supplied shall be accompanied by manufacturer's test certificate. The cement shall be tested for Normal consistency, Compressive strength (3 days and 7 days) & Initial and final setting time for every batch/week no. subject to minimum of 1 test per 250 MT.

Sample extracted from prepared mix, before compaction shall be tested at site for OMC requirement for every 200 cum.

The soil cement mix shall be tested at the age of 3 days & 7 days for unconfined compressive strength, at the rate of one sample (consisting of three specimens) from each layer for every 2500 sqm. For the purpose of this testing, the core/ specimen shall be extracted from the compacted soil cement layer with the help of sampler immediately after compaction i.e. in green condition and removing the core from the sampler with the help of plunger.

Both soil & soil-cement mixes shall be tested for in-situ density in each layer along with moisture content. The testing frequency shall be one test per 500 sqm of each layer.

After completion of compaction of all the layers of soil, SPT shall be conducted as per the given frequency: one test per 900 m2 area for the improved portion of soil. For soil-cement mix one SPT per 9000 m2 area shall be conducted. The SPT shall be done at 1.5 M interval throughout the depth of improvement for both soil and soil-cement mix.

In case of soil-cement mix owing to high resistance to penetration (as observed during mockup), the test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, efforts shall be made to extract the core for conducting Unconfined Compressive Strength.

After completion of SPTs the bore hole shall be grouted with cement sand in the proportion of 1:10.

The consolidated recommended ITP for various activities is summarized below:

Testing frequency for soil mix		
S.No.	Type of test	Frequency of test

1	Grain Size	1 Test per 1000 cum
2	SPT	1 Test per 900 sqm
3	Moisture Content (before mixing)	1 Test per 200 cum
4	Moisture Content (after mixing before compaction)	1 Test per 200 cum (*to be staggered with S.No.3 above)
5	In-situ dry density with moisture content	1 Test per 500 sqm per layer

Testing frequency for soil-cement mix		
S.No.	Type of test	Frequency of test
1	Grain Size and Modified Proctor's Density in case of both soil and soil cement	1 Test per 1000 cum
2	Cement content of soil-cement mix	1 Test per 500 cum(Through procedural checks on cement consumption)
3	Soil cement core compressive strength	1 Test per 2500 sqm per layer (3 & 7 days)
4	Cement- Normal consistency	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
5	Cement- Compressive strength (3 days & 7 days)	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
6	Cement- Initial & Final Setting time	1 Test per batch/week no. subject to minimum of 1 test per 250 MT
7	Moisture Content (before mixing)	1 Test per 200 cum with minimum of 1 test on each day of ground improvement
7a.	Organic matter (before mixing)	1 Test per 50000 cum
8	Moisture Content (after mixing before compaction)	1 Test per 200 cum (to be staggered with S. No. 7 above)
9	In-situ dry density with moisture content	1 Test per 500 m2 per layer
10	SPT	1 Test per 9000 m2 *
11	Stability test of soil-cement mix	1 Test per 2 lakhs cum of GI considering the grain size distribution of soil covering different soil types.
12	Multichannel Analysis of Surface Wave Studies for confirmation of uniformity in improved ground.	Two profiles covering the entire area of improved ground for every 10000 m2 after laying all the layers.

* In case of high resistance to penetration (as observed during mockup), the test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, efforts will be made to extract the core for conducting Unconfined Compressive Strength.

4.12 RECORDS

Records shall be kept for procurement, production, compaction and post compaction and testing activities. The following records shall be maintained by contractor and submitted to NPCIL:

1. Test certificates of cement.
2. Testing records of soil & cement.
3. Batching/ mixing records.
4. Testing records on soil & soil-cement mix.
5. Field records on placement & compaction at site.
6. Testing records connected with post compaction testing

4.13 SUPERVISION & QUALITY ASSURANCE

During the entire process of works under this specification, independent qualified QA inspectors shall be deployed by the contractor. Contracting agency shall make all the arrangements for testing and inspection by NPCIL.

A detailed work procedure with resources deployment and cycle time calculations shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work.

4.14 ACCEPTANCE CRITERIA

The target minimum in-situ dry density of compacted soil/ soil-cement layers shall be 1.8 gm/cc as one of the acceptance criteria to be met during compaction. This is on the basis of densities achieved during the mockup.

For soil-cement method of ground improvement, 7 days UCS of samples casted at mixing plant shall be controlled. SPT will be conducted however, in case of high resistance to penetration, the SPT test will be terminated once the desired SPT counts have been reached from liquefaction consideration. Further, in the event of non-feasibility of SPT, the core shall be extracted for conducting Unconfined Compressive Strength as a quality control measure for variability

Contractor may optimize the type of equipment (roller type) and number of passes to achieve and demonstrate meeting the acceptance criteria as per ITP mentioned above by conducting mockup.

5. **DEWATERING :** The dewatering for the area will be carried out by the Purchaser through some other agency.

6. CONCRETE

6.1 SCOPE

a) This specification covers all the aspects of concrete production like procurement of ingredients, storing, proportioning, mixing, placing, vibrating and curing of plain, reinforced, pre-stressed and pre-cast concrete etc. This specification broadly covers: -

i) Requirements for source-qualification, procurement, batch qualification testing and storage of concrete ingredients.

ii) Requirements for proportioning of concrete mix, batching, mixing, Transportation, sampling, testing and acceptance of concrete of specified grades.

iii) Requirements for preparation and placement of concrete including chilling, conveying, depositing, compaction, curing, finishing, inspection, testing and preparation of construction joints and repairing, if needed.

b) Wherever information shown is in contradiction to the contents of this specification, all information pertaining to plain, reinforced, pre-stressed and pre-cast concrete shown and noted on the drawings shall be considered part of this specification and shall supersede this specification.

c) During concrete mix proportioning, it may be required, in consultation with the Engineer, to include pozzolanic material (fly ash, micro silica, GGBS etc.) either individually or in combination, to meet the specified requirement of strength and durability. Special provisions with regard to allowable limits of these pozzolanic materials, effect on properties of concrete, durability requirements of concrete have been highlighted. To achieve high level of mechanization in concrete production and placement, special requirements for batching plant, concrete pumping equipment, field practices etc. have also been highlighted.

6.2 QUALIFICATIONS AND APPROVAL OF SOURCES

All materials required for the manufacture of concrete and used for curing of concrete shall be procured only from approved sources. Such approvals shall be given by the Engineer only after due evaluation of tests and test certificates and also after further sampling and testing the materials as per relevant specifications by the contractor. It is the responsibility of the contractor to carry out investigations and evaluation of sources of material for pre-qualification. The contractor shall also ensure that at least two sources of each material are pre-qualified for ensuring uninterrupted supply of material. Bulk procurement of the ingredients of the concrete shall be made only after the contractor has completed the process of pre-qualification and the Engineer has

duly approved the sources/ products. The approval of the Engineer does not, however, absolve the contractor of his responsibility for the quality and consistent supply of the materials.

6.3 STANDARDS AND SPECIFICATIONS

The provisions of the latest revisions with amendments, if any, of the following Indian Standards and other relevant codes shall form part of this specification to the extent they are relevant. Where the provisions of these Standards/Codes are in conflict with the stipulations of this specification, the specification supersedes the respective Standard or Codes.

6.3.1 BUREAU OF INDIAN STANDARDS

IS – 383	Specification for coarse and fine Aggregates from natural sources for concrete.
IS – 456	Plain and reinforced concrete – code of practice
IS – 460	Specification for Test Sieves (Part I, II & III).
IS – 516	Methods of Tests for strength of concrete.
IS – 1199	Methods of sampling and Analysis of concrete.
IS – 1343	Pre-stressed Concrete - Code of practice
IS – 1727	Methods of test for pozzolanic materials.
IS – 1791	General requirements for batch type concrete mixers
IS – 2386	Methods of Test for Aggregates for concrete. (Part I to VIII)
IS – 2395 Part I & II	Painting of concrete, masonry and plaster surfaces - Code of practice.
IS – 2430	Methods of sampling of aggregates for concrete.
IS – 2505	Concrete vibrators – immersion type. - General requirements
IS – 2506	General requirements for concrete vibrators, screed board type.
IS – 2514	Specification for Concrete vibrating Tables.
IS – 2645	Integral Waterproofing Compounds for Cement Mortar and Concrete – Specification.
IS – 2722	Specification for portable swing weigh batchers for concrete. (Single & Double bucket type).
IS –3025	Methods of sampling and test (Physical and Chemical) for water and waste water (Part 1 to63)
IS – 3085	Method of test for permeability of cement mortar & concrete.
IS – 3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS-3812 (Part-I)	Pulverized Fuel Ash – Specification: For use as Pozzolana in Cement, Cement Mortar and Concrete.
IS – 4031	Methods of physical tests for hydraulic cement (Part 1

	to 15).
IS – 4032	Method of chemical analysis of hydraulic cement.
IS – 4082	Stacking and storage of construction materials and components at Site - Recommendations.

IS – 4634	Batch type concrete mixers - method of test performance of.
IS – 4845	Definitions and terminology relating to hydraulic cement.
IS – 4925	Concrete batching and mixing plant: specification
IS – 5816	Splitting Tensile Strength of Concrete – Method of Test.
IS – 5892	Concrete transit mixers - specification
IS – 6461	Glossary of terms relating to cement concrete (Part-1 to 12)
IS – 7320	Specification for Concrete slump test apparatus.
IS – 7325	Specification for Apparatus for determining constituents of fresh concrete.
IS – 7861	Code of practice for Extreme weather concreting (Part 1 & Part 2).
IS – 8112	Specification for 43-grade ordinary Portland cement.
IS – 8142	Method of test for determining setting time of concrete by penetration resistance.
IS - 9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS – 9103	Concrete Admixtures – Specification
IS – 10262	Concrete mix proportioning - Guidelines.
IS – 12089	Specification for granulated slag for manufacture of Portland slag cement.
IS – 12269	Ordinary Portland cement 53-grade - Specification.
IS – 12600	Portland cement low heat - Specification.
IS – 14687	Falsework for concrete structures – guidelines.
IS –14959 (Part-I)	Determination of Water Soluble and Acid Soluble Chlorides in Mortar and Concrete (Fresh mortar and concrete).
IS- 15388	Silica fume- Specification
SP-23	Handbook on Concrete Mixes.

6.3.2 ASTM STANDARDS

ASTM C-33	Standard Specification for Concrete Aggregates.
ASTM C-94	Standard Specification for Ready Mixed Concrete
ASTM C-295	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C-494	Standard Specification for chemical admixtures for concrete.
ASTM C–1202	Standard Test method for electrical indication of concrete's ability to resist chloride ion penetration.
ASTM C-1240	Standard Specification for silica fume used in cementitious mixtures.

ASTM C–1260	Standard test method for Potential Alkali Reactivity of Aggregates (Mortar - Bar Method)
ASTM D–75	Standard practice for Sampling Aggregates
ASTM D–1411	Standard Test methods for Water - Soluble chlorides present as admixtures in graded aggregate road mixes.

6.3.3 ACI / ASME CODES AND SPECIFICATIONS

ACI 211.1	Standard Practice for selecting proportions for normal, Heavy Weight and mass concrete.
ACI 304.1R.	Guide for the use of Preplaced Aggregate Concrete for Structural and Mass concrete Applications.
ACI 304.2R	Placing Concrete by Pumping Methods.
ACI 318	Building code requirements for structural concrete and commentary.
ACI 349	Code requirements for Nuclear safety - related concrete structures
ASME Sec-III Division-2	Code for Concrete Containments

6.3.4 OTHER STANDARDS

a) Railway Specifications – Tests for chloride and sulphate content of aggregates.

b) The European guidelines for Self-Compacting Concrete – Specification, Production and Use (EFNARC Publication).

c) DIN-1048 Specification for water permeability of concrete.

d) Concrete library of JSCE No. 36 – Recommendations for construction of concrete containing ash as a mineral admixture

e) JSCE Concrete engineering series 31- Recommendation for self-compacting concrete

f) BS6699- Specifications for Ground Granulated Blast Furnace Slag for use with Portland cement

6.4 STORAGE OF MATERIALS

a) The contractor shall make necessary arrangements, for safe storage and ensure prevention against deterioration of the materials. Cement, fly ash, GGBS, micro silica, super plasticizers, admixtures, retarders etc. shall, invariably, be stored in weather proof sheds of adequate capacity for storage of the material for at least 3 weeks' of work. However, the contractor shall ensure that sufficient quantities of all materials are available for uninterrupted progress of the work. Cement and other construction materials shall be stored as per recommendations of Indian Standards and as per manufacturer's recommendation. Storage silos shall be watertight. In the

storage area, proper access and lighting shall be provided for inspection, identification and drawl of material. The material shall be stored batch wise with proper identification tag, indicating the quantity received, batch number and the date of receipt and issue. The consignments shall be used in the order of receipt at site, unless otherwise directed. In case of large concrete pours, the material to be used shall be identified and procured well in advance, taking the quantity required for a particular concrete pour into consideration. The cement shall be used within three months from the date of manufacture. However, in exceptional circumstances, if approved by the Engineer, the above stipulation may be relaxed subject to the condition that the material shall be retested to ensure the conformity with the technical specifications. Normally, materials of different type or grade shall not be stored in the same godown. If materials of different type or different grade are stored in the same place, it shall be clearly demarcated and separated to avoid intermixing.

b) The contractor shall prepare an elaborate procedure for the periodic inspection and testing of the materials to detect any deterioration and also for segregation of the deteriorated material. The above procedure shall be approved by the Engineer and implemented by the contractor. It is the responsibility of the contractor to provide all samples and other facilities to the Engineer for carrying out inspection and testing of materials both at the source and at the site of work at his own cost. The rejected materials shall be removed from the site within 48 hours. If the contractor fails to remove the rejected material within 48 hours, the right to get the materials removed from the site rests with the Engineer and all the expenditure incurred by the Engineer for such removal shall be borne by the Contractor.

c) Coarse and fine aggregate (both normal and heavy) shall be stacked on concrete/masonry platforms separately in a manner to prevent their intermixing and to avoid contamination by foreign materials. Each size of aggregate shall be kept separately with wooden, steel, concrete or masonry bulkheads in such a way, to prevent intermixing. If necessary, rock ladders, reclamation tunnels etc. may be provided so that the grading of the material is not affected.

d) All storage arrangements, handling schemes shall be subject to the approval of the Engineer. If the storage arrangement is not to the satisfaction of the Engineer, he may direct the contractor to make such arrangements as he considers necessary and in the event of non-compliance, the Engineer reserves the right to make such arrangements as may be needed at the contractor's risk and cost.

e) A detailed record of receipt and issue of all materials with the associated test certificates shall be maintained by the contractor and shall at all times be available to the Engineer for his scrutiny.

6.5 CONCRETE INGREDIENTS

6.5.1 CEMENT

6.5.1.1 SOURCE QUALIFICATION

a) In no case, cement shall be purchased from agents/ distributors. A minimum of two cement plants shall be pre-qualified well before the start of the concreting works.

b) In general, Ordinary Portland cement (OPC) of 43 grade conforming to IS 8112 and 53 grade conforming to IS 12269 shall be used. In addition to the requirements specified in these standards, following additional requirements shall also be met with:

i) Chloride content shall not be more than 0.05% by mass of cement.
ii) C_3A content shall be between 5% and 8%.
iii) In case of alkali reactive aggregate, alkali content, as Na_2O equivalent shall not be more than 0.6% by mass of cement.

c) Any other special type of cements i.e. Portland Pozzolana Cement (IS 1489 – Part 1 and 2), Portland Slag Cement (IS 455), Sulphate Resisting Cement (IS 12330), Low Heat Portland Cement (IS 12600), Rapid Hardening Portland Cement (IS 8041) may be used in works only with the written permission of the Engineer and only if the design of structures demands the usage of the same.

6.5.1.2 PRE-DISPATCH TESTS

All the consignments of cement shall be accompanied by the manufacturer's test certificate for individual batches, ensuring that cement meets all the requirements of the specification.

6.5.1.3 TEST AT SITE (BATCH QUALIFICATION)

a) In addition to the manufacturer's test certificate, the Contractor shall arrange for testing of the cement either at site laboratory or at any other outside laboratory approved by the Engineer. Cement samples, for such tests, shall be drawn, in the presence of the Engineer or his authorized representative. A composite sample shall be collected representing 250 MT (or such smaller quantity as may be decided by the Engineer) of cement from each grade / brand with proper batch identification. At least 10 grab samples shall be taken representing the entire batch. When cement is supplied in bowser / bulker and directly fed to the silo, grab sample shall be taken from each bowser / bulker. Composite sample shall be prepared by thorough mixing of the grab samples to represent the entire batch.

b) The tests and their frequency shall be as given in Table 6.1.

TABLE 6.1

FREQUENCY OF TESTING OF CEMENT

Sl. .No	Description of Test	Frequency
1	Normal consistency	250 MT or lesser
2	Compressive strength 3 days, 7 days, 28 days	250 MT
3	Initial and final setting time	250 MT
4	Specific gravity	2000 MT

5	Soundness	
a	Le Chatelier's method	2000 MT
b	Auto clave method	2000 MT
6	Specific surface	2000 MT

c) All the chemical tests specified in the relevant standards shall be conducted at an independent laboratory for every 20000 MT of cement supplied or at every 6 months whichever is earlier for each brand/grade. All the chemical compounds shall be reported separately. Bogue's compounds shall also be calculated and furnished.

d) The Engineer shall be able to witness sampling, testing and inspection of cement at the site laboratory or at independent laboratory. Cement shall be released for use, only after ensuring that it meets the requirements of initial and final setting time as well as 3 days compressive strength results. If required, necessary co-relation shall be established between accelerated 1-day strength with 3, 7 and 28-day strengths. Based on this co-relation, cement may be inducted into the work with the prior approval of Engineer in exceptional cases only.

e) Cost of above testing shall be borne by the Contractor. Contractor shall ensure that the construction schedule is not affected because of testing of material at outside laboratory.

f) Test results either from the site laboratory or from an approved outside laboratory shall be taken as final for acceptance or rejection criteria.

6.5.2 FLY ASH

a) Fly Ash conforming to IS 3812 (Part 1) shall only be used. Bottom ash, Ash from Air pre-heater and pond ash shall not be used for mortar as well as for concrete production. Fly ash shall be collected in dry condition from the source with proper moisture proof packing arrangement. Fly ash can also be supplied in bulk containers. For source qualification, three samples from a particular source shall be collected and tested for physical and chemical properties. If all the three samples pass the requirements given in IS 3812 (Part-1) then the source shall be considered as acceptable. However, loss on ignition shall not be more than 2% and particles retained on 45-micron sieve shall not exceed 20%. This requirement is in variance with IS 3812 (Part-1). Bidder will have to meet the requirements given in the specification. In case the quality of fly ash collected from the source does not meet the requirements the contractor will have to use the processed flyash or install a classifier at his own cost.

b) All the physical and chemical tests specified in IS 3812 (Part-1) shall be conducted at every 2,000 MT of fly ash or at every 1-month intervals whichever is earlier. However for fineness only percentage retention on 45-micron sieve shall be the criteria for acceptance or rejection. The discretion to change this frequency rests with the Engineer depending upon the consistent performance of the previous batches. The fly ash, if stored for more than 3 months, it shall be re-qualified before its use.

c) The contractor shall get the test certificate for each batch of supply from the fly ash supplier. The contractor at his own cost shall undertake the following tests either at field laboratory or at outside approved laboratory for each batch of 100 T or part thereof:

i) Percentage retained on 45 micron sieve
ii) Loss on ignition
iii) Moisture content

6.5.3 MICRO SILICA

a) Though micro silica is available in three forms i.e. un-densified, densified and slurry form, only densified form of silica fume shall be used and shall conform to the requirements of IS: 15388.

b) Test requirements of micro silica for source qualification as well as batch qualification shall be as per Table 6.2. For batch qualification tests specified under serial No. 2, 3,5 and 6 of following table (Table 6.2) shall be conducted for every 100 Tons and all other tests shall be carried out at every 2000 Tons.

TABLE 6.2

TEST REQUIREMENTS OF MICRO SILICA

Sl. No.	Description of test	Test method	Requirements
1	SiO_2,(%), min	IS 1727	85.0
2	Maximum Moisture content (%)	See Note 1	3.0
3	Loss on ignition (%), max	IS 1727	4.0
4	Alkalies as Na_2O (%), max	See Note 2 and 3	1.5
5	Oversize percent retained on 45 micron IS sieve (%), Max	IS 1727	10.0
6	Compressive strength at 7 days as percent of control samples	IS 1727 See Note 3	85.0
7	Specific surface (m^2/g), min	IS 15388 Annexure A	15.0
8	Specific gravity*	IS 1727	-

NOTE:

1. For determination of moisture content, dry a weighed sample as received in an oven at 105^0C to 110^0C. Express the percentage loss in mass and record as moisture content.

2. For determination of alkalis, method of test used for determination of alkali in cement may be adopted.

3. In the test method for determination of compressive strength of silica fume cement

mortar in accordance with IS: 1727, the value of factor N may be taken as 1.

4. Specific surface test is optional.

5. Tests specified above shall be carried out by the contractor at his own cost.

(*) For batch qualification the specific gravity value shall not deviate by ±0.2 from the values obtained during mix qualification

6.5.4 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

a) The GGBS shall conform to BS 6699. The GGBS may be used with OPC (Ordinary Portland Cement) 43 grade conforming to IS: 8112 or 53 grade conforming to IS: 12269.

b) Test requirements of GGBS for source qualification as well as batch qualification shall be as per Table 6.3. Cost of testing shall be borne by the Contractor.

TABLE 6.3

TEST REQUIREMENTS OF GGBS AS PER BS 6699

Sl. No	Description of test	Test method	Requirements
1	Fineness (M^2/Kg)	EN-196-6	275 (minimum)
2	Soundness (Le Chatelier Expansion) in mm	EN-196-3	10.0 (maximum)
3	Loss on ignition (%), max	EN-196-2	3.0 %
4	Insoluble Residue (%)	EN-196-2	1.5 (max)
5	Initial Setting Time (IST)	EN-196-3	Not less than IST of OPC
6	Magnesia content (%)	EN-196-2	14.00 (max)
7	Sulphide Sulphur (%)	EN-196-2	2.00 (max)
8	Sulphite Content (%)	EN-196-2	2.50 (max)
9	Magnese Content (%)	EN-196-2	2.00 (max)
10	Chloride Content (%)	EN-196-21	0.10 (max)
11	Moisture Content (%)	BS 6699-APPN-E	1.00 (max)
12	Glass Content (%)	BS 6699-APPN-D	85 (min)
13	Compressive strength in (N/mm^2) After 7 days After 28 days	EN-196-1	 12.0 (min) 32.5 (min)
14 a b c	Chemical Moduli $CaO + MgO + SiO_2$ $CaO + MgO / SiO_2$ CaO / SiO_2	EN-196-2	66.66(Min) > 1.0 < 1.4

In case of use of Portland Slag Cement the cement shall meet all the requirements

given in IS 455.

c) All the physical and chemical tests shall be conducted at every 500 MT of GGBS or at every 6 months intervals whichever is earlier. The discretion to change this frequency rests with the Engineer depending upon the consistent performance of the previous batches. The contractor shall also get the test certificate for each batch of supply from the GGBS supplier.

6.5.5 AGGREGATE

a) The samples of coarse and fine aggregate shall be tested by the contractor at his own cost as per Table-6.4 while qualifying the source and thereafter at regular intervals as mentioned therein. The regular supply of coarse and fine aggregates shall commence only after approval of the source. The layout of the crushing, washing and batching plant shall be subject to the approval of the Engineer. The crushing plant shall include vertical shaft impactor in the system, so as to obtain cubical aggregate as well as crushed fine material for use as manufactured sand. ***Contractor shall note that crushing of aggregate at GHAVP site is prohibited.*** Direct purchasing of crushed aggregate from outside suppliers may be allowed subject to the condition that the material so procured meets this specification. The contractor, however, is advised to procure the boulder and crush the same at a place convenient to him. Alternatively, he may establish crushing machinery at the quarry and transport the crushed aggregates/ crushed sand. All efforts should be made by the contractor to contain the dust level to the minimum so as to meet environmental standards by incorporating suitable filters and/ or any such arrangements.

TABLE 6.4

AGGREGATE TESTING SCHEDULE AND REQUIREMENTS

Sl. No.	Activity/Test	Frequency	Applicable Code	Requirement
1(*)	Petrographic strained quartz analysis by weight	One sample for new source or change in source of aggregates	IS: 383 / ASTM C-295	<20%
2(*)	Alkali reactivity			
a)	Mortar bar method	One sample fornew source or change in source of aggregates.	ASTM C-1260	Expansion shall be less than 0.10% at 16days
b)	Chemical method	One sample for new source or change in source of aggregate and Subsequently once in 6 months during progress of work.	IS: 2386 / IS: 383	Shall fall in innocuous zone
3	Chloride content	-do-	IS 14959(P-I) / Railway Spec	0.04% by wt. max.
4	Sulphate	-do-	IS 3025(P-24)	0.40% by wt. max.

Sl. No.	Activity/Test	Frequency	Applicable Code	Requirement
	content		/Railway Spec.	
5	Iron content for heavy density aggregates	One sample for every 5000 MT for new source or change in source	NPC Spec.	Shall not be less than 60% 4.65 (for HA)
6	Specific gravity (SSD condition)	-do-	IS: 2386	2.6 (for C.A.) 2.55(for F.A.)
7	Deleterious material	-do-	IS: 2386 / IS: 383	Refer Table No.6 and 8
8	Size and Gradation	One sample for every 1000 Cum of concrete (minimum one sample per week)	IS: 2386 / IS: 383	Refer Table No. 5 and 7
9	Absorption/. Moisture content	One sample daily	IS: 2386	3% max.
109	Silt content (for natural sand only)	Once in a week	IS: 383	8% max. By volume
10	Organic impurity (for natural sand only)	Once in six months	IS: 2386 / IS: 383	No impurity
11	Flakiness and elongation index (for C.A. only)	Once in a month	IS: 2386	Individual-15% max.
12	Crushing value (for C.A. only)	Once in six months	IS: 2386	45%** max.
13.	Abrasion value (for C.A. only)	Once in six months	IS: 2386	
14.	Impact valve (for C.A. only)	Once in six months	IS: 2386	

(*) Based on the test results of Petrographic examination and /or alkali aggregate reaction test, if aggregate is found alkali reactive, remedial measures like restricting the alkali content of cement, admixture and/or addition of pozzolanic material shall be resorted to with the approval of the Engineer. As a normal rule, such aggregate shall not be used into work and efforts shall be made to obtain non-reactive aggregate.

(**) These limits shall be 30% (maximum) for aggregate to be used in road construction.

6.5.5.1 WASHING OF AGGREGATE

The impurity level in both coarse aggregate and fine aggregate shall be controlled. If impurities are beyond acceptable limits, the contractor shall at his own cost make necessary arrangements to wash the river sand/ aggregate before inducting the same into concrete. Silt content of sand shall be checked for each truckload and shall be brought within acceptable limits by washing. Both coarse aggregate and fine aggregate shall be washed thoroughly to remove all vegetation, perishable substances, and objectionable amounts of foreign matter, quarry dust, clay lumps, silt and such other deleterious materials. A suitable washing mechanism shall be provided as per scheme approved by the Engineer. The contractor shall prepare a detailed procedure for washing indicating the washing arrangement and get approval of the same from the Engineer. The washing arrangement shall be such as to remove the wastewater along with the unwanted materials and drain the same away from the site. It shall also not be directly let into the river/ nallah or such other existing water bodies.

6.5.5.2 FINE AGGREGATE

Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof. Fine aggregate having a specific gravity of less than 2.55 (saturated surface dry condition) shall not be used. Fine aggregate shall be graded within the limits specified in Table 6.5. The sand shall be of siliceous material, sharp, hard, strong and durable and shall be free from adherent coating, clay, dust, alkali, organic material, deleterious matter, lumps, etc. Sampling of fine aggregate shall be in accordance with IS: 2430. Fine aggregate shall be so graded that concrete of required workability, density and strength could be produced using the specified water binder ratio. The method of determination of gradation shall be as per IS: 2386.

TABLE 6.5

GRADING LIMITS FOR FINE AGGREGATES

IS Sieve designation	Percentage passing by weight		
	Zone-I	Zone-II	Zone-III
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-75	55-90	95-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

NOTE :

1. For crushed sand, the permissible limit on 150 micron IS sieve shall not exceed 20%. This shall not affect 5% allowance permitted on clause 1.3 of IS – 383 applying to other sieve size.

2. Fine aggregate complying with the requirement of both grading Zone-I and II of Table–1.5 are only suitable for concrete production. However, in exceptional cases, with the specific permission of Engineer the Zone –III sand may also be used.

3. In addition to above, the fine aggregate shall be so graded that the concrete of the required workability, density and strength can be produced. The method of determining gradation by sieve analysis shall be in accordance with IS: 2386.

6.5.5.2.1 FOREIGN MATERIALS LIMITATIONS IN FINE AGGREGATE

The fine aggregate shall be free from injurious amounts of dust, clay lumps, pyrites, coal, lignite, soft, elongated or flaky particles, shale, alkali, organic matter, loam, mica and other deleterious substances. The percentage of deleterious substances in the fine aggregates, as delivered to the mixer, shall not exceed the values given in Table 6.6, when tested in accordance with IS: 2386.

TABLE 6.6

LIMIT OF DELETERIOUS MATERIALS IN FINE AGGREGATE

Description of test	% By weight	
	River sand	Crushed Sand
a) Material passing 75 micron	3.0 (max)	15.0 (max)
b) Shale	1.0 (max)	Nil
c) Coal and Lignite	1.0 (max)	Nil
d) Clay lumps	1.0 (max)	1.0 (max)
e) Total of other deleterious substances such as alkali, Mica coated grains, soft and flaky particles and loam	2.0 (max)	2.0 (max)
f) Total of all above substances	5.0 (max) *	2.0 (max) *

* Excluding (a)

6.5.5.2.2 ORGANIC IMPURITIES

Aggregate, when tested in accordance with IS: 2386 (Part-2), "The method of test for aggregate for concrete – Estimation of deleterious materials and organic impurities", producing a colour darker than the standard shall be rejected. However, such sand, when tested for mortar-making properties and the mortar develops a compressive strength at 7 and 28 days of not less than 95% of that developed by a similar mortar made from another portion of same sample which has been washed in 3% solution of sodium hydroxide followed by thorough rinsing in water, then the Engineer may permit use of such sand on works.

For sand that is used after washing, the washed water from the sand shall be free from water-soluble chloride and sulphate content. The presence of chloride and sulphate

content can be checked with silver nitrate and barium chloride respectively. Prior approval of the Engineer shall be taken for bringing sand from new sand quarry or change in quarry.

6.5.5.2.3 USE OF CRUSHED SAND

If the contractor desires to replace sand partially or completely, with crushed sand, he may do so only if the quality of final product meets all the requirements of these specifications. It shall be noted that crushed sand shall be manufactured by specially crushing it from the aggregate by deploying proper machinery for the same. Crusher dust obtained while producing aggregate shall not be directly used for replacing sand unless it meets the technical specifications/ grading limits specified in Table Nos.6.4, 6.5 and 6.6.

6.5.5.2.4 FREQUENCY OF TESTING AND OTHER CHARACTERISTICS

The fine aggregate shall be tested for physical, chemical & mechanical properties and impurities content as per schedule given in Table Nos. 6.4, 6.5 and 6.6.

6.5.5.2.5 COARSE AGGREGATE

Coarse aggregate for normal concrete shall consist of hard, strong, durable particles of crushed stone and shall be free from thin elongated soft pieces, vegetation or other deleterious matter. It shall have no adherent coating. Coarse aggregate shall have an average specific gravity (saturated surface dry condition) 2.6 or more and no individual value shall be less than 2.55.

6.5.5.3.1 GRADING

The size of normal aggregate shall be selected from the standard sizes given in Table 6.7. The method of determining grading by sieve analysis shall be according to IS: 383. The stones required for making aggregates shall be transported to the crushing plant, preferably to be installed near the site of work and shall be crushed by the Contractor in primary and secondary crushers to yield the aggregates to the required sizes and specification as described under various items of schedule of quantities in Section-VIII of the document. In areas, where there is congestion of reinforcement and embedment, the Engineer may direct the contractor to use smaller size of aggregate without any additional cost for screening off the higher sizes.

TABLE 6.7

GRADING REQUIREMENTS OF COARSE AGGREGATES

Sl. No.	Nominal size	Amounts finer than each sieve (square openings) weight							
		50 mm	40 mm	20 mm	12.5 mm	10 mm	4.75 mm	2.36 mm	1.18 mm

1	40 to 4.75 mm	100	95 -0	30-70	-	10-35	0-5	-	-
2	20 to 4.75 mm	-	100	95-100	-	25-55	0-10	-	-
3	12.5 to 4.75 mm	-	-	100	90-100	40-85	0-10	-	-
4	10 to 2.36 mm	-	-	-	100	85-100	0-20	0-5	-
5	20 to 10 mm	-	100	85-100	-	0-20	0-5	-	-
6	40 to 20 mm	100	85-100	0-20	-	0-5	-	-	-

6.5.5.3.2 FOREIGN MATERIALS LIMITATION

The amount of deleterious substances in coarse aggregate shall not exceed the limits given in Table 6.8.

TABLE 6.8

LIMIT OF DELETERIOUS MATERIALS IN COARSE AGGREGATE

Sl. No.	Deleterious substances	Maximum percent by weight of total sample
1	Coal and Lignite	1.00
2	Shale	NIL
3	Clay Lumps	1.00
4	Soft fragments	NIL
5	Material finer than 75 micron	3.00
6	Sum of percentage of all Deleterious materials	5.00

6.5.6 WATER

a) Water used for both mixing of concrete and curing shall be clean and free from injurious amounts of oil, acids, alkalis, salt, sugar, organic materials or other substances that may be deleterious to the concrete or steel. Potable water is generally considered satisfactory for mixing and curing of concrete. The pH value of water shall generally be not less than 6. The sources of water shall have approval of the Engineer. The quality of water shall meet the provisions of IS: 3025 particularly Parts 22 and 23. The sample of water taken for testing shall represent the water proposed to be used for concreting, due attention being paid to seasonal variation. The quality of water shall be tested at every 6 months. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete or curing. The sample shall be stored in a clean container previously rinsed out with similar water. ***The exploitation of Ground Water for construction work is prohibited at GHAVP site .***

b) Permissible limits of solids, when tested in accordance with IS: 3025 are given in Table 6.9.

TABLE 6.9

PERMISSIBLE LIMIT FOR SOLIDS

Sl. No.	Description of test	Tested as per	Permissible limits (max.)
1	Organic	IS3025 (Part 18)	200 mg/l
2	Inorganic	IS3025 (Part 18)	3000 mg/l
3	Sulphates (as SO_3)	IS3025 (Part 24)	400 mg/l
4	Chlorides (as Cl)	IS3025 (Part 32)	2000 mg/l for concrete not containing embedded steel and 500 mg/l for reinforced concrete work
5	Suspended matter	IS3025 (Part 17)	2000 mg/l

c) In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests of concrete.

d) Average 28-day compressive strength of at least three 15 cm size concrete cubes, prepared with water proposed to be used, shall not be less than 90 percent of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with IS: 516.

e) The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes. The initial setting time shall also not differ by more than +30 minutes from the initial setting time of control test block prepared with the same cement and distilled water. The test blocks shall be prepared and tested in accordance with IS: 4031 (Part 5).

6.5.6.1 USE OF ICE AND CHILLED WATER

a) The Contractor shall study the placement temperature requirement, the ambient conditions and work out the refrigeration plant capacity to meet the construction schedule. It shall be noted that the temperature of the concrete indicated in the drawings/ specifications is at the placing point. The contractor shall submit his scheme of temperature control of concrete with detailed calculations before the actual commencement of work. The temperature control may be achieved either by mixing chilled water or by addition of ice flakes depending upon the ambient conditions and transportation time.

b) Mixing water shall be kept cool by storing it under cover. Storage tank shall always be kept clean. Water shall be transported to the mixing plant in such a way that there

is no rise in temperature. If chilled water or crushed ice is used as a part of mixing water to achieve the specified temperature of water, the Contractor shall install and maintain in good working condition a refrigeration plant to produce chilled water at temperature not exceeding 8°C. The Contractor shall also build and maintain well-insulated adequate capacity storage tanks for cold water with insulated piping. To supplement this refrigeration facility, the Contractor may establish ice plant of suitable capacity. The full quantity of crushed ice shall be stored in cold storage 24 hours in advance of start of concreting. The temperature in the cold storage shall not be higher than (-2°C).

c) Ice, if used as replacement for a portion or all of the mixing water, shall be produced from water, which meets the requirements of this specification. Ice shall be in flaky condition and such ice flakes shall have thickness less than 3 mm. The ice plant should be capable of producing flaked ice. The Contractor shall make his own arrangement for storing adequate quantity of ice. Commercial ice shall not be used. In case of large pours, where the existing refrigeration capacity is not adequate, the contractor may use commercial ice, subject to the approval of the Engineer, after ensuring that the quality standards of this specification are met with.

6.5.7 CHEMICAL ADMIXTURES

a) The Contractor shall procure all chemical admixtures required in the specification. The Contractor shall ensure consistent behavior of proposed admixtures in concrete mixes and at all ambient temperatures likely to be experienced at project site throughout the year, and especially at the recommended placement temperatures. Contractor shall arrange for pre-qualification of such admixtures to fulfill the requirements specified in ASTM C-494 at his own cost. Qualification of chemical admixtures shall be carried out as per the guidelines given in ASTM C 494, using concrete with a cement content of 307 kg/m^3. Setting time of concrete with admixtures shall be decided by casting specimens and keeping the same in a temperature controlled room at a temperature of 23 (+/-) 2^{0}C. Base material of admixture shall be either sulphonated naphthalene formaldehyde based or poly carboxylic ether based only. High range water reducing and retarding admixture conforming to type G of ASTM C-494 shall be used.

b) Generically high range water reducing and retarding admixture shall be of either Sulphonated Naphthalene Formaldehyde condensate (SNF), Sulphonated Melamine Formaldehyde condensate (SMF) or Poly Carboxylate and conform to type G of ASTM C-494 depending on the fines content and limitation of chlorides, sulphates and other alkali contents.

c) The admixture to be used for Viscosity Modifying Agent (VMA) shall generically be either of Modified Cellulose or Poly-ethylene Glycol.

d) Admixture samples, when tested, shall meet the requirements given in Table 6.10.

TABLE 6.10

ADMIXTURE QUALIFICATION TEST

Sl. No	Description of Test	Acceptance values for Type G
1	Water Reduction as % of Control Mix	18 % minimum (*)
2	Air entrainment	± 1 % of control mix
3	Initial Setting Time Deviation from control At least Not more than	 1:00 hour later 3:30 hours later
4	Final Setting Time Deviation from control At least Not more than	 -- 3:30 hours later
5	Compressive strength As % of Control Mix 1 day 3 day 7 day 28 day	 125 % min 125 % min 115 % min 110 % min
6	Flexural Strength as % of Control Mix 3 day 7 day 28 day	 110 % min 100 % min 100 % min
7	Specific gravity at 25^0C	Within ±0.02 of the value stated by manufacturer
8	Solid content	With ± 3% of the value stated by the manufacturer
9	Ph	7-8
10	Chloride content	0.2 % max
11	Infrared Spectrograph	Identification of base material of the admixture

(*) This value is at variance with the ASTM C 494.

6.5.7.1 SAMPLING

a) The manufacturer's tests certificates shall accompany all individual batches of admixtures. Batches of admixture, not accompanied with correlating test certificates, shall not be inducted into the work till the tests are completed and the material found

meeting the standards. The batches/lots of admixture, accepted for testing, shall be identified with the unique sample number. Location of the product containers shall be distinctly identified and cordoned off to prevent mix-up with other products and brands and unacceptable materials.

b) Admixture shall be thoroughly agitated by using mechanical agitator, prior to sampling and a composite sample shall be collected representing 25.0 MT of admixture with proper batch identification. Grab sample shall be taken from each batch. Even if number of batches are less than 4, minimum 4 such grab samples shall be taken representing 25 MT of admixture and composite sample shall be prepared by thoroughly mixing the grab samples. Volume of each grab sample and composite sample shall be as decided by the Engineer.

c) It may also be noted that the admixture shall be thoroughly stirred before actual use. Mechanical stirring is mandatory and manual stirring shall not be permitted.

6.5.7.2 BATCH QUALIFICATION

Each batch of 25 MT (or lesser) of admixture shall be tested and qualified before use. All the tests, as given in Table-6.10, except 1-day compressive strength and flexural strength, shall be conducted. Admixture shall be released only after meeting the specified requirements. Infrared spectrograph of each batch shall be compared with the signature infrared spectrograph of that brand taken at the time of brand qualification to ensure consistent quality. In the event of tests failing to meet the specified requirements during batch qualification, the particular batch shall be rejected and removed from site.

Once accepted by the Engineer, one representative sample of 5 litres (approx.) shall be preserved from each batch upto 1 month from its expiry date. Such representative samples shall be identified, tagged and sealed indicating the sample identification number, brand name, batch number, date of manufacture, date of collection and expiry date.

6.5.7.3 STORAGE

The admixture shall be accompanied by manufacturer's certificate indicating the expiry date. The product shall not be used after this date. Admixture shall be used as per manufacturer's instruction and with the control specified by the Engineer.

Utilization and storage conditions shall conform to in the corresponding technical documentation given by the manufacturer.

Contractor shall make adequate arrangement for procurement of admixture at least 45 days prior to use, as testing time for batch qualification takes minimum 30 days. Adequate quantity of tested material shall be stored to meet the construction schedule.

6.5.7.4 OTHER TYPE OF ADMIXTURES

The Engineer may, at his discretion, instruct the contractor to use any other type of admixture in concrete i.e. admixture conforming to ASTM C-494 Type A to F, water proofing admixture conforming to IS 2645 etc. These admixtures, if used, shall be qualified, on the same lines before use.

6.5.7.5 VISCOSITY MODIFYING AGENT (VMA)

a) Viscosity modifying agent shall be used in self-compacting concrete (SCC) to increase the segregation resistance of concrete. VMA shall be added in SCC as per the recommendations of the manufacture and it shall be ensured through trials that it does not have any adverse effect on any of the properties of green and hardened concrete.

b) The VMA shall generically be of water-soluble polymers, Modified Cellulose or Poly-ethylene Glycol, which are adsorbed on to the surface of the cement granules causing changes in the viscosity and the rheological properties of the mix. It shall be chloride free and compatible with all cements envisaged by IS standards.

c) Sulphonated Naphthalene based superplasticizer SNF is avoided, as it is not compatible with VMA. Other type of VMA can also be used if it meets the desired parameters of SCC, and compatible with the superpasticizer. It may be noted that there is no specific testing for qualification of VMA, other than its meeting desired properties of SCC for each batch of material (VMA).

d) Super plasticizers containing VMA may also be used for the production of self-compacting concrete subject to meeting all the desired properties of SCC.

6.6 CONCRETE MIXING PLANT

A numbers of modern concrete batching and mixing plant capable of producing concrete of specified quality and at the required output rate shall be established by the Contractor at site. For mixing fly ash at site, Pan type mixer is preferred. A balanced complement of mixing, transporting, handling and placing equipment shall be deployed. Prior to use, the concrete mixing plants shall be completely installed and operated for a sufficient length of time to enable the Engineer to make the necessary physical tests (to assess the performance). Batching plants shall be fully automatic with computerized control along with the facility of automatic moisture correction.

Contractor shall provide, along with the tender proposal, full details of the batching plants to be deployed at site. After the award of the work, the layout of the plants, the full technical data and other details shall be submitted to the Engineer well before the actual setting of the plant.

6.6.1 TYPE OF PLANT

a) The type of plant to be deployed shall be automatic. The term ‘automatic’ is used to define a plant in which:

i) Batch weights are set on a mix selector manually,

ii) Mixes are batched in weigh hopper by operation of electric switch in one operation automatically,

iii) Ingredients are charged in the mixer, concrete is mixed and unloaded in a hopper in one operation by selecting mix number and operating a push button or through operation by computer.

b) Batching plant shall be capable of producing concrete according to the proportion set and controlled by the computer within the desired accuracy and tolerances specified for each of the ingredients, with different combinations of mixing sequences to produce concrete of different grades with the help of a single command. Plant software shall be capable of giving the batch weight records for each batch along with mixing cycle time in a format approved by the Engineer.

c) Each batching and mixing plant shall preferably comprise offour or five overhead storage bins for coarse and fine aggregate and cylindrical silos for cement, fly ash, GGBS and / or micro silica of adequate capacity, arrangement of adding water and admixture, to meet uninterrupted supply of concrete for placement in different pours. If cement is brought to the site in browsers / bulkers and directly loaded to the silos, then it is preferable to have minimum 3 silos for each batching plant for storage of cement. Alternatively, the silos can be kept connected to all the batching plants by providing interchangeable facility. Separate silos of adequate capacities are to be provided for fly ash, GGBS and micro silica, as the case may be, with suitable arrangement for direct loading and charging into the mixer. For loading fly ash, GGBS and micro silica, pneumatic conveyer shall be used, as screw type conveyers get choked frequently.

d) Storage bin of sufficient capacity for ice flakes shall be installed and fixed in such a way that water from melting ice shall not flow in the mixer through batcher but shall be collected in a conical vessel and drained outside.

e) The least count of weighing dials for 1 cu.m batch size plant shall be as per Table 6.11

TABLE 6.11

CAPACITY AND LEAST COUNT OF WEIGHING MECHANISM

Si.No.	Item	Capacity of dial (Kg.)	Least Count (Kg.)
1.	Cement	600	1
2.	Fly ash	600	1
3.	GGBS	600	1
4.	Microsilica	100	0.2
5.	Aggregate	2500	5
6.	Water	250	1

7.	Ice	250	1
8.	Admixture	25	0.1

f) If the batch size is different from 1 cu.m, then the capacity and least count of dials shall be modified accordingly. However, considering the demand rate of concrete, batching plant mixer of 2 cu.m. Capacity is preferred for all major concrete works.

g) Control room of the batching plant housing the instrumentation shall be free from vibrations and dust and shall be arranged as per the specification of the manufacturer. Indicators shall be fixed in such a way that operator is able to see batching of aggregate, mixing of concrete etc. directly and also all the dial indicators are clearly visible from one point.

h) All operations from charging the mixer to unloading of mix shall be interlocked so that unless mixer is empty, no new batch of ingredients is charged into the mixer.

6.6.2 WEIGHING AND BATCHING

6.6.2.1 WEIGHING UNITS

Every delivery point of aggregate, cement, fly ash, GGBS and/or micro silica into the mixer charging hopper shall have a weighing unit and each weighing unit shall include a visible, spring-less direct reading dial which shall indicate the scale load at all stages of the weighing operation from zero to full capacity. As far as practicable, the scale dials and the weighing equipment shall be in full view of the operator, so that he may conveniently observe the operation of the batcher gates and the discharge of the materials. Provision shall be made for adjustment and change in weights of materials being charged into the hopper.

Bins with adequate compartments shall be provided in the batching plant for fine aggregate and for each required size of coarse aggregate. Each bin compartment shall be designed and operated so as to discharge efficiently and freely into the weighing hopper with minimum segregation. Means of control shall be provided such that, when quantity desired in the weighing hopper is approached, the gate shall shut off with precision. Weighing hoppers shall be so constructed that it will eliminate accumulations of tare materials and material is discharged fully.

6.6.2.2 MEASURING WATER AND ICE

Water and Ice shall be measured by weight. The mechanism for measuring and delivering water to the mixers shall not permit leakage when the valves are closed. The filling and discharge valves for the water tank shall be so interlocked that the discharge valves cannot be opened before the filling valve is fully closed.

6.6.2.3 MOISTURE CORRECTION

The batching plant shall be provided with at least one moisture probe attached to the fine aggregate bin. This probe shall sense the moisture in the fine aggregate at the

time of batching and send the appropriate signal to the computer of batching plant so that adjustment in water quantity and fine aggregate quantity is made.

6.6.2.4 DISPENSER FOR ADMIXTURE

The concrete plant shall include dispensing device to accurately measure and deposit the full quantity of admixture into each mix at one time. The dispenser shall be interlocked with the batching and discharging controls of the water so that the batching and discharge of the admixtures will be automatic. The device shall be capable of ready adjustment to permit varying the quantity of the admixtures to be batched. The equipment shall be kept in a clean and fully operable condition.

6.6.2.5 TOLERANCE IN BATCHING WEIGHMENT ERRORS

The accuracy of weighing devices shall be as per Table 6.12:

TABLE 6.12

ACCURACY OF WEIGHING MECHANISM

Material	Percent of accuracy
Cement / Fly ash/GGBS	± 1 (by weight)
Water/Ice	± 1 (by weight)
Aggregate	± 2 (by weight)
Admixture	± 1 (by weight)
Micro silica	± 1 (by weight)

At least once in a month, the contractor shall check that the quantities of materials leaving the scales comply with the specified quantity within the tolerances. If discrepancies are noticed, he shall immediately make necessary required corrections and shall undertake re-calibration.

6.6.3 MIXING TIME

a) The mixing time required should be based upon the ability of mixer to produce uniform concrete throughout the entire manufacturing process and for this; the manufacturer's specifications shall be followed. However, final mixing time should be based on the result of mixer performance test (uniformity test) made at frequent intervals throughout the duration of job. The mixing time shall be measured from the time all ingredients are in the mixer. Batch time with audible indicators used in combination with interlocks, to prevent under or over mixing of the batch and premature discharge, should be provided. The mixer shall be design for starting and stopping under full load.

b) In case of concrete with micro-silica, to ensure that agglomerates of densified micro silica break fully, mixing time required would generally be 1.5 times the time

required for normal concrete and the same shall be established by conducting trials. Micro silica concrete needs additional mixing time. It is preferable to charge micro silica into the mixer along with coarse and fine aggregate, premix it for 10 seconds followed by charging of remaining ingredient i.e. cement, fly ash, water, ice and admixture into the mixer and final mixing of around 30 to 60 seconds. The time and sequence of loading shall be established by conducting trials.

c) Mixer is considered to pass the uniformity test if two samples taken after discharge of approximately 15% and 85% of the load meet the requirement given in Table 6.13**.**

TABLE 6.13

MIXER PERFORMANCE REQUIREMENTS

Sl. No.	Test	Requirement, expressed as maximum permissible difference in result of tests of samples taken from two locations in the concrete batch
1	Air entrainment	1.0 %
2 a) b)	Slump Average slump is less than 100mm Average slump is more than 100mm	 25 mm 40 mm
3	Average compressive strength at 7 days for each sample, based on the average strength of all compressive test specimens	7.5 %

d) Once the batching plant passes the performance test, for further compliance only slump test will be conducted at the frequency specified in Table 6.13.

6.6.4 RECORDS AND CHARTS

a) The Contractor shall maintain accurate records of the following at the batching plant for each batch:

i) The weight of cement, fly ash, GGBS, micro silica, water and admixture.
ii) The weight of coarse aggregate for each size recorded separately.
iii) The weight of fine aggregate for each size separately.
iv) The concrete Temperature immediately after mixing.
v) Mixing time of each batch, after all the materials are loaded into the mixer.
vi) Time of delivered of the concrete is from the mixer.
vii) Ambient temperature

b) The record shall be maintained by automatic recording and printout. Computer printouts shall also indicate the preset quantity of each ingredient, actual quantity discharged and error in it. The limits specified in the Table 6.12 shall be met (as an average) at the end of loading cycle of each transit mixer.

6.6.5 MAINTENANCE

The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free from hardened concrete. Mixer blades shall be replaced when worn down more than 10 percent of their depth. Should any mixer at any time produce unsatisfactory results or mortar leakage is observed, its use shall be promptly discontinued, till it is repaired.

6.6.6 PROVISION FOR INSPECTION

The complete plant assembly shall include provisions to facilitate the inspection of all operations at all times.

6.6.7 SAMPLING FACILITIES

Suitable facilities shall be provided for readily obtaining representative samples of concrete ingredients from any of the batchers and suitable devices for obtaining representative samples of concrete for determination of properties of fresh and hardened concrete to be made by the Contractor. All necessary platforms, tools and equipment for obtaining samples shall be made available at the start of work and shall be maintained throughout contract period.

6.6.8 CONCRETE SPECIMEN

Concrete specimen shall be prepared from the mixes used in the work and tested to determine the adequacy and accuracy of control for the materials entering into the concrete mix. The Contractor shall perform preparation, storage and testing of the specimen in presence of the Engineer to his entire satisfaction.

6.6.9 TEST WEIGHTS AND CALIBRATION

The Contractor shall provide standard test weights and any other auxiliary equipment, required for checking the operating performance of each scale or other measuring device. All the weighing scales shall be calibrated every month or whenever doubts arise or before any major pour, as directed by Engineer. Batching plant shall be allowed to use for production of concrete only if it meets the specified requirements.

6.7 PRE-REQUISITIES OF CONCRETE

6.7.1 CLASSES OF CONCRETE

Unless otherwise specifically stated as Nominal Mix, all concrete, contemplated under this specification, shall be taken to mean as "**Controlled Concrete**".

6.7.2 CONTROLLED CONCRETE

Controlled concrete is a concrete where the mix proportions are determined by mix design, preliminary mix proportioning and laboratory tests. These shall be carried out at specified intervals and also whenever the Engineer has reasons to believe that there

has been a change in the quality, properties, or grading etc of any of the constituents of concrete, which, in his opinion, would impair the strength and /or durability.

Each class of concrete shall be identified by designation consisting of a prefix and two numbers like N/25/40. Prefix 'N', 'H' and 'SH' signifies Normal concrete, Heavy concrete made with hematite aggregates and Super Heavy concrete with a combination of hematite aggregates and chilled iron shots or steel punching respectively. Next two numbers e.g. 25 and 40 would denote the Uniaxial characteristic compressive strength at 28 days in MPa (25 MPa and maximum size of coarse aggregate in mm (40 mm) respectively.

6.7.3 NORMAL CONCRETE

Class designation of concrete shall be as specified on the drawing. Maximum size of aggregate shall be 20 mm unless specified otherwise. However, when concreting has to be carried out in congested areas, maximum size of aggregate may be suitably reduced, with the approval of the Engineer.

Unless otherwise specified on drawings or called for in the schedule of Quantities, the class designation of normal concrete to be used shall, generally, be selected from Table 6.14.

TABLE 6.14

GRADES OF NORMAL CONCRETE

Class	Characteristic Compressive Strength of 15 cm cubes at 28 days in MPa	Maximum size of aggregate in mm
N/10/20	10	20
N/20/20	20	20
N/30/20	30	20
N/35/20	35	20
N/40/20	40	20
N/45/20	45	20
N/50/20	50	20
N/60/20	60	20
Normal Grout	30*	Fine Aggregate

Normal concrete shall have a net unit weight of not less than 2400 Kg/cu.m.
* The compressive strength for grout shall be on cubes having area of face 50 cm^2.

6.7.4 MIX PROPORTIONING CRITERIA

The mix proportioning, in case of OPC concrete shall be based on 28-day characteristic strength. For concrete containing fly ash, GGBS or any other mineral admixture, the concrete acceptance criteria shall be based on 56- day strength. Any other specific requirement, if any, will be as indicated on the construction drawings.

6.7.5 DURABILITY OF CONCRETE

To meet the requirement of durability, the water content as well as water to binder ratio shall be as low as practicable. In addition, there shall be adequate compaction and immediate curing as well as curing for longer period is necessary.

6.7.6 EXPOSURE CONDITIONS

Various conditions for which the concrete will be exposed during its service life are given in the Table 6.15.

TABLE – 6.15

ENVIRONMENTAL EXPOSURE CONDITIONS

Sl. No	Environment	Exposure Condition
1	Mild	Concrete surface protected against weather or aggressive conditions except those situated in coastal area.
2	Moderate	Concrete surface sheltered from severe rain or freezing whilst wet Concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non-aggressive soil / ground water. Concrete surfaces sheltered from saturated salt air in coastal area.
3	Severe	Concrete surface exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in seawater. Concrete exposed to coastal environment.
4	Very Severe	Concrete surface exposed to seawater spray, corrosive fumes or severe freezing conditions whist wet. Concrete in contact with or buried under aggressive subsoil / ground water.
5	Extreme	Surface of members in tidal zone Members in direct contact with liquid/solid aggressive chemicals

Unless otherwise specified in the drawing, **'Severe' and 'Moderate'** exposure conditions shall be considered for Coastal and inland sites of NPP respectively and mix proportioning of all types of concrete shall be carried out accordingly.

6.7.7 MINIMUM CEMENT CONTENT, MAXIMUM W/C

Unless specifically mentioned in the drawings, the values for minimum cement content and the maximum free water-cement ratio given in the Table 6.16 for different exposure conditions and for 20 mm maximum size aggregate may be used in the mix design.

TABLE 6.16

MINIMUM CEMENT CONTENT, MAXIMUM WATER-CEMENT RATIO AND MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH NORMAL WEIGHT AGGREGATE OF 20MM NOMINAL MAXIMUM SIZE

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum Cement Content kg/m^3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m^3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete
Mild	220	0.60	-	300	0.55	M 20
Moderate	240	0.60	M 15	300	0.50	M 25
Severe	250	0.50	M 20	320	0.45	M 30
Very Severe	260	0.45	M 20	340	0.45	M 35
Extreme	280	0.40	M 25	360	0.40	M 40

Notes:

a) Cement content prescribed in this table is irrespective of grade of cement and is inclusive of mineral admixture like fly ash, micro silica, GGBS etc

b) Maximum quantity of fly ash that shall be taken into account in the concrete composition for minimum cement content computation specified above shall be 35 % of Minimum cementitious material specified in above table, which is in line with IS 1489 requirements. However, 35% is not a maximum limit on fly ash content of concrete mix proportion.

c) Maximum quantity of GGBS that shall be taken into account in the concrete composition with respect to minimum cement content requirement specified above shall be 65 % of Minimum cementitious material specified in above table, which is in line with IS 455 requirements. However, 65% is not a maximum limit on GGBS content of concrete mix proportion.

d) Minimum cement content shall be increased by 40 kg/m^3 for 10 mm maximum size of aggregate and shall be reduced by 30 kg/m^3 for 40 mm maximum aggregate size.

6.7.8 EXPOSURE TO SULPHATE ATTACK

Requirements for concrete exposed to sulphate attack shall be as per relevant provisions of IS 456. All the recommendations for the type of cement, maximum free water/cement ratio and minimum cement content, which are required at different sulphate concentrations in near-neutral ground water having pH 6 to 9, given in the Table 6.17, shall be followed.

For the very high sulphate concentrations in Class 5 conditions, some form of lining such as polyethylene or polychloroprene sheet; or surface coating based on asphalt, chlorinated rubber, epoxy, or polyurethane materials should also be used to prevent access by the sulphate solution.

The decision of Engineer shall be followed in this regard. Such liner shall be measured and paid separately.

TABLE 6.17

REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK

Class	Concentration of sulphates expressed as SO_3			Type of Cement	Dense fully compacted concrete made with 20mm nominal Max. Size of Aggregate complying with IS 383	
	In soil		In ground water (g/l)		Minimum cement content kg/ m^3	Maximum W/C ratio
	Total SO_3 (%)	SO_3 in 2:1 water soil extract(g/l)				
1	Traces <0.2	< 1	< 0.3	OPC, PPC or Portland Slag cement	280	0.55
2	0.2 to 0.5	1 to 1.9	0.3 to 1.2	OPC, PPC or Portland Slag cement Super sulphated cement or Sulphate resisting Portland Cement	330 310	0.50 0.50
3	0.5to 1	1.9 to 3.1	1.2 to 2.5	Super sulphated cement or Sulphate resisting Portland Cement PPC or Portland Slag cement	330 350	0.50 0.45
4	1 to 2	3.1 to 5	2.5 to 5	Super sulphated cement or Sulphate resisting Portland Cement	370	0.45

5	More than 2	> 5	> 5	Sulphate resisting Portland Cement or Super sulphated cement with protective coatings	400	0.40

Notes:

a) Cement content given in this table is irrespective of the grade of cement.

b) Use of Super sulphated cement is generally restricted where the prevailing temperature is above 40°C.

c) Supersulphated cement gives an acceptable life provided that the concrete is dense and prepared with a W/C ratio of 0.4 or less in mineral acids, down to pH 3.5.

d) The cement content given in above table is the minimum recommended. For SO_3 contents near the upper limit of any class, cement content above these minimums are advised.

e) For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, consideration should be given to a further reduction of W/C ratio.

f) Portland Slag Cement conforming to IS: 455 with slag content more than 50% exhibits better sulphate resisting properties.

g) Where chloride is encountered along with sulphate in soil or ground water, ordinary Portland cement with C_3A content from 5 to 8% shall be desirable to be used in concrete, instead of sulphate resisting cement. Alternatively, Portland slag cement conforming to IS: 455 having more than 50% slag or a blend of ordinary Portland cement and slag may be used provided sufficient information is available on performance of such blended cements in these conditions.

6.8 PROPERTIES OF CONCRETE

6.8.1 CONCRETE MIX PROPORTIONING

Concrete shall be proportioned to obtain workable mixes for intended purpose and to meet the strength and finish requirements.

Preliminary mix proportioning shall be established by conducting trials by the contractor, well in advance, so as to meet the time schedule. Mix proportion adopted shall meet the specified properties of green as well as hardened concrete.

While conducting trials, contractor shall use the ingredients that are qualified for actual work. All efforts shall be made to carry out the trials in laboratory and after the mix is finalized, final trials shall be done at batching plant for final qualification of the mix proportion.

6.8.2 TARGET MEAN STRENGTH

The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times standard deviation. The standard deviation for each grade of concrete shall be calculated separately. When sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in Table 6.18 may be assumed for mix proportioning in the first instance. As soon as the test results on sufficient number of samples are available, actual standard deviation shall be calculated and used in mix proportioning. However, when adequate past record for a similar grade exists the same may be used for deciding target mean strength.

TABLE 6.18

ASSUMED STANDARD DEVIATION

Grade of Concrete	Assumed Standard Deviation MPa
M 10 M 15	3.5
M 20 M 25	4.0
M 30 M 35 M 40 M 45 M 50 M 60	5.0

Note:

a) The above values correspond to the site control having proper storage of cement; weight batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. In case there is deviation in the control measures at site, the value of standard deviation given in the Table-6.18 shall be increased by 1 MPa.

6.8.3 MIX PROPORTIONING METHOD

Concrete mix proportioning may be done by methods given in IS 10262, SP-23, ACI 211.1, or on the basis of past experience or by any other suitable method so that the final product meets the specified requirements for green as well as hardened concrete. Efforts shall be made to keep cement content as well as unit water content as minimum as possible, with the use of suitable quality of chemical admixture.

6.8.4 POZZOLANIC MATERIAL

Fly ash, micro silica or ground granulated blast furnace slag (GGBS), individually or in combination, may be used in concrete along with OPC of 43 or 53 grade with the approval of Engineer. The upper limit for use of these pozzolanic materials is as given below:

a) Fly ash - 50% (max.) of total cementitious material for RCC and Prestressed concrete and 70%(max) for PCC
b) Micro silica - 7.5% (max.) of total cementitious material
c) GGBS - 65% (max.) of total cementitious material for RCC and Prestressed concrete and 80%(max) for PCC

However, minimum cement content requirement specified in 6.7.7 above shall be fulfilled. It has to be ensured that desired concrete characteristics are met with. In case of self-compacting concrete, fly ash quantity in excess of 50% can be used to meet the requirement of higher fines content.

6.8.5 WORKABILITY AND SLUMP

The workability measured in terms of slump shall be determined by slump tests as per IS 1199. As majority of concrete is desired to be placed using pumps, the workability of concrete shall be such that mix is pumpable. As a general guideline, slump of 125 mm at placement point is suitable for pumping of concrete. The requirement of slump for various pours, based on the placement methods and reinforcement congestion shall be decided at site with the concurrence of the Engineer.

6.8.6 UNIT WEIGHT

Normal concrete should have a net dry theoretical unit weight of 2400 kg/m^3, when tested as per IS 1199. The unit weight of concrete of any grade shall not be lower than 2375 kg/m^3.

6.8.7 AIR CONTENT

Air content of the concrete shall be tested as per IS 1199. While deciding on mix proportioning, air content for different aggregate sizes shall be as per Table 6.19

TABLE 6.19

AIR CONTENT OF CONCRETE FOR DIFFERENT MAXIMUM AGGREGATE SIZE

Maximum Aggregate Size	Max Air Content
40 mm	1%
20 mm	2%
10 mm	3%

The actual air content of concrete mix shall not exceed by more than 1% of the values given in Table 6.19.

6.8.8 SETTING TIME

Setting time of concrete shall be determined as per IS 8142. As the setting time depends on the temperature of concrete at the time of production as well as ambient conditions, it is required to check the setting time of concrete under same temperature and ambient conditions, as envisaged in the work.

Final setting time of concrete may be kept around 10 hours during summer and around 12 hours during winter. This parameter is required to be established for different ambient conditions for deciding time at which green cutting at construction joints is to be carried out.

6.8.9 BLEEDING

Bleeding of concrete shall not exceed 5% of the water content of the concrete, when tested as per IS 9103.

6.8.10 CHLORIDE CONTENT IN CONCRETE

The total acid soluble chloride in fresh concrete determined as per IS 14959 Part-1 shall not exceed 0.6 kg/m^3 and 0.4 kg/m^3 for reinforced and pre stressed concrete respectively.

6.8.11 CUBE COMPRESSIVE STRENGTH

Uniaxial Compressive cube strength shall be determined on 150 mm size cubes, as per IS 516.

6.8.12 CYLINDER COMPRESSIVE STRENGTH

Uniaxial Compressive cylinder strength shall also be determined on 150 mm diameter 300 mm long size cylinder, as per IS 516.

Uniaxial characteristic compressive cylinder strength shall not be less than 80% of characteristic compressive cube strength.

6.8.13 Deleted

6.8.14 FLEXURAL STRENGTH

Flexural strength of concrete shall be determined as per IS 516. Flexural strength shall not be less than $0.7\sqrt{f_{ck}}$ MPa where f_{ck} is the characteristic compressive cube strength of concrete in MPa.

6.8.15 MODULUS OF ELASTICITY

The modulus of elasticity of concrete shall be determined as per IS 516. The modulus of elasticity shall not be less than $5000\sqrt{f_{ck}}$ MPa, where f_{ck} is the characteristic compressive cube strength of concrete in MPa.

If the actual measured value differs by more than ± 20% from the value obtained from the above expression then it shall be reported to the Engineer.

6.8.16 PERMEABILITY

Permeability shall be determined by conducting Rapid Chloride Penetration Test (RCPT) as per ASTM C-1202. RCPT value shall not exceed 2000 Coulombs at 56 days.

6.8.17 TRIAL MIX AT LABORATORY

Based on the guidelines given above concrete mix design and proportioning shall be carried out so that it meets the requirements of strength, workability and durability.

Preliminary trials shall be carried out to optimize the quantity of cement, pozzolanic materials and other ingredients of concrete. To qualify a mix proportion, at least 4 trials shall be carried out in the laboratory using the preliminary mix design. Following tests shall be carried out on these mixes.

(a) Slump at 0 min, 30 min and 60 min.

(b) Unit weight

(c) Air content

(d) Initial and final setting time

(e) Compressive cube strength at 7, 28 and 56 *days

(f) Split tensile strength**

(g) RCPT at 56 days

* Only for concrete containing fly ash, GGBS or other pozzolana

** Only for containment structure or specified elsewhere

The concrete shall meet the specified values for all the above properties. The mean of 28 days cube compressive strength of all the four sets shall be more than or equal to fck + 4.0 MPa and individual test value shall be greater than or equal to fck, where fck is the characteristic cube strength of the concrete in MPa.

6.8.18 ACCEPTANCE TEST AT BATCHING PLANT

To ensure that laboratory proportioned concrete mix meets all the requirements when produced using the actual batching plant and other equipment, at least 4 trials shall be conducted at batching plant. It has to be ensured that all the requirements specified in above clause are met with. At least one test shall be conducted to check the yield of the concrete. In case of significant difference from the theoretical yield and the observed yield, it shall be investigated and rectification measures shall be taken.

Contractor shall submit a detailed report on the concrete mix proportioning to the Engineer for his approval. This report shall include the test results on concrete ingredients, laboratory trial results and batching plant trial results.

6.9 TESTS ON CONCRETE

Samples from fresh concrete shall be taken as per IS 1199 at the placement point or pumping point. Frequency of testing shall be as given in Table 6.20

TABLE 6.20

FREQUENCY FOR DETERMINATION OF PROPERTIES OF FRESH AND HARDENED CONCRETE

Sl. No.	Description of test	Frequency of testing
1	Slump	First 3 transit mixers and then from every 5th transit mixer
2	Temperature	First 3 transit mixers and then from every 5th transit mixer
3	Unit weight	At the time of casting of cubes one sample per day for each grade
4	Air content	One sample per week for each grade
5	Initial and final setting time	One sample per week for each grade
6	Bleeding	Whenever required
7	Cube compressive strength 7, 28 and 56* days	One sample per 50 cum up to 100 m^3 of concrete, there after one sample for each 100 m^3 or part thereof. At least one sample on each day of concreting for each grade.
8	RCPT	One sample per week for each grade
9	Chlorides and sulphate content test	One sample for each grade of concrete per six monthly

- Only for fly ash concrete/GGBS concrete.
- One sample for strength test means sufficient number of cubes to determine average of at least 3 cubes at specified time

6.9.1 ACCEPTANCE CRITERIA

Concrete of each grade shall be analyzed separately. The concrete shall be deemed to comply with the compressive strength requirements when both the following criteria are met with:

a) The mean strength determined from any group of four consecutive test results compiles with the value given in column (2) of Table 6.21

b) Any individual test result complies with the value given in column (3) of Table 6.21

TABLE 6.21

COMPRESSIVE STRENGTH COMPLIANCE REQUIREMENT

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in MPa	Individual Test Result in MPa
(1)	(2)	(3)
M 15	$\geq (f_{ck} + 0.825$ X established standard deviation (rounded off to nearest 0.5 MPa) or $(f_{ck} + 3)$ MPa Whichever is greater	$\geq f_{ck} - 3$ MPa
M 20 or Above	$\geq (f_{ck} + 0.825$ X established standard deviation (rounded off to nearest 0.5 MPa) or $(f_{ck} + 4)$ MPa Whichever is greater	$\geq f_{ck} - 4$ MPa

NOTE:

a. In the absence of established value of standard deviation, the value given in Table 6.18 may be assumed, and attempt should be made to obtain result of 30 samples as early as possible to establish the value of standard deviation.

b. Concrete is liable for rejection, if criteria mentioned in Table 6.21 is not met with.

c. If the concrete, after opening the shutter, is found to be porous or honeycombed, or concrete placing is interrupted without providing a proper construction joint or the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met with, it is liable to be rejected.

d. However, the same may be accepted if remedial measures are feasible and if the same are carried out to the satisfaction of the Engineer-in-charge.

6.9.2 USE OF 7 DAYS TEST

For any mix, a correlation between 7 day and 28 day strengths may be established in the laboratory. Soon after a job starts, a similar correlation shall be established during actual progress of the work. After the correlation has been established, the results of

the 7 day test may be used as the precursor for the expected compressive strength at 28-days. If 7-day test indicates low compressive strength, corrective measures shall be taken without waiting for 28-day strength results. Similarly for concrete with fly ash, GGBS and micro silica, co-relation shall be established between 7, 28 and 56-day compressive strength.

6.9.3 FAILURE TO MEET STRENGTH REQUIREMENT

In the event of concrete, tested in accordance with the relevant standards, fails to meet the acceptance criteria specified in Table 6.21 above with the approval of Engineer, any or all of the following measures shall be taken by the contractor, with no extra cost to the owner.

1. Taking cores from the structural element, where the test has failed, (IS: 456).
2. Extended curing of the concrete represented by the specimen.
3. Load tests on part of structures as per IS: 456.
4. Non -destructive test on structure.
5. Replacement of affected part / parts of the structure.

6.9.4 NON DESTRUCTIVE TESTS

In case of doubts about the quality of concrete in the construction, non -destructive tests shall be conducted as directed by the Engineer. The tests shall be carried out by a specialized agency as per the provisions of IS 456. Based on the NDT evaluation, decision on acceptance of structure or otherwise shall be taken by the Engineer.

6.9.5 CORE TEST

Three cores shall be extracted from the structure for determination of compressive strength represented by that structural element. The diameters of core shall be at least 3 times the maximum size of aggregate used in the concrete and height to diameter ratio shall be 2.0. Core shall be tested as per IS 516. Concrete in the member, represented by a core, shall be considered acceptable, if the average equivalent cube strength of the core (computed as 125% of the core cylinder strength) is equal to at least 85 percent of the specified characteristic strength and no individual average equivalent cube strength of core has strength less than 75% of the specified characteristic strength.

6.10 CONCRETE PRODUCTION, TRANSPORTATION & PLACEMENT

6.10.1 TEMPERATURE CONTROL

a) The concrete placement temperature shall be specified in the construction drawing. Normally, four different placement temperatures i. e. not exceeding 19^0C, 23^0C, 29^0C & 38^0C may be specified in the drawings. Generally, concrete temperature at the production point shall be maintained lower than the specified placement temperature so as to meet the criteria of specified placement temperature. Required temperature shall be achieved by reducing the temperature of water, replacement of part of mixing water with ice flakes and also by controlling the temperature of coarse and fine aggregate.

b) The stockpiles of the aggregate shall be protected from direct sunlight to avoid heating of aggregate. Wherever water is sprayed, suitable correction shall be applied so that the mix proportioning is not altered. Water shall be sprayed on the aggregate stockpile at every 300 mm or 450 mm height as the stockpiles are built up. The stockpiles, thereafter, shall be kept cool by water sprays. Fine aggregate may be stored under shed / in covered area, if the contractor so chooses.

c) If necessary, the coarse aggregate shall be taken into the bins and chilled water at temperature not more than 8^0C shall be sprayed on it through perforated pipe and allowed to be drained through screen fixed at the bottom. Draining screen shall remove excess water from the aggregate. The capacity and arrangement of the bins shall be such as to supply moisture free cooled aggregate to the top of the batching plant so that continuous supply of temperature controlled concrete is maintained.

6.10.2 TRANSPORTATION

a) The concrete shall be transported from the batching plant to the placement point as rapidly as possible by using insulated transit mixers for preventing segregation and loss of any of the ingredients. During hot weather, transit mixer shall be insulated to reduce loss of water by evaporation and heating of concrete from the ambient heat.

b) Once the concrete is mixed in the batching plant, no further water shall be added.

c) Concrete shall be placed and compacted in its final position within the forms within 90 (Ninety) minutes after the addition of water to the mixer or initial setting time of the concrete whichever is less.

d) The Concrete that has been left standing and has become stiff, such that it cannot be placed in satisfactory condition, shall be removed from the place of work immediately.

e) All equipment, used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, transit mixers and other equipment shall be thoroughly cleaned periodically during placement and after completion of concreting.

6.10.3 RE-DOSING OF ADMIXTURES

a) In case, when transit mixer reaches placement point, the loss of slump is observed, re-dosing of admixture may be carried out, to get required consistency for getting pumpable mix. However, basis for re-dosing shall be established by conducting trials in advance to establish re-dosing requirement for getting required slump. The total quantum of admixture established at the trial stages shall, however, not be exceeded during re-dosing.

b) Suitable arrangements for re-dosing of admixture with dispensing unit shall be made to ensure accurate re-dosing and proper mixing.

c) Record shall be maintained for each such re-dosing and shall be incorporated in batch weight record of batching plant. Samples for determination of compressive strength and other parameters shall be taken only after re-dosing.

6.10.4 PLACING OF CONCRETE

a) The concrete shall be preferably placed to its final position in the structure using pumps and placer booms in such a manner that both quality and uniformity of concrete, in terms of W/B or W/C ratio, slump, air content and homogeneity is preserved.

b) Before any concrete is placed, the entire placing programme detailing equipment, layout, and proposed method shall be submitted to the Engineer for approval. No concrete shall be placed until the Engineer's approval is obtained. Such plan shall include all the standby arrangements and shall be submitted at least 48 hours prior to actual concreting.

c) Sufficient plant capacity and transportation equipment shall be available to ensure continuous delivery of concrete at the desired rate of pour. The rate of delivery of concrete shall be such as to ensure proper handling, placing, vibrating and finishing of the concrete and to ensure that the cold joint is avoided. No concrete shall be transported in open, while it rains. If there is any sign of washing of cement and sand, the concrete shall be removed immediately. If the concrete is to be placed at night, sufficient illumination shall be ensured. Safe working condition shall also be ensured.

d) The method of delivering and handling of concrete shall be such as to facilitate placing with minimum of re-handling and without damage to the structure or the concrete.

e) All items to be embedded in concrete shall be correctly positioned and securely held in position, well in advance of placing of concrete. However, shutter alignment shall be checked and cleared only after fixing and correctly aligning the embedded parts.

f) Concrete shall be deposited at or near its final position in the form. The concrete shall not be pushed laterally with the help of vibrator. Struts, stays and braces serving temporarily to hold the forms in correct shape and alignment during the placing of concrete, shall be removed only when the concrete placing has reached an elevation

rendering their service unnecessary. These temporary members shall be entirely removed from forms and not buried in the concrete.

g) While preparing for placing of concrete, all sawdust, wood chips and other construction debris, shall be removed from the forms. Prior to placing of concrete on a rock surface, it shall be thoroughly cleaned and soaked with water for about 24 hours and surface shall be remain moist condition.

h) Concrete shall be placed in such a way that segregation is avoided and also the displacement of the reinforcement and embedment is avoided. Open troughs and chutes shall be of metal or metal lined. Where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths to adjust the direction of movement. The addition of water, at any point in the system of transportation, to facilitate the movement of concrete shall not be permitted. All chutes, troughs and pipes, shall be kept clean and free from coatings of hardened concrete by thoroughly flushing them with water after each placement. Water used for flushing shall be discharged clear of the structure. Concrete shall neither be permitted to fall freely from a height of more than 1.50 m nor to strike the forms at an angle. Where drop chutes are used, a sufficient numbers must be provided so that the concrete discharged from the chutes are not required to flow laterally more than 10 m However, SCC can flow horizontally upto approx. 12 m to 15 m without segregation. Where a drop chute is swung from the vertical, the bottom two sections must be maintained in a vertical position to avoid segregation. Flushing water quality shall be same as that of the water, which is being used, for making concrete. Based on the work demand, if lift height is to be increased beyond 1.5 m proper arrangements for vibration shall be ensured. In locations, where direct placement is not possible and in narrow forms, suitable drop chutes or “elephant trunks” shall be provided to confine the concrete during placement.

i) Concrete shall not be placed into the forms, until the cleaning of concrete surfaces of previous pours and the placement of reinforcing steel and embedded parts have been inspected and cleared by the Engineer.

j) Storm water or water from curing of concrete, which may get accumulated on the surface of the bedding layer, shall be removed by suitable means before start of placement. No concrete shall be placed on a water-covered surface. However, the surface must be sufficiently soaked and shall be in saturated surface dry condition.

k) Concrete shall be placed in successive layers ranging in thickness not exceeding 500 mm or as directed by the Engineer. The bucket loads or other units of deposit shall be spread progressively along the face of the layer with such overlap as will facilitate spreading the layer of uniform depth and texture with a minimum hand shoveling. Any tendency to segregation shall be corrected by shoveling stones into mortar rather than mortar on to stones. If such condition arises, the cause or causes shall be investigated and corrective action shall be planned. If required, mix proportion can be revised or method of placement can be modified.

l) When less than a complete layer is placed in one operation, it shall be terminated at a vertical bulkhead. Each layer of concrete shall be placed and compacted before initial setting of concrete of the previous layer takes place, to prevent injury to green concrete and to avoid separation between the consecutive layers.

m) During hot weather and rains, the concrete shall be covered with tarpaulins. Transportation, placement and consolidation of concrete shall be done in shortest possible time. Adequate precautions shall be taken to cover the transit mixer and chilled water may be sprayed over the transit mixer and the pipelines to maintain the temperature during the hot weather.

n) When concrete is to be placed in hot weather conditions, special provision shall be made for handling, placing and protecting the concrete, to ensure that concrete of full strength and free from damage, is obtained. For meeting the desired objective, means such as concreting during cooler hours of the day, use of chilled water, cooling of pipes etc., shall be resorted to. Commencement of concrete pour shall be avoided during heavy rains, storms and high winds.

6.10.5 COMPACTION

a) Vibrator should be inserted and withdrawn vertically at close intervals, using a systematic pattern of vibration to ensure that all concrete is adequately consolidated. As long as a vibrator needle sinks into the concrete by its own weight, it is not too late for the concrete to benefit from re-vibration, which improves compressive and bond strengths. Vibrators should not be used to move concrete laterally

b) On vertical surface, where air void holes are expected, voids can be reduced by the use of form vibrator or light tamping with wooden mallets.

c) Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into corners and angles of the forms.

d) Internal vibrators shall be inserted in a vertical position only, at intervals of about 450 mm depending upon the mix, the equipment used, the type of structure and experience gained on job. The vibrator needle shall be inserted by minimum 100mm in the previously laid layer. The zone of influence of needle vibrator is approximately 100 times cross sectional area of the needle being used. The vibrators shall be withdrawn slowly, approximately at the rate of 75 mm/sec. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to move concrete laterally inside the forms. Vibrator needle shall be kept clear of forms least by 100 mm. Over-vibration as well as under vibration shall not be done.

e) The internal-immersion type vibrators shall be high frequency vibrators with speed of not less than 7000 rpm when immersed in the concrete. Vibrators shall be used in sufficient numbers and power of each unit to properly consolidate all concrete in each layer immediately after it has been placed in the forms. It shall be ensured that sufficient numbers of vibrators are available at site along with adequate standby units.

f) While placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be taken to ensure adequate vibration, blending and melding of the concrete between the succeeding layers. The vibrator shall penetrate full in the layer being placed and also penetrate the layer below by about 50 mm while the under-layer is still plastic, to ensure good bond and homogeneity between two layers and prevent formation of cold joints.

6.10.5.1 USE OF FORM VIBRATORS

In case of the columns having congestion of reinforcement, supplemental form vibration may be used in addition to needle vibrators. Care should be taken to avoid excessive vibration, which would cause a weak paste on surface. However, this shall be preplanned activity and shutter as well as staging shall be designed for the additional loads form the vibrators.

6.10.5.2 USE OF SURFACE VIBRATORS

Surface vibrators may be used for horizontal elements like slabs. The vibrator operator shall be qualified before deploying on a job. Re-qualification shall be carried at suitable interval.

6.10.6 CONSTRUCTION JOINTS AND KEYS

When the work is to be interrupted, horizontal and vertical construction joints and bonding keys shall be located and shall conform to the details given on the drawings. In case of water retaining structure, containment structure and other structures, water stops as specified on the drawing shall be provided.

In case of columns, beams and slabs etc, the location of the joints shall be as indicated in the drawing or as directed by the Engineer. Concrete in a beam shall be placed throughout, without a horizontal joint. Before fresh concrete is placed, cement skin or any loose or porous material of partially hardened concrete shall be thoroughly removed and cut back until the solid face is exposed and surface made rough by hacking, or any other method. Rough surface shall be thoroughly wetted for about two hours and shall be in surface dry condition before new layer of concrete is placed over it.

6.10.7 TREATMENT ON SUSPENSION OF WORK

Whenever work is suspended on any section for more than two hours, the horizontal edges of the concrete next to the forms on surfaces that will be exposed shall be brought to a horizontal plane perpendicular to the plane of the forms and treated, so that the finished work will show smooth straight lines.

6.10.8 EXPANSION JOINTS AND SEPARATION JOINTS

These joints in concrete structures shall be provided, as specified in the drawing. The thickness of polythene sheet, if used, shall not be less than 500 microns. For Expansion joints relevant specification shall be followed.

6.10.9 WASH WATER

Wash water shall be removed in a manner to prevent running down and staining of concrete surfaces, exposed on completion of the job. Should unsightly wash-water streaks develop on the exposed surface, the same shall be removed to get a uniform colour and texture.

6.10.10 PLACEMENT INTERVAL

Placement interval between two subsequent or adjacent pours shall be as specified in the drawing.

6.10.11 CONSTRUCTION JOINT TREATMENT

Green cutting shall be made to treat the entire construction joint. Suitable surface retarder shall be used to retard the setting of concrete to a depth of 5 to 7 mm from the exposed surface that is going to receive subsequent concrete.

Green cutting shall be done by using air water jet at a suitable pressure to remove laitance from concrete surface at construction joint, exposing aggregate matrix, and shall be done only after the concrete is in final set condition. The water from the air water jet, used for green cutting of the concrete surface, shall be properly drained so as not to harm the quality of the concrete already placed. It shall also be ensured that this water does not get stagnated on the surface of concrete, depositing washed cement particles. As a pre-qualification, field mock-ups shall be conducted to check the adequacy of the material and method to be deployed on the job, before adopting in the field. In case of change in material source / type or methodology of green cutting, pre-qualification shall be redone. In areas where green cutting is not feasible, spraying of retarders followed by wire brushing immediately after final setting shall be adopted.

Approved brand of surface retarding (set retarding) agent shall be used for preparation of construction joint by green cutting of concrete. It shall be solvent free poly-hydroxyl compound and shall have a distinctive colour, which could be easily identifiable on its application over concrete. It shall be suitable for removing the cement-sand matrix between 5 to 7 mm depth after final setting time, when air water jet with a pressure of around 7 Kg/cm^2 from distance of approx. 500 mm is used. It may be noted that there is no specific testing for qualification of surface retarders other than its meeting desired performance specified above.

6.10.12 PLACEMENT OF CONCRETE AROUND LARGE OPENINGS

While placing concrete around large openings in walls, adequate care shall be taken to ensure proper flow and compaction of concrete on the underside of such openings. Adequate number of windows shall be provided in the formwork for air to escape and also for insertion of vibrators. Once the concrete reaches the level of such window, the same shall be properly closed before proceeding with further concreting.

6.10.13 PLACING CONCRETE BY PUMPING

a) As far as possible, concrete shall be placed using pumping. A steady supply of pump-able concrete is necessary for satisfactory pumping. Concrete pumps to be deployed on the work shall be able to deliver concrete at a desired rate up-to the placement point uninterruptedly.
b) Requisite numbers of concrete pumps, capable of pumping concrete at required rate, together with a complement of pipelines, accessories, spare parts, power controlled placer booms, experienced pump operators and maintenance staff shall be deployed.
c) The pumping plant shall be installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of concrete, to enable conducting pump-ability tests and necessary adjustments for the mix proportioning, prior to use in actual work.

6.10.14 PUMPABILITY TRIALS

No mix shall be used in actual work until pump-ability trial is conducted. The actual field condition shall be simulated. The batching and conveying by transit mixers shall be in the same way as that will be in actual work. The pipe and hose layouts shall simulate the actual condition, as far as practicable. The system shall be able to meet uninterrupted desired supply of cohesive mix at the placement point. The samples shall be collected at batching plant, at pumping point and at placement point after pumping for slump and determination of compressive strength.

6.10.15 FIELD PRACTICES

a) Proper planning of concrete supply, pump location, line layout, placing sequence and the entire pumping operation shall be done by the Contractor, before commencement of concreting.

b) The pumps shall be as near to the placing area as practicable and proper access roads shall be available for movement of transit mixers and other equipment around the location.

c) Direct communications shall be maintained between the pump operator, concrete placing crew and the batching plant. As a final check, the pump shall be started and operated without concrete to assess that all moving parts are in operating conditions.

d) The mortar shall be pumped into the line to provide initial lubrication for the pump and pipeline. The mortar used for lubrication shall be collected in the bucket and disposed off. This mortar shall not be placed in the forms. As soon as concrete is received, the pump shall be run slowly until the lines are completely filled and the

concrete is slowly moved. Once the pumping starts, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking.

e) Continuous pumping should be ensured. If delay occurs due to supply of concrete, form repairs, or any other reason, the pump shall be slowed down to maintain some movement of the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be kept moving in the line by giving one stroke of the pump at longer interval. In confined areas, attempt shall be made by the Contractor to run a return line back to the pump, so that the concrete can be re-circulated during such delays.

f) Minor blockages shall be cleared by operating a few strokes of the pump in reverse direction and then by returning to normal forward pumping. If this fails, a succession of reverse and forward strokes shall be carried out to remove the blockage. Should this fail, the blockage may be due to air lock and the entrapped air has to be removed.

g) Blockages in the pipe are usually assessed by the sound when the pipe is struck. To remove the obstruction, the concrete pipe shall be taken out at the assessed location and cleaned. The pumping process shall then be started again.

h) This method of checking the blockage and setting it right shall be done as early as possible, as excessive delay will cause setting of concrete in the pipeline downstream of the blockage. When the blockage is being found out and remedial measures taken, the pump shall periodically be given one or two strokes forward to keep the concrete in motion. If blockage occurs in the placer boom, a pipe joint near the base of the placer boom shall be opened and the boom made vertical to drain the concrete by gravity.

i) The termination of pumping operation shall be carefully planned to utilize the concrete dormant in the pipeline and the hopper, when the pump is stopped. However, concrete at placement point shall be kept green, avoiding cold joint, by operating standby pump or by any other standby arrangement.

j) When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a go-devil be inserted and forced through the line to clear it out. Water under pressure shall be used to push the go-devil. The go-devil shall be stopped about one meter from the end of the line, so that the water in the line does not spill over into the placement area. After flushing, water in the pipe shall be removed by drain cock provided for this purpose, in the lowest part of the line. After all concrete has been removed from the line, pipes and equipment shall be immediately cleaned.

6.10.16 QUALITY CONTROL

Contractor shall ensure good workmanship and also the plant shall be maintained to meet peak demand. Degree of control on all the concrete operation, right from

selection of the ingredients to the final testing of specimen, shall be in line with the approved Quality Assurance Plan.

The Contractor shall engage experienced supervision at all levels. Complete crew, engaged in each of the concreting activity, shall be duly qualified for a particular activity and shall demonstrate their skills and capabilities to produce the final product meeting specified parameters.

6.10.17 CURING OF CONCRETE

a) Exposed surface of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least 7 days (10 days for hot weather condition) from the date of placing concrete in case of OPC Concrete and at least 10 days (14 days for hot weather condition) where mineral admixture or blended cement is used. The Quality of curing water shall be the same as that used for mixing concrete. Any type of the covering that would stain or damage the concrete during or after the curing period shall not be permitted. Covering shall be kept continuously wet during the curing period.

b) The structural elements with concrete having low water binder ratio and also when cement is partially replaced by pozzolanic material, the curing shall be done in two stages viz., initial curing and final curing.

c) **Initial Curing:** The initial curing shall start immediately after finishing. The concrete surface exposed to environment shall be kept covered by plastic sheet or other type of impermeable covers. The wet curing shall start immediately after the final set. This shall be carried out with the help of placing wet burlaps over the concrete surfaces.

d) **Final curing:** The final curing shall be done with water. It shall commence immediately after initial curing and continue upto a minimum period specified above. Hessian cloth can be wrapped on to columns and on vertical surfaces and the same shall be kept wet all the time by a suitable arrangement.

e) Contractor shall make suitable arrangement for continuous water supply, along with necessary equipment for getting a nozzle pressure of not less than 7 kg/cm^2, even at the highest elevation, for convenient and effective jetting on concrete surfaces for green cutting, for cooling aggregate, for curing and for other requirements. All necessary appliances such as hose, sprinklers, spraying devices etc. may be made available.

f) For curing of concrete in pavements, sidewalks, floors, flat roof or other level surfaces, the ponding method of curing is preferred. Special attention shall be given to edges and corners of the slab to ensure proper protection. The ponded area shall be kept continuously filled with water throughout the curing period.

g) **Membrane Curing:** Curing compound may be used in lieu of moist curing with due qualification of material and process, if permitted by the Engineer. Such compounds

shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

6.10.18 PROTECTING FRESH CONCRETE

Newly placed concrete shall be protected from rain, sun and wind. Concrete placed below the ground level shall be protected from falling earth during and after placing. Concrete placed in ground, containing deleterious substances, shall be kept free from contact with such ground or with water percolating from such ground during placing of concrete and for a period of at least 3 days. The ground water around newly poured concrete shall be maintained to a level lower than the fresh concrete layer by pumping or other means of drainage. Adequate steps shall be taken to prevent flooding. Fresh concrete shall be protected by, leaving the forms in place, prevention of disturbing shocks and vibrations and avoiding premature stressing until the concrete attains sufficient strength to sustain such loads or shocks.

6.11 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

A procedure shall be prepared by the contractor for carrying out inspection, repair and replacement of unsatisfactory concrete. Repair of unsatisfactory concrete shall be carried out by means of removing the unsatisfactory portion and replacing it with new concrete. Suitable keys, dovetail slots etc. may be provided to get proper bond between new concrete and old concrete. Prepared surface shall be kept wet for 24 hours immediately before the patching material is placed. However, surface shall be dry. Repair of concrete shall be carried out using skilled workmen. Repairs shall be undertaken as soon as practicable, after removal of forms, so as to meet the requirements of finish in that particular location. The portion of the concrete to be repaired may be reinforced with steel mesh, if directed by the Engineer. The contractor shall carry out all such repair with no extra cost to the owner.

The complete methodology for the repair shall have approval of the Engineer before undertaking such repair job. Proper curing shall be ensured for the repaired portion.

6.11.1 USE OF EPOXY

For bonding fresh concrete with old concrete epoxy shall be used if specifically directed by the Engineer. The type of epoxy and its application shall be as directed by the Engineer. Epoxy shall be applied in strict accordance with the instructions of the manufacturer. Approved material shall be arranged by the Contractor to undertake this activity.

The epoxy shall meet the requirements of ASTM C-881 and shall be used as per manufacturer’s recommendations.

6.11.2 REPAIR WITH EPOXY MORTAR

The defects in concrete (within the acceptable limits, as decided by the Engineer) may be repaired using Epoxy mortar as per the instructions of the Engineer. No extra payment shall be made for such repairs.

6.11.3 MATCHING OF PATCH SURFACES

Filling material used in repair of surfaces, which will be exposed after completion of the project, shall be used with cement from the same source as that used in concrete and blended with a sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. Patched surface shall be given a final treatment to make the texture of the patch to match with the surrounding area.

6.11.4 CURING OF PATCH WORK

Immediately after any patchwork is completed, the area shall be covered with non-staining, water-saturated material and the same shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the area shall be kept continuously wet by a fine spray or sprinkling of water. The layers of patch may be reinforced with steel wire mesh, if directed so by the Engineer at no extra cost to the owner.

6.11.5 APPROVAL BY ENGINEER

All materials, procedures and activities for repair work as well as finishing work shall be subject to the approval of the Engineer.

6.12 FINISHING & OTHER GENERAL WORKS

6.12.1 FINISHING

a) Unless otherwise specified, concrete finishes shall conform to the following classifications and shall be provided as specified in the drawing.

b) Finish F1, F2 and F3 shall describe formed surfaces.

c) Finish U1, U2 and U3 shall describe unformed surfaces.

d) Offsets or fins caused by displaced or misplaced form panels, lining or form section or by defective form lumber shall be referred to as ‘abrupt irregularities’. All other irregularities shall be referred to as ‘Gradual irregularities’. Gradual irregularities shall be measured as deviation from a plane surface with a template 1.5 m long for formed surfaces and 3.0 m long for unformed surfaces.

6.12.2 FORMED SURFACE

a) Finish F1 shall apply to all formed surfaces for which finish F2, F3 or any other special finish is not specified.

b) Finish F1 shall include filling all form tie holes and localized air holes.

c) Finish F2 shall apply to all formed surfaces as shown on the drawings. Finish F2 shall include filling all form tie and localized air holes, repair of gradual irregularities exceeding 6 mm, removal of ridges and fins and abrupt irregularities by grinding.

d) Finish F3 shall apply to all formed surfaces exposed to view or where shown on the drawings. It shall include all measures specified for finish F2. In addition, filling air holes with mortar and treatment of the entire surface with sack rubbing shall include in F3 finish. It shall also include clean up of loose and adhering debris. The surfaces shall be prepared within two days after removal of the forms. The surfaces shall be wetted and allowed to dry slightly before mortar is applied by sack rubbing. The mortar used shall consist of one part cement to one and half part by volume of fine sand passing IS No. 16 sieve. Only sufficient mixing water, to give the mortar a workable consistency, shall be used. The mortar shall then be rubbed over the surface with a fine burlap or linen cloth so as to fill all the surface voids. The mortar in the voids shall be allowed to stiffen and solidify after which the whole surface shall be wiped clean with burlap so that the entire surface presents a uniform appearance without air holes and irregularities. The finished surface shall be cured for a period of 3 days.

6.12.3 UNFORMED SURFACES

a) Finish U1 shall apply to all unformed surfaces for which finish U2, U3 or any other special finish is not specified. Finish U1 shall include screeding the surface of the concrete to the required slope and grade, as specified on drawings.

b) Surfaces, to be covered with concrete topping, terrazzo etc., shall be smooth, screeded and leveled to produce an even surface and irregularities not exceeding 6 mm.

c) Finish U2 shall apply to all unformed surfaces, as shown on the drawings. Finish U2 shall include screeding and applying a wood float finish to the surface of the concrete to the required slopes and grade, repair of abrupt irregularities unless a roughened texture is specified and repair of gradual irregularities exceeding 6 mm.

d) Finish U3 shall apply to unformed surfaces for which a high degree of surface smoothness is required, where shown on the drawings. Finish U3 shall include screeding, floating and applying a steel trowel finish to the surface of the concrete to the required slope and grade, repair of gradual irregularities exceeding 6 mm, finishing joints and edges of concrete with edging tools.

6.12.4 FOUNDATION BEDDING, BONDING AND JOINTING

a) All surfaces or concrete beds shall be prepared by suitable shaping, thorough cleaning, washing and keeping the surface in SSD condition

b) All soil surfaces, upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or yielding soil shall be removed and replaced with lean concrete or with selected soil and compacted to the same density as the surrounding area. The surface of absorptive soil, against which concrete is to be placed, shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete.

c) The concrete surfaces, upon which additional concrete is to be placed, shall be prepared by green cutting technique. Surface retarder shall be spread on the surface of newly laid concrete, just after finishing work is completed. After the concrete attains final set, high-pressure air water jet shall be used to remove cement matrix, exposing aggregate matrix. The water shall be drained properly along with cement particles. In case where green cutting is not adopted, with approval of the Engineer, scarifying and cleaning while the concrete is between its initial and final set shall be done. Great care shall be taken in performing this work to avoid removal of too much mortar and weakening of the surface by loosening of aggregate.

d) Concrete surfaces, upon which new concrete is to be placed, shall be cleaned and wetted, immediately before placement of the concrete. The bonding shall be with mortar having the same cement-sand ratio as that of the concrete being placed. Cost of the same will be deemed to have been included in the rate for concrete. However, no bonding mortar is required when green cutting technique is adopted for surface preparation.

Similar treatment shall be given at vertical construction joint.

6.12.5 WORKMANSHIP OF CONCRETE

Workmanship shall be conforming to relevant Indian Standards and good engineering practices. The mix proportioning shall have prior approval of the Engineer. Concrete shall be produced at fully automatic batching plants. In case, where the tilting drum mixer is used, adequate and accurate weight batching arrangement shall be provided. Tilting drum mixer shall be fully discharged before taking new batch. Partly set concrete shall be immediately removed. On completion of work the mixer as well as all other equipment shall be thoroughly cleaned.

6.13 SELF-COMPACTING CONCRETE (SCC)

Self-Compacting Concrete shall conform to European specification for Self-Compacting Concrete – Specification, Production and Use. All the ingredients of SCC are same as that of normal concrete, except Viscosity Modifying Agent (VMA) as an additional ingredient Quality of all the ingredients shall be the same as that for normal concrete. VMA shall be added to increase shear resistance of the concrete. All

the test equipment as well as desired parameters for fresh concrete shall be as detailed in European specification. After the mix proportion is finalized, adequate mock-ups shall be done, to ensure consistent quality of self-compaction. SCC may be used for casting all the structural elements of the plant buildings. It shall be kept in mind that formwork design shall be carefully done for SCC, as the SCC remains in liquid form for a longer period. As far as possible, pumping shall be resorted to. All other requirements for testing shall be the same as that of normal concrete, specified elsewhere in these specifications.

Properties of the fresh concrete are to be checked as per the provisions in the European specification. The desired parameters are given in Table 6.22. Testing methods and testing equipments like flow table, V-funnel, L-box, U-box, fill box and segregation resistance test shall be as per European specification. The tests to be carried out to establish various properties are given in Table 1.24. Once it is established that the mix proportion is meeting the desired parameters and after establishing the consistency of the results, the flow table test and V- funnel test are to be conducted at production point and placement point as a quality control measures. For hardened concrete, the tests specified in Table 6.20 are to be carried out. These Two (2) tests shall be conducted for first 3 transit mixers and subsequently one for every set of 5 transit mixers.

TABLE 6. 22
PARAMETERS FOR SCC

Sl. No.	Test	Unit	Minimum	Maximum
01	Slump flow	mm	650	800
02	T50 cm slump flow	Sec	2	5
03	“V” funnel	Sec	5	15
04	‘L’ box	h_2 / h_1	0.8	1.0
05	‘U’ box	$(h_2 - h_1)$ mm	0	30
06	Fill box	%	90	100
07	Segregation Resistance test	%	-	20

TABLE 6.23
PROPERTIES TO BE ESTABLISHED BY TESTS

Slump flow test	Stability of mix (Cohesiveness)
T-50 cm time slump flow test	- do -
V-funnel test	Flow ability
L-Box test	Passing ability
U-Box test	- do -
Fill box test	Filling ability
Segregation Resistance test	Segregation

6.14 MATERIAL TESTING LABORATORY

The contractor shall establish a state of the art material-testing laboratory at site for testing of all the concrete ingredients, fresh concrete and hardened concrete. Fully automatic cube testing machines of adequate capacity and numbers shall be installed in the laboratory. Facilities for water permeability test as per DIN 1048 and Rapid Chloride Permeability Test (RCPT) as per ASTM-C-1202 shall also be available in the laboratory. Laboratory pan type mixer shall be available with the Contractor.

7. FORM WORK

7.1 SCOPE

The work covered under this section shall include the providing, erection and removal of formwork for all normal, and pre-cast concrete in walls, columns, foundations, slabs and beams, including its supporting members.

7.2 GENERAL

7.2.1 The formwork shall consist of but not limited to shores, bracings, sides of beams, columns, walls, rafts and bottom of slabs including ties, anchors, inserts, hangers, false work, wedges, etc. complete which shall be properly planned for the work. For the floors, supports can be taken from the floor down below with prior permission of the Engineer. Wherever required, provision shall be made to support the floor shuttering by means of trusses, which shall be spanned from the nearby walls/columns. Wherever specified, the left-in shuttering of adequate capacity shall be used.

7.2.2 The Contractor shall prepare, before commencement of actual shuttering work, design and drawing for formwork and centering and get them approved by the Engineer well in advance before fabrication and erection of formwork. Formwork shall be designed to fulfill the following requirements.

a) Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

b) Made of suitable materials.

c) Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.

d) Capable of withstanding without deflection the worst combination of self-weight, reinforcement and concrete weight, all loads including lateral pressure on vertical surfaces and dynamic effects arising from construction and compacting activities, wind and weather forces.

e) Capable of easy striking without shock, disturbance or damage to the concrete.

f) Soffit forms capable of imparting a camber if required.

g) Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete, design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

7.2.3 Forms shall conform to the shapes, lines, grades and dimensions including camber of the concrete as called for on the drawings. Ample struts, walers, braces, etc. shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of forms. Unless otherwise specified all forms in contact with concrete having F-3 finish shall be plywood panel formworks. Forms will be firmly bolted to previous pour of concrete. No through bolts embedded in concrete will be permitted in any underground structures. Threaded mild steel sleeves designed for holding in concrete and standard coil nuts/cone anchors shall be embedded in preceding concrete pours to anchor tie rods on lower end, while on the other end tie rods shall be provided beyond the lift under construction. Tie arrangement with baffle plate within the concrete may also be used as substitute for through tie with prior approval of the Engineer. The Contractor should finish all the coil nuts by dry packing. The recesses, if any, formed by removable timber wedges shall be filled with caulking compound or Epoxy mortar if depth is less at the Contractor's own cost. Formwork for removable hatchways and plugs shall be installed in place wherever possible. Back form for sloping concrete surfaces shall be provided as decided by the Engineer at no extra cost.

7.3 DESIGN AND FIXING OF FORMWORK

The formwork shall be designed and fixed to meet the tolerance in various areas as specified elsewhere in this specification. All floors and beam centering shall be crowned not less than 8 mm in all directions for every 5-meter span. Forms in contact with concrete shall be free from adhering grouts, projecting nails, splits or other defects. Formwork shall be so designed and erected with the forms for slab so that the sides of beams, columns and walls may be removed first, leaving the formwork to the soffits of beams and their supports in position. Where formwork for column is erected for its full height, one side shall be left open and built up in sections as placing of concrete proceeds, if so directed by the Engineer.

7.4 DESIGN LOADS

7.4.1 Unless prior approval in writing has been received from the Engineer all vertical wall forms shall be constructed for the minimum pressure as per CIRIA/ European Guidelines recommendations. The Contractor shall ensure that the constructions of the forms are adequate for all concrete placing condition and all the applicable CIRIA/European Guidelines recommendations are followed. However, in case of self-compacting concrete, the entire height of the pour shall be considered to be in fluid state and the lateral pressure shall be w x h, where "w" is the unit weight of green concrete and "h" is the height of pour.

7.4.2 All horizontal forms shall be constructed for pressures from the dead load of concrete including embedment and a minimum live load of 200 Kg/sq.m.

7.4.3 Forms constructed for retaining heavy concrete shall be built for pressures which have been increased by the ratio of the unit weight of heavy concrete to normal concrete.

7.4.4 Further, the formwork shall be designed to withstand all pressures arising out of placement of concrete using pumps, incidental loads if any and live load on the working platforms.

7.4.5 The form work shall be designed and fixed to meet the tolerances in various areas specified by the Turbine Manufacturer or as specified in the relevant drawings

7.5 TEMPORARY OPENINGS

Temporary openings, which can be conveniently closed, shall be provided at the base of the columns and wall forms and other places necessary to facilitate cleaning, inspection and vibration of concrete. Immediately before concrete is placed the forms shall be made sufficiently rigid and tight, thoroughly cleaned properly treated and free from foreign material. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected.

7.6 MATERIALS

7.6.1 Materials for the formwork shall be of plywood, formed steel plates, timber form covered with steel sheets, oil tempered hard board. Sliding forms and slip form shall be used for tall structures where specified and after approval by the Engineer. The supporting system shall be either adjustable props made of mild steel pipes for heights up to 6 meter or composite columns fabricated using M.S. Structural steel members.

7.6.2 Shuttering arrangement for concreting shall be of 12 mm/16 mm thick plywood backed with steel/DOKA framework and supports of horizontal and vertical walers connected to turn buckles. In case steel shuttering plates are used for formwork, the joints between the panels shall be sealed with suitable foam to make the formwork leak tight. Flat bar at top of soldier to be provided for maintaining thickness. Supports shall be rigid and strong enough to withstand effect of vibration without any deflection, bulging, distortion or loosening of its supports and shall be so as to prevent loss of slurry from the concrete. Plywood used shall be waterproof plywood conforming to IS: 4990. Test certificates from the manufacturers will be obtained and verified. Form strips or any other suitable sealing tapes will be used to prevent loss of slurry through the joints of formwork.

7.6.3 Suitable working platform will be provided for execution/ inspection of reinforcement, embedded parts and concreting.

7.7 CENTERING REQUIREMENTS

Centering using steel tubular props, H frames, built-up sections, with provisions to adjust heights of props shall be used and they shall be to true levels and rigid. They shall be adequately braced horizontally and vertically. For faster construction, quick strike decking system/ Acro/Doka systems shall also be used for shuttering supported on floors below, vertical props shall be so supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the shuttering. Bamboos or wooden poles shall not be used as props or cross bearers. Centering supported on structural steelwork shall also be designed for the conditions mentioned above.

7.8 TIE RODS

As far as possible MS tie rods left in type shall be used for supporting all forms. Retrievable type can also be used with prior approval of the Engineer. Tie rods shall have provisions for removal of a section of each rod at surface of the concrete to a depth of approximately 50 mm. All holes left by the removal of conical nuts or other removable fixtures embedded in the face of the concrete shall be filled and finished with sand-cement mortar in a manner specified in the finishing specification. Threaded inserts embedded on each face of the wall be cut for attaching the forms to previously placed concrete and when permitted shall be out off flush with the face of concrete or countersunk, filled and finished as required by the Engineer in the manner specified in the finishing specification. Measures shall be taken to prevent rust stains on concrete.. Through left-in Tie rods shall be permitted only upon approval of the Engineer.

7.9 FORM OIL

7.9.1 *Use of form oil shall not be permitted on the* surfaces, which require painting. If the Contractor desires to use form oil on the inside of the formwork of the other concrete structures, a non-staining mineral oil or other approved oil may be used provided it is applied before placing reinforcing steel and embedded parts. Such form oil shall be insoluble in water and not injurious to concrete and shall not become flaky or be removed by rain or wash water. Form oils that retard the setting of concrete shall not be used.

7.9.2 All excess oil on the form surface and any oil on metal or other parts to be embedded in the concrete shall be carefully removed. Before treatment with oil, forms shall be thoroughly cleaned of dried splatter of concrete from placement of previous lift.

7.9.3 The Contractor shall clean the concrete surfaces from any leftover form oil at his own cost if form oils are used.

7.10 SUSPENDED FORMWORK

7.10.1 In certain areas, as identified by the Engineer, metal decking/ and supported on structural steel framework shall be used as self-supporting shuttering as an alternative to the conventional shuttering in places where the area below has to kept free of scaffolding and centering works. The fixing of metal sheets to structural steel members shall be done by bolting / welding or any other alternative as advised by the Engineer .

7.10.2 Plate inserts may be embedded in the sidewalls during concreting, from which bracket supports can be obtained. Structural steel built-up sections or trusses shall be used for supporting the formwork. The Contractor shall submit the design and detailed drawings for the above scheme for the approval of the Engineer. The scope of work shall include design, fabrication, erection and dismantling of the supporting structure.

7.11 CHAMFERS AND FILLETS

Unless shown on drawings or elsewhere to the contrary, all corners and angles shall be formed with 45 Degree mouldings to form chamfers or fillets on the finished concrete. The standard dimension of chamfers and fillets, unless otherwise detailed or specified shall be 25 mm by 25 mm. For heavier work, chamfers or fillets may be 40 mm to 50 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the mouldings shall be planed or surfaced to the same texture as the forms to which it is attached. Unit rates quoted shall include providing the chamfers as specified or shown in the drawings.

Vertical construction joints on faces, which will be exposed at the completion of the project, shall be chamfered as above except where not permitted by the Engineer.

7.12 JOINTS

Joints in forms shall be truly horizontal or vertical unless otherwise specified and shall be sufficiently tight to prevent any leakage of cement slurry to avoid formation of fine or blemish. Faulty joints shall be sealed as directed by the Engineer. Suitable devices shall be used to hold adjacent edges together in accurate alignment. The Contractor shall use sealing tapes to avoid leakage of slurry through the formwork joints. On removal of forms the Contractor shall finish marks left by sealing tapes so as to merge with other concrete surface. The Contractor shall take care to maintain symmetry in formwork in slabs, walls, columns etc. so as to give a pleasant appearance to finished concrete surface. All forms shall be so made that they can be removed without hammering or prying against the concrete.

7.13 REUSE OF FORMS

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired or re-oiled before resetting. Formwork shall not be used/ reused, if declared unfit or unserviceable by the Engineer.

7.14 CLEANOUT PROVISIONS

Forms with limited working space within, shall be provided with temporary clean-out doors or openings for cleaning, washing, blowing and removal of water, wood chips, trash etc.

7.15 WORKING PLATFORM

The Contractor shall provide safe working platform for workmen, when working above ground level. Safe method of approach shall be provided to reach locations above ground level. Handrails shall be provided for all working platforms. Hanging platforms shall have safety net provisions. All ladders shall have handrails and shall not be kept vertical. All platforms, ladders, handrails etc. shall be firmly secured to ground or on supports. No loosely supported ladders or platforms shall be used in the work. All ladders and platforms shall have a kick plate 150 mm high either MS or wooden board for safety of personnel. Ladders and platforms shall be periodically cleaned of loose debris etc.

7.16 REMOVALOF FORMS

7.16.1 In the determination of time for removal of forms, consideration shall be given to the location and character of the structure, the weather and other conditions including the setting and curing of the concrete and materials used in the mix.

7.16.2 Forms and their supports shall not be removed without approval of the Engineer. Improper methods of removal of formwork likely to cause overstressing or damage to the concrete shall not be used. Supports shall be removed in such a manner so as to permit the concrete to uniformly and gradually take the stress due to its own weight.

7.16.3 The supports can be reinstated in anticipation of abnormal conditions. Re-propping of beams shall not be done except with the approval of the Engineer.

7.16.4 The minimum period for removal of forms shall be as mentioned below. However, The seven-day test results shall be as per IS: 456 (latest revision). If the strength requirements are not met with, the formwork shall be removed as per the instructions of the Engineer.

TABLE 7.1

MINIMUM PERIOD FOR REMOVAL OF FORMWORK

Sl. No.	Class of Structures	Earliest Concrete age at stripping for placing Temperature above 20 deg. C	
		Where ordinary Portland cement is used	Where mineral admixture is used
1.	Walls, Columns & Vertical sides of Beams	24 to 48 hrs. as decided by the Engineer	48 to 96 hours
2.	Slabs (props left under)	3 days	7 days
3.	Beam soffits (props left under)	7 days	14 days
4.	Removal of props to slabs		
	For thickness above 300mm		
	a) Spanning upto 4.5M	14 days	21 days
	b) Spanning over 4.5M	21 days	28 days
	For thickness upto 300mm		
	a) Spanning upto 4.5M	7 days	14 days
	b) Spanning over 4.5M	14 days	21 days
5.	Removal of props to beams and arches		
	a) Spanning upto 6M	14 days	21 days
	b) Spanning over 6M	21 days	28 days
6.	Cantilever construction	Not until adequate fix-ity is developed subject to a min. of 10 days	Not until adequate fix-ity is developed subject to a min. of 21days

7.16.5 For rapid hardening Cement Concrete 3/7 th of the period specified for ordinary Portland Cement will be sufficient subject to the minimum period of 24 hours.

7.16.6 Striking shall be done with utmost care to avoid any damage to concrete surfaces or any projections on it and without shock and vibrations, by gently easing the wedges/jacks. If after removing the formwork, it is found that timber has been embedded in the concrete, it shall be removed and made good as approved.

7.16.7 Tie rods, clamp form bolts etc., which must be entirely removed from the walls or similar structure, shall be loosened not sooner than 24 hours after the concrete was deposited. Works damaged due to premature or careless removal/withdrawal/ loosening/striking of forms shall be reconstructed at Contractor's cost.

7.17 STOPPER FORMWORK

Stopper formwork (Bulkhead) shall be provided at all vertical construction joints. Such formwork shall be leak-tight and shall not allow leakage of cement slurry. Wherever specified in the drawings, gas barrier/water stopper shall be provided in the stopper shutter. In addition to the erected stopper, emergency stopper formwork shall be kept ready before starting large concrete pours, with provision for gas barrier/water stopper if required. All stopper formwork shall be measured and paid in the item of

formwork only.

7.18 SLOPING FORMWORK

The bottom formwork shall be made out of plywood with wooden backing members. For slope above 15 Degree with the horizontal it is recommended to have plywood formwork for the top surface and supported on steel or wooden truss. These shall be divided into panels, which shall be fabricated in the shop to the required profile. The bottom of truss will be closed by plywood formwork at the time of concreting. Subsequently further closer formwork for the top surface will be extended after concreting and compaction of the lower portion The entire formwork shall be supported on structural steel/scaffolding supported on a firm base.

7.19 FORMWORK FOR SELF COMPACTING CONCRETE

The formwork shall be made out of plywood with wooden backing members. These shall be divided into panels, which shall be fabricated in the shop to the required profile. Special care should be taken so that there is no gap in the formwork joints so as to ensure not leakage of slurry due to increased workability and slump achieved by using appropriate admixtures. The lateral green concrete pressure on the formwork shall be governed as per Para titled “DESIGN LOADS” of this specification.

7.20 POCKETS FOR FOUNDATION BOLTS

Pockets for foundation bolts shall be made out of plywood or timber. These shall be made slightly tapered for ease of removal. The bottom of such formwork shall be necessarily closed so as not to allow entry of concrete from bottom. The timber pocket may have to be broken to withdraw after concreting. Templates shall be provided wherever required or as directed by the Engineer.

7.21 CURVED FORMWORK

This shall cover all such formwork, which is curved in plan. The formwork shall be fabricated to the required curvature at shop before use. Mismatch if any at site, shall be rectified by cutting or replacing the panel/members.

7.22 FORMWORK FOR PRE-CAST CONCRETE WORKS

All pre-cast units shall be cast in a suitable yard, bed or platform with firm foundation and free from wind. The platform shall have a smooth plaster finish. The yard shall be fenced and shall have a curing tank of adequate size and capacity. The Contractor shall be responsible for the accuracy of the level and shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or printed on each unit. Each unit shall be concreted in one operation. Reinforced concrete members shall be marked to indicate the upper surface.

The form shall be of steel sheets with only rigid steel frames. All components of

formwork shall be so held that during casting there is no deformation of the form resulting in the concrete units not confirming to dimensions indicated in the drawings. The shuttering shall be made with a tolerance of (±) 3 mm in all directions.

The side shutters shall not be struck in less than 24 hours for ordinary Portland cement after concreting and no pre-cast unit shall be lifted during striking the form.

7.23 METAL DECK SHEETING WORKS AS LEFT IN SHUTTERING

7.23.1 GENERAL REQUIREMENT

This part of the specification covers the technical requirements for deck sheeting to be used as left in shuttering for floors & roofs. Supply and installation of the deck sheeting shall be done by same agency. During handling / stacking, if any damage is done to sheet like distortion of edges, scratches on sheet etc., then such damaged sheet shall stand rejected and shall be immediately replaced by the contractor.

7.23.2 MATERIAL

7.23.2.1 Troughed permanently metal decking sheet for Floor / roof decking shall be made by steel feed material of minimum 1.0 mm (bare metal thickness i.e. metal thickness excluding thickness for coating and galvanizing) galvanised to grade 275 as per as per IS 277, of minimum yield strength of 250 Mpa of drawing grade as per IS 513 of approved profile, sectional properties.

7.23.2.2 For metal decking the sectional modulus and moment of inertia of troughed profile per meter width shall be so as to limit the deflection of sheets to span/250 over a span of 1.5 m under total super imposed loading (DL +LL) of minimum 1000 kg per Sq.M.

7.23.2.3 The maximum spacing of the fasteners shall be 390 mm c/c along the length of purlins/runners. However exact spacing shall be as per the design done by the bidder for the fasteners considering the wind load, self-load and other associated loads. Minimum diameter of the fastener shall be 5.5 mm and at least 3 nos. of fasteners shall be used per sheet.

7.23.2.4 Percentage elongation of the mild steel sheet having minimum yield strength of 250 MPa, shall be 23% as per IS:2062.

7.23.3 INSTALLATION AND FIXING

a. The sheeting shall be fixed as per the approved drawings. Sheets shall be supplied in required sizes (based on supporting member spacing) according to the cutting schedule. Generally cutting of sheets to length shall not be permitted at site. Specific approval under exceptional circumstances shall be obtained before cutting of any sheet at site. Power tools shall be used for cutting. Cutting and trimming of small openings which were not finalised at the time of working drawings can be allowed at site. Wherever possible, site cut edges shall be concealed at laps or with flashings.

Suitable steel members for stiffening shall be provided at the cut edges. No gas cutting shall be done on the sheet. If any sheet is found with gas cut mark, same shall stand rejected and shall be immediately replaced.

b. Distorted, blemished or water stained sheets shall not be used.

c. Before installing decking sheet, it shall be ensured that the purlins / supporting members are in true planes, correctly placed and securely fixed.

d. Side and end laps of the sheets shall be made weather proof by securing them with the fasteners not less than 4.0mm dia with 2.0 mm thick neoprene washer. Maximum spacing of the fasteners shall not to exceed 500 mm.

e. Precautions shall be taken during the erection of the sheets to ensure that partially erected decking sheets are protected during inclement weather and damage at all times.

f. Side and end of decking sheet shall be located and positioned in such a manner as to provide the maximum weather protection taking into account the direction of the prevailing wind.

g. Length of the sheet shall be such as to cover minimum 3 span purlin/ supporting members spacing.

h. The roof decking sheets shall be fixed to the purlins/ supporting members with the help of self drilling and tapping type fasteners and neoprene washers.

i. Sheets shall be laid over the supporting members/ purlins with a minimum bearing of 50 mm and end projection of 75 mm at lap joints.

j. End and side laps between the sheets shall be sufficiently large to ensure the weather tightness. In no case, the end laps shall be less than 150 mm and side laps less than one trough length with proper weather tight arrangement.

k. As required the suitable shear connectors shall be provided on deck sheeting for proper shear transfer between sheet & floor/ roof concrete.

7.24 CONSTRUCTION JOINTS & GROOVE FOR CAULKING

These shall provided as shown in the approved drawings or as desired by the Engineer. A trapezoidal groove tapering from the face of the wall to inside will have to be provided on containment walls and roof at all construction joints. For construction joints in thin sections a steel cover plate exposed from one side of the surface will be provided replacing the water stop within the thickness and concrete will be cast against the plate. Suitable grooves will be provided at the junction of the plate and the concrete. Also embedded parts passing through the wall will be provided with grooves around its periphery on the containment walls. All such

grooves shall be caulked by the flexible polysulphide compound or epoxy mortar as directed by the Engineer.

7.25 TOLERANCES

The following tolerances are permitted unless otherwise mentioned in the relevant drawings. The tolerances shall be taken as the departure from the true position at any point after completion of the structure.

Sectional dimensions	:	(±) 5 mm for cast-in-situ concrete.
Plumb	:	5 mm in 5 m but not cumulative. Tolerance in various sections should be compensatory and not cumulative
Levels	:	2 mm before any deflection has taken place for both cast-in-situ and pre-cast works.

Tolerances for climbing type of form work. Variation in walls: Not more than (+) 3 mm.

Total deviation at any point of climbing form / other formwork measured in horizontal plane with respect to the projection of a corresponding reference point at the base of the structure. (Total deviation consists of translational and rotational components.) : 3 mm per 6m height unless specifically required otherwise.

Latest computerised survey instruments shall be used for checking the verticality and alignment of the form works.

7.26 SUBMISSION OF CONTRACTOR'S SCHEME

Bidder shall submit along with his tender the scheme for shuttering, centering, scaffolding for important elements. These should be supported by preliminary drawing and design calculations. Final drawing shall be submitted before start of work.

The scheme submitted by the Contractor should be for all the different type of centering and shuttering schemes proposed and should be so elaborate keeping in mind the entire cross-section of the respective structures in general. The scheme should be such that the construction of one part of any building should not hinder the work on the other parts and keeping in mind the construction schedule.

For centering and shuttering of walls, columns, beams & slabs all the working drawings, details of erection methods calculation of stress and of deflections shall be supplied to the Engineer for approval at least six (6) months in advance of erection.

7.27 ALTERATIONS AND MAINTENANCE

Any modification that the Engineer may require shall be made by the Contractor. Notwithstanding the approval of or alteration suggested by the Engineer in the submitted design for any of the temporary work etc., the Contractor shall remain wholly and entirely responsible until the final acceptance of works, for the efficiency, security, safety and maintenance and for all obligations and risks in regard to such work specified or implied in the contract. The Contractor shall reinstate the same at their own cost, should any mishap or accident occur causing damage or injury thereto, subject however to such provisions of the conditions of contract as may be applicable in the case of such damage or injury.

8. WATERPROOFING OF UNDERGROUND CONCRETE STRUCTURES

8.1 SCOPE

This specification covers waterproofing of underground concrete structures viz. basement, sump, pit, tunnel and trenches against ground water.

The specification described here covers material description, physical and mechanical properties, testing, applicable codes and standards, acceptance criteria, surface preparation, placing in position, lapping and QA requirement etc of water proofing treatment of basement slab and walls.

8.2 GENERAL REQUIREMENTS

As a general guidance, the provisions contained in the contract shall be followed unless otherwise mentioned. Considering safety requirement, Nuclear Power Plant structures should meet special requirement regarding leak tightness.

The contractor shall do the proper concreting so that concrete is water tight in itself without waterproofing treatment. Quality control of concrete construction shall include inspection of preparations for concreting, mixing, transportation, placement, compaction, curing and protection.

The work of waterproofing of underground concrete structure shall be entrusted by the contractor to expert agency approved by NPCIL. The specifications of waterproofing mentioned here are generic in nature. The Contractor shall submit the detailed specification of waterproofing for NPCIL's approval.

8.3 MATERIAL

The plasticized PVC membrane shall be minimum 2.0 mm thick, single ply, twin colored preformed flexible membrane. The single ply plasticized PVC membrane shall be thermoplastic membrane manufactured by co-extrusion process. The membrane shall be of twin colour to provide visual indication of damage, due to any movement or any other reason. The sheet shall be minimum 2 meter wide and appropriate length to minimize the number of joints. The compartmentalization shall be done using specified size of water stop to confine any accidental damage within 100 square meters. All lap joints shall be tested for water tightness upto 2 Kg/sq cm

pressure prior to concreting. The membrane shall be suitable for defect free installation on all type of surfaces viz. horizontal, vertical and overhead and it shall be loosely laid (unbounded) to act independent of structural movement. Adjacent sheets shall be laid with an overlap of at least 80 mm.

The PVC membrane used for waterproofing membranes shall exhibit the following properties.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Thickness	UNI EN 1849 -2	mm	Minimum 2.00 mm
Specific weight	UNI EN 1849 -2	kg/m2	2.600
Ultimate Tensile strength	UNI EN ISO 527-3 Transverse Machine direction	 N/mm2 N/mm2	 Minimum 14.9 N/mm2) Minimum 15.2N/mm2)
Ultimate Tensile Strength (Ageing by complete immersion in ground water for 16 months at 50 ^{0}C)	UNI EN ISO 527-3 Transverse Machine direction	 N/mm2 N/mm2	Minimum 14.9 N/mm2) Minimum 15.2N/mm2)
Elongation	UNI EN ISO 527-3 Transverse Machine direction	 % %	 min 280 (-30%) min 280(-30%)
Mean Tensile Strength Variation	DIN 53455	%	3.5
Impact strength	DIN 16726 - 5.12	mm	> 600
Puncture resistance	DIN 16726 - 5.12	mm	> 1000 mm
Hydrostatic pressure resistance (6 hours at 5 bar)	UNI EN 1928 meth.B		Waterproof
Tear resistance	ISO 34 /ASTM D624	MPa	> 45
Resistance to static punching (CBR)	UNI EN ISO 12236	N	> 1700 N
Root resistance	DIN 4062		No penetration
Fire Behaviour	EN ISO 11925-2		Class E

For Sub-soil applications the chemical resistance of the PVC membranes shall be as fully resistant to the chemicals along with the respective compositions as listed below

as per ASTM D 6943 (i.e. complete immersion of sample in respective solutions for 15 days).

CHEMICAL NAME	NATURE OF CHEMICAL	% CONCENTRATION
Sulphuric Acid	Inorganic Acids	≤ 25
Sulphurous Acid	Inorganic Acids	≤ 6
Nitric Acid	Inorganic Acids	≤ 5
Benzoic Acid	Organic Acid	≤10
Acetic Acid	Organic Acid	≤10
Oxallic Acid	Organic Acid	≤ 25
Phthalic Acid	Organic Acid	≤ 25
Tartaric Acid	Organic Acid	≤25
Citric Acid	Organic Acid	≤ 25
Ammonium Hydroxide	Inorganic Bases	≤ 5
Potassium Hydroxide	Inorganic Bases	≤ 5
Sodium Hydroxide	Inorganic Bases	≤ 10
Chlorides	Salt Solutions	≤ 25
Sulphates	Salt Solutions	≤ 25
Nitrates	Salt Solutions	≤ 25
Soap Solution	Salt Solutions	≤ 25
Drinking Water	Salt Solutions	Any Concentration

8.4 THICKNESS & SPECIFIC WEIGHT OF SHEET

The thickness of the single ply plasticized PVC membrane shall be 2.00 (minimum as per UNI EN 1849). The specific weight of 2.0 mm thick single ply plasticized PVC membrane test piece shall be determined in mass per unit area.

8.5 TENSILE STRENGTH & ELONGATION TEST

The tensile strength and elongation requirement shall be as per UNI EN ISO 527-3. In this test, dumbbell shaped single ply plasticized PVC test pieces are cut using the standard dumbbell die are stretched in a tensile testing machine at a constant rate of traverse of the driven grip. Readings of transverse loads and elongation are taken as required during the uninterrupted stretching of the test piece and when it breaks. For the tensile strength of the joints they are subjected to varying tensile stresses for the overlap joints as per ASTM D638.

8.6 PUNCTURE RESISTANCE

The puncture resistance requirement shall be as per DIN 16726 - 5.12. This is measured using the truncated cone test, in which truncated cones are used as puncture points. The heights of the truncated cones are varied to determine the critical cone height, which is the height at which the puncture occurs for a given pressure. The

minimal permissible height for a 2.0 mm thick single ply plasticized PVC membrane used for waterproofing in case of basements is >800 mm.

8.7 HYDROSTATC PRESSURE RESISTANCE

The hydrostatc pressure resistance requirement shall be as per UNI EN 1928 meth.B. In this test the lateral hydrostatic pressure is exerted on below-grade foundations and slabs on grade by an elevated water table. Tests to quantify resistance to the passage of water should be specific as to the maximum pressure the membrane must be capable of withstanding. In case of single ply plasticized PVC membranes the minimum amount of pressure that the membrane can withstand is tested for a water table of 60mts as per the code. Subjected to these conditions there should be no penetration of water as per the specifying needs.

8.8 ROOT PENETRATION RESISTANCE

Root resistance is tested for single ply plasticized PVC waterproofing membrane through the composition of the membrane which provides an impenetrable barrier to root growth. Root resistant 2.0 mm thick single ply plasticized PVC membrane is quicker to install than separate waterproofing and root barrier layers.

8.9 TEAR RESISTANCE

This test method measures the force per unit thickness required to rupture, initiate, or propagate a tear through a sheet of 2.0 mm thick single ply plasticized PVC membrane. This testing is done so that the specified waterproofing membrane does not fail in service due to the generation and propagation of a special type of rupture called a tear. Tear strength is calculated as T= F/d, where T is the tear resistance, F is the load acting on the membrane and d is the thickness of the membrane. Tear strength of 2.0mm thick single ply plasticized PVC membrane should at least be 45MPa.

8.10 STATIC PUNCHING RESISTANCE

CBR Puncture is an index of puncture resistance that measures the force required to push a flat ended plunger through a 2.0 mm thick single ply plasticized PVC membrane. Instead of an 8 mm diameter probe with a beveled edge; this test utilizes a 50mm diameter, flat-ended probe (plunger) that is pushed slowly through the PVC membrane. The relatively large size of the plunger provides a multidirectional force on the PVC membrane and simulates big stones pressed onto the PVC membrane laying a relatively soft sub-base. The minimum value for a static punching resistance should be at the very least of 1700 N for subsoil applications.

8.11 FIRE RESISTANCE

This test determines the ignitability the specimen is subjected to direct impingement of a small flame at the edge or at the surface. The test specimen of size 250 mm × 90 mm is attached vertically on a U shaped specimen holder. A propane gas flame with a

height of 20 mm is brought into contact with the specimen at an angle of 45 °. For subsoil applications of 2.0 mm thick single ply plasticized PVC they should belong to Class E as per the ISO 11925-2 (Reaction to fire tests-ignitability of products subjected to direct impingement of flame-Part 2:single flame source test).

8.12 TESTING

For acceptance of material listed in above table, Manufacturer Test Certificate (MTC) from manufacturer confirming to above specified properties shall be submitted to NPCIL. However, membrane supplied from each batch shall be got tested for Thickness, Ultimate Tensile Strength, Elongation & Puncture Resistance. Testing of the membrane shall be carried out by the contractor as per approved QAP in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL as per above mentioned relevant standards at no extra cost to NPCIL.

8.13 PACKAGING SHIPMENT AND STORAGE

Materials delivered at site shall be clearly marked with legible and intact labels with manufacturer's name, brand name, product identification and batch number. The products (adhesives etc.) shall be in original, unopened containers.

Materials shall be stored in areas where temperatures conform to manufacturer's recommendations and instructions. All materials shall be stored in covered clear away from reinforcements, coarse aggregates and heavy engineering activities at site. All the materials like membranes, sealants etc. shall be kept away from sources of ignition.

All empty containers of various chemicals employed, left over chemicals shall be disposed off; in a safe manner on a dumping site approved by the site authorities.

All personnel of the applicator should wear all safety gears like gloves, helmet, goggles etc during installation.

8.14 INSTALLATION AGENCY

The works shall be carried out only by trained and certified applicator of the specialized agency carrying water proofing treatment/ membrane supplier.

8.15 INSTALLATION OF MEMBRANE

The plasticized PVC membrane shall be fixed on PCC surfaces strictly as per the detailed application guidelines of the manufacturer. Broadly the installation steps shall include

- Removal of Sharp protrusions
- Installation of Geo textile made of needle-punched 100% pure polypropylene yarns, with a minimum weight of 300 gsm.

- In case of Vertical walls, installation of roundels with mechanical fixtures.
- Laying of plasticized PVC membrane with specified lap joints
- Welding of Joints and testing for water tightness up to 2 Kg/Sqcm
- Water tightening of Pile heads/ rock anchors etc as applicable
- Compartmentalization of the PVC membrane using PVC surface water stops
- Laying of Second layer of Geo textile.
- Laying of Protective screed on horizontal surfaces
- Laying of minimum 25mm thick Protective boards / 115 thick Brick wall protection (the protective board shall be used in case of back filling done with soil / crushed sand , having no boulder/aggregate bigger than 80mm size) for the vertical walls.

A detailed scheme shall be submitted by the contractor including the layout of PVC water stop arrangement and injection ports etc (if proposed) for NPCIL approval prior to its application.

The main contractor shall ensure that all areas of the finished basement waterproofing system shall be protected from site related work traffic and other trades until completion of all works.

Adequate temporary protection shall be provided over the installed membrane during the works program, particularly at temporary walkways, access points to the basement, concreting material stockpiles etc. in order to prevent damage.

8.16 PREPARATION OF THE SUBSTRATE

The substrate shall be PCC concrete of sufficient thickness (minimum 50 mm) to ensure a firm substrate that will not crack or deform under normal trafficable conditions during waterproofing installation, and structural concreting operations. It should be smooth, free from debris and other irregularities, which may puncture and damage the waterproof liner.

The surface will be made clean, dry, smooth and free of contaminants such as grease, animal fats, coal tar and oil based products. Accumulation/ ponding of water shall be removed from the work surface prior to installing the system.

All horizontal or vertical surfaces should be covered with a uniform adjustment layer using Non-Woven Geotextile. It has the purpose of ensuring the uniformity of the substructure in order to avoid irremovable debris or other roughness in the underlying layer which may cause damage, perforate or punch, the waterproof layer.

8.17 WATERPROOFING SYSTEM FOR BASEMENT RAFT SLAB

The 2.0mm thick single ply twin colored plasticized PVC loosely laid membrane waterproof system should be installed over the hardened well leveled surface of the PCC overlaid with first layer of Geotextile. The Geotextile shall be resistant to micro-organisms, needle-punched 100% pure polypropylene yarns, with a minimum weight of 300 gsm. The PVC membrane system shall be compartmentalized using PVC

surface water-stop maximum size of compartmentalization shall be limited to 100 sq m). The PVC water stop used for compartmentalization shall be minimum 320mm wide, min thickness of 2.5mm and shall have minimum 4 ribs of 15 mm depth. These PVC water stops shall be welded with PVC membrane by hot air welding. The membrane shall be further covered with second layer of Geotextile ensuring no gaps in the Geotextile. The geotextile should be checked prior to laying of protection screed.

After checking all the joints & any visible damage, second layer of geotextile shall be laid over the member followed by laying of minimum 50mm thick layer of protection PCC (Minimum Grade M20) screed. The damage if any found, shall be recorded and the necessary patch repairs shall be conducted before laying of second layer of geotextile and protection layer.

8.18 WATERPROOFING SYTEM FOR VERTICAL/RETAINING WALL

The first layer of Geotextile Membrane shall be laid over the hardened well leveled surface. Over the Geotextile membrane 2.0mm thick single ply, twin colored, and plasticized PVC membrane waterproofing system shall be installed using rondels having maximum C/C spacing 1.0m .The rondels are provided to anchor & hold the Membrane at its position. The membrane is to be protected after installation with a 300gsm geotextile followed by protective layer of 25 mm thick expanded polystyrene boards (in case of back filling done with soil / crushed sand, having no boulder/aggregate bigger than 80mm size) or 115 mm thick brick wall. The PVC membrane system shall be compartmentalized using PVC surface water-stop at required locations, based on the site requirements (maximum size of compartmentalization shall be limited to 100 sq m).

8.19 CHECK FOR MEMBRANE TO MEMBRANE JOINT

Two adjacent membranes shall be welded using hot air welding. It shall be a double seam weld to maximum clear length of the membrane installed; double seam weld shall allow pressure testing of every length of joint. The double seam joint shall be tested to a pneumatic pressure of maximum 2 bars kept for minimum duration of 8 minutes. The loss of pressure after holding for 8 minutes shall not exceed 20%.

Wherever the double seam welding machine cannot be used, the single seam welding shall be done after obtaining prior permission from engineer, in such case the weld width shall be preferable 40mm, but shall not be less than 20mm in any case. The single seam weld shall be tested using a seam probe hook to check for any opening in the weld. In addition to above if any destructive testing is found necessary shall also be performed.

8.20 PILE HEAD TREATMENT

The single ply plasticized PVC membrane is dressed up to the outer surface of the pile head or anchor or up stand. The membrane is then encapsulated in with a high strength flowable epoxy mortar having a minimum thickness of 10mm below the

membrane and mini 20mm on top of it and extended to the edge of outer surface of the interface. The key properties of the high strength flow able epoxy mortar shall be as mentioned in the following table.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Solids Content	DIN 53213	%	100
Tensile Strength	BS 6319, Part 7	MPa	11
Compressive Strength	BS 6319, Part 2	MPa	100
Flexural Strength	BS 6319, Part 3	MPa	25

8.21 QUALITY ASSURANCE & SUPERVISION

A detailed work procedure and inspection and test plan (ITP) in line with this specification and manufacturer's specification with resources deployment shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work. Contractor shall carry out testing of materials as per direction of Engineer and shall submit testing reports and manufacturer's test certificates to the Engineer. A strict check on membrane properties and installation shall be exercised by Contractor's QA Engineer and necessary records in this regard shall be submitted to NPCIL. Contractor shall provide necessary assistance to NPCIL in supervision of water proofing work.

During the entire process of work under this specification, the Contractor shall arrange at his own cost the supervision of the work on water proofing by the manufacturer's/ specialized agency's representative to ensure that the work is being executed as per manufacturer's specifications and instructions.

8.22 GUARANTEE

The Contractor shall make periodical inspection and repair the waterproofing for any apparent defects to ensure complete waterproofing during the guarantee period. The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for an amount of 10% of the cost of water proofing works carried out. The bank Guarantee shall be valid for a period of ten (10) years from the date of acceptance of the water proofing work by NPCIL.

9. DELETED

10. REINFORCEMENT

10.0 SCOPE

The work covered under this section shall include supplying, cleaning, cutting, bending, placing, binding and securing of reinforcement in position for all structures.

For use of Fusion Bonded Epoxy Coated bars the relevant specification shall be followed.

10.1 STANDARDS AND SPECIFICATIONS

The provisions of the latest revisions with amendments, if any, of the following Indian Standards and other relevant codes shall form part of this specification to the extent they are relevant. Where the provisions of these Standards/Codes are in conflict with the stipulations of this specification, the specification supersedes the respective Standard or Codes.

10.1.1 BUREAU OF INDIAN STANDARDS

IS – 1786	High strength deformed steel bars and wire for concrete reinforcement-Specification.
IS – 456	Plain and reinforced concrete – code of practice
IS – 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS – 9417	Welding cold worked steel bars for reinforced concrete construction – recommendation for welding.
IS – 2751	Code of practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
IS – 822	Code of procedure for inspection of welds.

10.1.2 OTHER STANDARDS

1. ASME Section III DIVISION
2. Qualification of splicing system

10.2 MATERIAL

Material covered under this specification is a high yield strength deformed bar (HYSD) and TMT bars of grade Fe 500 conforming to IS: 1786, as specified in the drawing. For Fe 500 grade steel, the total elongation shall be more than 14.5 % and the ultimate tensile strength of the bar shall be 15 % more than the specified 0.2 % proof stress/ yield stress. This requirement is over and above the requirements specified in IS 1786. The Contractor shall submit the manufacturers test certificate for the material. Random tests i.e. minimum 1 sample per 150MT or at least one sample from each heat, for each diameter of bar shall be performed as required by the Engineer in his presence. All costs, incidentals to such tests shall be borne by the Contractor and shall be deemed to have been included in his quoted rates. Steel not conforming to the specifications shall be rejected. All reinforcement shall be clean, free from grease, oil, paint, dirt, loose mill scales, loose rust, dust, bituminous material or any other substance that will destroy/ reduce bond. All bars shall be thoroughly cleaned before fabrication and placement. Pitted and defective bars shall not be used.

The steel shall be supplied by main manufacturers like SAIL, TATA Steel & RINL etc., who manufacture the rebars using billet produced from ore itself and not by rerolling of steel.

10.3 STORAGE

10.3.1 The reinforcement steel shall not be kept in direct contact with ground but stacked on top of an arrangement of concrete pedestal or timber sleepers. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deteriorations.

10.3.2 It shall be stored under cover, as desired by the Engineer without any extra cost. If necessary, the reinforcement steel, other than Fusion Bonded Epoxy Coated bars, shall be coated with cement wash before stacking, to prevent scale and rust. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage. Any reinforcement, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for the work.

10.4 FABRICATION

10.4.1 The reinforcement bars shall be straightened, cut to size using cutting machine & shall be cold bent using bar bending machine, without the use of heat, to the shapes mentioned in the Drawings, as per relevant Indian Standards. Bars having cracks or splits on the bends shall be rejected. The bar bending schedules shall be prepared by the contractor in general (except for critical structure as decided by the Engineer) according to the reinforcement drawings and shall get it approved by the Engineer. In any case, the details given in the drawings shall be final. The high strength deformed steel bars/ TMT Bars shall not be re-bent or straightened without the approval of the Engineer. Crossing bars shall not be tack welded. Bars shall be properly tagged for easy identifications.

10.4.2 Where reinforcement bars are bent aside at construction joints and afterwards bend back into their original position, care should be taken to ensure that at no time the radius of the bend is less than 6 times the dia for HYSD TMT bars.

10.5 FIXING / PLACING

10.5.1 Rough handling, shock loading (prior to embedment) and the dropping of reinforcement from a height shall be avoided. Reinforcement shall be accurately placed and fixed by any approved means to maintain the correct position of bars as shown on the drawings for this purpose. The contractor shall use cover blocks, spacers and chairs as per IS: 2502 to prevent displacement during placing & compaction of concrete. Concrete cover blocks as directed by the Engineer shall be used for providing specified cover to the rebars. Bars intended to be in contact at crossing joints shall be securely bound together at all such points with 1.6 mm dia soft annealed Iron wire (Binding wire). The vertical and horizontal distance required between successive layers of bars in beams, walls or similar members shall be

maintained by the provisions of spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bar. The dia. of such spacer bar shall not be less than the dia. of the main bar. No reinforcement shall be bent when in position in the work, without the approval of the Engineer. In-situ bending of embedded bars using oxy-acetylene flame shall not be done. However, if it can be proved that cold bending is not possible the same may allowed at the discretion of the Engineer by taking due precautions. Erected and secured reinforcement shall be inspected and approved by Engineer prior to placement of concrete.

10.5.2 When reinforcement of the specified diameter is not available, Contractor may be allowed to replace with diameter higher than originally specified in the drawing on written approval of the Engineer at no extra cost to NPCIL. However, this option shall be used under exigency situations only and not as a general practice.

10.5.3 Exposed ends of dowel bars for underground structures shall be protected if necessary, by encasing the same in lean concrete, at no extra cost. Bars for the portion of structures above ground shall be given adequate coat of cement wash and if additional protection is needed as per the Engineer, shall be wrapped with plastic tape at no extra cost.

10.5.4 Wherever necessary/ as directed by the Engineer, before placing the reinforcement in the congested areas full-scale mock-ups shall be carried out and approval from Engineer shall be obtained. Such Mock-ups will be paid as per relevant items of BOQ.

10.5.5 For supporting the horizontal bars at height, supports drawings shall be prepared by the Contractor & shall be approved by the Engineer. Reinforcement chairs, spacers & support embedded in concrete as mentioned in the drawing or specified by the Engineer will be measured & paid separately.

10.6 TOLERANCE ON PLACING OF REINFORCEMENT

Unless otherwise specified in the drawings, reinforcement shall be placed in accordance with IS: 456.

10.7 LAP SPLICING OF REINFORCEMENT BARS

Lapping of reinforcement bars shall be done at locations shown in the drawings or as directed by the Engineer. The lap length shall not be less than that specified in the drawings and unless otherwise specified, the lap length shall be as per IS: 456. At locations where lap splice gives rise to congestion of reinforcement, such splice shall be replaced with welding/ mechanical splicing. For mechanical splicing of bar the relevant specification of mechanical splices (Threaded Coupler) shall be followed.

10.8 WELDING

10.8.1 Generally bars joints are to be made using mechanical splicing using threaded

couplers or lapping. In exceptional cases only joints shall be made by welding or any equivalent splicing system like CADWELD etc. The splicing system shall be qualified as per ASME Section III DIVISION 2.

10.8.2 Field welding of reinforcement will not be permitted, without the written permission of the Engineer. Such approval will require identification of the type of steel used. Where welding is permitted, detailed welding procedure shall be submitted to the Engineer for approval. Welding of reinforcement to structural steel if required shall be done as per standard practice. Welding of reinforcement if required will be paid for as per relevant item of schedule. Welding of High Strength Cold Twisted deformed bars/TMT bars conforming to IS 1786 shall be made in accordance with the relevant Indian Standards (IS 9417).

10.8.3 The material shall be examined and compared with the manufacturer's test certificates, ISI certification marks and inspection stamps. Special attention shall be paid to the chemical composition of the material and its general weldability to meet the required standards for strength. The material shall be examined for surface defects, rust and corrosion products, presence of contaminants and any other factors, which may hamper the production of a satisfactory weld.

10.8.4 The qualifying tests for welders engaged in arc welding shall be in accordance with IS: 2751.

10.8.5 The Procedure to be adopted for the welding shall be arc welding with double V butt joints. Oxy-acetylene welding is not permissible.

In addition to the requirements specified in IS 9417, the requirements given below shall also be followed:

10.8.6 All welding operations shall be controlled to prevent a supply of more heat to the steel at a time than can be dissipated by the steel owing to its high thermal conductivity without adversely affecting the strength of the welded bars. The non-twisted portion of the deformed bar at weld junctions (25 to 50 mm) must always be cut off. Scraping of rust at joint- surfaces prior to welding is essential.

10.8.7 For edge preparation, the bar ends to be welded should be shaped by power shears and grinders. If oxyacetylene torches are used for shaping the edges (chisel edge) last 2-3 mm of the cut faces shall be removed by grinding. The amount to be ground off may be determined by tests, but should not be less than 2 mm. To avoid crookedness in bars after welding, their axes should be properly aligned prior to the welding operation. During the welding procedure, the bar may be supported to about 1 m. on each side of the joint over steel channels 2 m. to 3 m. long. Removal of slag after each alternate welding run is to be effected by brushing. The electrode shall never be lighted from the hot bar, to avoid notch effect.

10.8.8 Fusion faces and surfaces adjacent to the joint for a distance of at least 50 mm on either side shall be absolutely free from grease, loose scales, moisture or any other substance which may interfere with welding or adversely affect the quality of the

weld.

10.8.9 Each layer of the multiple layer weld may be moderately peened with light blows from a blunt tool. Care must be taken to prevent scaling or flaking of weld.

10.8.10 Welded junctions of all reinforcing bars may be carried out at same section provided there are no bends, curved parts in reinforcement bars, or zones where variable loads predominate. It is recommended that all welds be located at least 50 dia away from bends.

10.8.11 Assessment after welding shall first be done to ascertain the correctness of the whole weldment by visual and dimensional inspection.

10.8.12 Mechanical testing in the form of tensile tests and 180-degree bend tests shall be carried out on prototype or sample welds. The choice of the samples will depend entirely on the Engineer, and will be made at random. Specimens for tension tests are to be chosen 1 out of every 100 joints prepared. The bend tests are to be conducted on 2 prototype specimens in 2 perpendicular directions, for every 200 joints. The specimen shall be bent by 180 degree for qualification.

10.8.13 The welded joint should be capable of resisting 90% of the actual bar strength and should not fail to develop at least 100% of the specified ultimate strength of the variety of steel under use. The failure shall not occur at the joint location.

Weldments incapable of developing full strength shall not be used as reinforcement.

Apart from tensile testing of weldments, liquid penetrate flaw detection test as recommended in IS: 822 shall also be made on 10% of total joints on root & final pass.

10.9 FUSION BONDED EPOXY COATING BARS

10.9.1 SCOPE

These specifications cover coating of reinforcement bars with fusion bonded epoxy coating (FBEC) to be provided as corrosion protection measure, in construction of Nuclear Power plant. This coating shall be used, wherever specified so in the drawings.

10.9.2 REINFORCING BARS

The reinforcing bars to be provided with Fusion Bonded Epoxy Coating shall conform to I.S. 1786. In spite of producing test certificates by contractor for the proper quality of reinforcing bars, the quality of steel should also be tested by the FBE coating agency for bend test before undertaking coating and that if the reinforcing bar fails in bend test, it shall be rejected.

Reinforcing bars to be coated shall be fresh from rolling mills as far as possible. If

the bars are rusted in quality before providing FBEC, the same shall be rejected.

10.9.3 Coating on Bars with FBEC

10.9.3.1 SURFACE PREPARATION

The surface of the steel bars to be coated shall be cleaned using shot blasting near to white metal .The surface profile shall be free from mill scale, rust and foreign matter.

10.9.3.2 The Coating shall be applied to the cleaned surface as soon as possible after cleaning. In no case the coating be delayed beyond 8 hours after cleaning.

10.9.3.3 The FBEC coating shall be done confirming to I.S. 13620 as well ASTM A775/775M.

10.9.3.4 The Fusion Bonded Epoxy Coating shall be carried out by an authorized FBE coating agency approved by Engineer.

10.9.3.5 Patch-up materials shall be procured in sealed containers with certificates from coating agency for supply of such patch-up material.

10.9.3.6 The Quoted rate for FBE coated bars shall include the use of PVC coated GI wire (Binding Wires) of 1.6 mm dia.

10.9.4 Tests for FBE Coating on Reinforcing Bars

10.9.4.1 The contractor shall produce certificate from the FBE coating agency that the quality of powder epoxy material and other components of FBEC conform to I.S. 13620 as well ASTM A775/775M. Such certificates shall accompany each delivery challan of coated bars. The Engineer may carry out such tests at plant to confirm use of proper quality of coating material.

10.9.4.2 The Coated reinforcement bars shall be tested for following properties at a specified frequency. Following tests on coated bars shall be as per I.S. 13620 at the specified frequency on routine basis and Test reports shall be jointly signed by authorized representatives of contractor and the coating agency:

Thickness of coating: One full-length bar for every twenty bars for each size of bars

Continuity of coating: One full-length bar for every twenty bars for each size of bars

Adhesion of coating: As per following frequency based on dia of bar

- Upto 16 mm dia: - 1 for every 1 tons
- Above 16mm and upto 25mm dia: - 1 for every 2 tons
- Above 25 dia: - 1 for every 4 tons

10.9.4.3 Inspite of conducting above tests and test certificates produced by the contractor and coating agency, Engineer reserves the right to carry out independent tests at coating plant for cross checking. The contractor's agreement with coating agency shall include the provision for Engineer's cross checking and that if the coating quality is not approved by the Engineer, the decision of the Engineer to reject or repair the coating shall be final and binding on all parties.

10.9.4.4 Thickness of Fusion Bonded Epoxy Coating shall be 250 (+/- 50) microns.

10.9.4.5 Holidays in coating shall not be more than two holidays per linear foot (six holidays per meter) of coated bar. All the damaged coating incurred during handling & fabrication, to the point of shipment to the job site shall be repaired. Damaged coating on a bar is permitted to be repaired if the amount of damaged coating does not exceed 1 % of the total surface area in each 0.3 m length of bar. The limit on the amount of repairable damaged coating does not include sheared & cut ends of the bars that are required to be coated with patching material. Repaired areas of damaged coating shall have a minimum coating thickness of 250 microns.

10.9.4.6 The Coating shall also meet all other requirements specified in IS 13612 as well ASTM A775/775M.

10.9.5 Handling

10.9.5.1 The coated bars shall be carefully handled in order not to drop them, not to rub them on hard surface or against another coated bar while conveying, stacking, placing or stacking of fabricated bars. For this purpose, wooden packing batons shall be used at spacing of not more than 60 cms.

10.9.5.2 The Coated bars shall be tied to make bundles with PVC binding material to avoid damages to coating.

10.9.5.3 The cut ends of bars shall be touched up with special touch up material of the same specifications as provided by coating agency. There shall be minimum time gap to repair the cut ends and damaged portions with touch up materials and that failure to do so may cause complete rejection of the coated bars. The cut ends and damaged portions shall be touched up with repair patch-up material within four hours time gap. All damages to coating in handling etc. shall be repaired irrespective of their size. This stipulation supersedes provision of clause 13 of IS 13620.

10.9.5.4 The Contractor will be paid for the same quantity of reinforcement bars used in the work and paid under relevant item.

10.9.5.5 While bending the bars, the pins of workbenches shall be provided with PVC or plastic sleeves. It is preferable that contractor install bar bending machines suitable for FBE coated bars and that each bending operation is done in a time of not less than 90 secs.

10.9.5.6 The coated steel shall not be directly exposed to sun rays and rains and shall be protected with opaque polythene sheets or such other approved materials.

10.9.5.7 While Doing concreting, the workmen or trolleys shall not directly move on coated bars, wooden planks shall be placed on the bars for movement of workman & trolley of material, by the contractor.

10.9.5.8 In spite of all test certificates, if the coated bars are roughly handled by the contractor either during transport, fabrication, stacking, placing and concreting etc. or handled in such a manner as to damage the coating for area or portion more than reasonable, the Engineer reserve the right to reject the FBE coated bars and such rejected bars shall be removed by contractor from work site within three days. The decision of Engineer will be final as to reject the bars with damage coating or to allow repairing the coating, or to get it recoated entirely at the contractor's cost.

10.9.6 STORAGE

10.9.6.1 The Bars shall be stored as close as possible to the area of the structure where they will be placed (fixed) to keep handling operations to a minimum. Deliveries of the coated bars to the job site should be well coordinated to avoid any long term storage at site when stored in open. If circumstances or other conditions make it necessary to store FBE coated bars outdoors for an extended period of time, the coated bars should be protected from sunlight & salt spray, and sheltered from the weather.

10.9.6.2 FBE coated bars shall be stored above ground on protective timbers, supports shall be provided at regular interval to avoid sagging of the bundle. Such wooden or padded contact shall be at spacing of not more than 60 cms.

10.9.6.3 If a relatively large quantity of FBE coated bars is to be stored in a small area, bundles of straight bars shall be stacked with adequate blocking between the layers of bundles.

10.9.6.4 FBE bars shall be covered with opaque polythene sheets or other suitable protective material. The protective cover shall be draped over the sides of the bundles around the perimeter of the stack. The cover shall be properly secured with provision of air circulation to minimize the condensation under the covering.

11. REINFORCEMENT, SPLICING AND MECHANICAL FASTENERS & MECHANICAL COUPLERS

11.0 SCOPE

These specifications cover threaded couplers to be used for joining reinforcement bars, in lieu of laps/welding/mechanical splicing.

11.1 GENERAL

The couplers shall be of standard parallel square thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that thread diameter is not lesser than the parent bar to be joined. The

material of the coupler shall be of same quality or of superior quality than the quality of material of the parent bars (i.e. reinforcement bars to be joined). The joint shall have guaranteed bar break i.e. when the joint is tested in universal tensile testing machine, the bar shall fail away from the coupler i.e. not within the coupler as well as within 2 times the diameter of bar from the ends of the coupler, which can be considered as affected zone. The Guaranteed Bar break condition is not mandatory, if the failure load of coupled specimen is higher than 1.15 times of its minimum specified yield stress. The coupler shall be qualified as per ASME, Section III, and Div.2. Additionally it shall meet all the requirements of "Class H" type coupler as specified in IS 16172. The safety margin in coupler design shall be such that guaranteed bar break is ensured even if 15% of the total threads length are out of coupler during installation.

The hand tightening of coupler shall be sufficient in the field and no mechanical means shall be essential for tightening. During testing, the coupler should only be hand tightened.

The process of manufacturing of the coupler, cold forging and threading including testing shall be carried out as per ASME approved quality assurance programme. The manufacturer of coupler shall hold a valid Quality System Certificate (QSC) from ASME. Installation of the coupler and supervision shall be done by the qualified personnel.

11.2 MANUFACTURING OF COUPLERS

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number, heat number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties.

11.3 THREADING OF ENDS OF THE REINFORCING BARS

This threading activity shall preferably be done at site. The various stages involved in threading are as given below

11.3.1 CUTTING

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain end surface, perpendicular to the axis of the bar.

11.3.2 COLD FORGING & THREADING

After cutting, the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done, preferably on lathe machine.

The threads shall be square parallel type, to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic caps, before taking the bars out of the shop.

11.3.3 QUALITY CONTROL IN MAKING OF THREADS

The work in shop shall be fully supervised by the Manufacturer representative. Double forging of bars is not permitted. In case of improper cold forging, the forged end of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges.

For threaded coupler systems, every prepared bar end shall undergo a load test prior to actual use. The minimum test loading shall be equivalent to 80% of specified yield strength of bar. For this purpose contractor shall deploy the machine having facility of integrated load testing. The "Integrated" means that the testing operation is performed automatically by the same machine used to prepare the bar ends. A positive indication shall be punched on the rebar to indicate that this operation has been carried out and bar end has qualified for specified strength.

11.4 INSTALLATION OF COUPLERS IN THE FIELD

The installation of couplers in the field, for joining reinforcing bars, shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned with acetone or any other solvent, just before installation.
Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached & then cleaned before joining the next bar.

11.4.1 The contractor shall arrange for a suitably qualified manufacturer's representative, experienced in mechanically connecting reinforcement, to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary.

11.4.2 The contractor shall submit to the Engineer, for his acceptance, a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

(a) requirements for cleanliness
(b) equipment for threading bars
(c) method of locking the connections on both rebars

(d) method of verification of final rebar alignment and coupler integrity.

11.4.3 Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance standards shall be completely removed and the bars re-connected, as required.

11.5 QUALIFICATION TESTS

The splices shall be qualified as per ASME Section III Div-2, IS 16172 and by conducting following tests:

11.5.1 STATIC TENSILE TEST

Mechanical connections shall be tested in all reinforcing rebar sizes. All rebar transition connectors shall also be tested. For each rebar size, a minimum of six connections in each load direction shall be tested in accordance with ASTM A 370. A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength.

- The average tensile strength of the splices shall not be less than the followings:

  a) 90% of the actual tensile strength of the reinforcing bar being tested.
  b) 100% of the specified minimum tensile strength

- The tensile strength of an individual splice system shall not be less than the 115% of the specified minimum yield strength of the spliced bar.

11.5.2 CYCLIC TENSILE AND COMPRESSIVE TEST

Cyclic tensile and compressive test: Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return. The test shall be performed as per Annexure D of IS 16172.

11.5.3 PERCENTAGE ELONGATION

The minimum uniform elongation (Elongation at maximum force) in the reinforcement bar outside the length of mechanical splice as measured as per Annexure B of IS 16172 shall be 3 % before failure of test piece.

11.5.4 SLIP TEST

The total slip value when measured in accordance to test procedure described in Annexure C of IS 16172 shall not exceed 0.10 mm.

11.5.5 TEST FOR AVOIDANCE OF STAGERRING

The strain measured over the full length of the splice at 90% of the specified minimum yield strength of the bar shall not exceed that of a bar that is not mechanically-spliced by more than 50%. The test shall be performed for all diameter of couplers.

11.5.6 LOW CYCLE FATIGUE TEST

The mechanical splice shall withstand 10000 cycles of alternating tension & compression load, when tested as per Annexure E of IS 16172.

11.5.7 HIGH CYCLE FATIGUE TEST

The mechanical splice when tested accordance to Annexure E of IS 16172 shall withstand 2 million cycles (2000000 Nos)of varying axial tensile load with a stress range of 60 MPa with upper stress in the test equal to 0.6fy.

11.5.8 PRODUCTION TESTS & ACCEPTANCE CRITERIA FOR A LOT

Static Tensile tests, as per ASTM A370, shall be conducted on each bar size & grade for each lot as follows. The criteria mentioned below are in variance with the above referred codes.

Sr No	No of Coupler in the Lot	No of sample to be tested	Acceptable Defective couplers
1	Upto 500	14	NIL
2	501-1200	20	NIL
3	1201-3200	32	1
4	3201-10000	50	2
5	10001 and above	50+ 2 for each 1000 Nos beyond 10000	Not more than 4% of the samples tested

The lot is defined as the group of couplers which are of same size, type, class, material traceable to same cast and manufactured under similar conditions of production. All the tests shall ensure guaranteed bar break at a load not lower than the specified tensile strength of the bar. The quoted rate shall be inclusive of carrying out above tests and no separate payment shall be made for these tests.

11.5.9 The Contractor shall submit to the engineer for acceptance a report on these Proving Tests, within seven working days of the tests. The report shall provide full details including:

(a) Results of all tests
(b) Details of dimensions, geometry.
(c) Details of test procedures
(d) Description of test rig/load cell
(e) Description of load monitoring, strain measurements
(f) Calibration certificates.

11.5.10 From each test on the coupler and control bar specimens, the following information shall be provided:

(a) Stress-Strain (or Load Displacement) curves
(b) Yield Load & Yield Strength
(c) Elongation of the mechanical connection
(d) Ultimate load & Ultimate Tensile Strength
(e) Mode of failure
(f) Gauge length used for strain measurement and statement of how gauge length was determined.

12 PILING WORKS

12.0 SCOPE

This specification covers the works involved for bored cast in situ reinforced cement concrete (RCC) piles including all specific requirements for installation/casting of pile, testing (initial, routine and other NDT) and analysis of the various test results to assess their vertical, horizontal and pull out load carrying capacities, confirm pile integrity, apportion skin friction and end bearing capacity of the pile and arrive at dynamic properties of soil-pile system. *All the piles within the scope of this tender needs be toe grouted. The procedure for Toe grouting shall be finalized by the contractor in consultation with Engineer.*

12.1 CODES, STANDARDS & SPECIFICATION

12.1.1 Latest Indian Standards on Piles

IS 2911 : Part 1: Sec 2 Code of practice for design and construction of pile Foundations: Part 1 Concrete piles, Section 2 Bored cast-in-situ piles
IS 2911 : Part 4: Load test on piles
IS 5121 : Safety code for piling and other deep foundations
IS 9716 : Guide for lateral dynamic load test on piles
IS 14362 : Pile boring equipment - General requirements
IS 14893 : Non Destructive integrity testing of piles-Guidelines

12.1.2 **Latest ASTM**

ASTM D 4945: Standard Method of test for High Strain Dynamic Testing of Piles
ASTM 6760: Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross-hole Testing
ASTM D 5882: Standard Test Method for Low Strain Integrity Testing of Piles

Reference to any code shall always mean reference to the latest revised edition of the code including all its amendments up to date, unless otherwise specified. In the event of any conflict between the requirements of this specification and those of the referred codes, the former shall govern.

12.2 DESCRIPTION

12.2.1 **GENERAL**

Specifications to be followed for providing RCC bored cast in situ piles wherever required as per design . The scope in general consists of constructing the RCC bored cast in situ pile foundation .

The testing of piles shall be carried out by the contractor in line with relevant BIS codes, and / or ASTM codes, as specified above and procedures to be developed by the contractor/Vendor and approved by NPCIL. Initial and Routine (static and dynamic) tests shall be carried out on test piles and working piles, respectively as per provisions of BIS/ASTM and as approved by NPCIL.

The work involves but is not limited to the following:

1. Construction of Pile foundation .
2. Conducting Initial, Routine Load tests (Static and dynamic) on designated Test / working piles namely Vertical, Lateral, Pull out and Dynamic load tests.
3. Conducting Non-Destructive Testing (NDT) to assess pile integrity.
4. Toe grouting of pile

The contractor shall submit the work procedures for different items of piling works in line with IS/ASTM, Technical Specification herein under and get it approved from Engineer.

Upon completion of the piling work, all casing equipments, construction tools, protective covering and debris resulting from the piling operations shall be removed from the works site with the permission of the NPCIL.

12.2.2 **MINIMUM REQUIREMENT OF PILING EQUIPMENT**

The equipment & accessories should be compatible with the type of sub-soil, method of construction, type of founding strata & required penetration in the founding strata. The capacity of rig shall be adequate so as to bore up to required depth with specified diameter. Rig shall be equipped with suitable chisel to penetrate through any local obstruction/ hard strata.

Hydraulic self-propelled rotary piling rigs complete with adequate torque capacity and crowd value shall be deployed to complete the entire job as per the time schedule and specifications provided in this tender document. The Contractor shall mobilize adequate spares; cutting tools (e.g. flat teeth bits, round shank bits, holders, etc.) to avoid any stoppage of work.

The Contractor shall provide all the equipment, tools and plants required for the work.

12.2.3 SURVEYING AND LAYOUT

It is the sole responsibility of the contractor to bring to site all surveying instruments necessary for the marking out, fixation of levels, etc. and conduct these survey operations with utmost accuracy. The contractor shall put-up stable bench marks etc. as necessary for the work. NPCIL will provide benchmark location and elevation with respect to plant grid. The contractor shall be entirely responsible for accurate setting out of the work and he shall at his own expense make good any defects arising from errors in line and levels.

12.2.4 BORING

The boring shall be done as per specific requirements of soil strata and the procedure / methodology shall be approved by Engineer-In-Charge.

The Contractor, while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classifications, these shall be immediately reported to the Engineer. Rig register and weekly report as per the format, approved by NPCIL shall be submitted to Engineer-In-charge of the project.

12.2.5 CLEANING OF PILE BORE

After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/bored material etc. Necessary checks shall be made to confirm the thorough cleaning of the pile bore as per the recommendations of IS 2911-Part1-section 2.

Pile bore spoil shall be disposed of from site within 1 Km. away as directed by the Engineer.

12.2.6 DEWATERING

The dewatering for the area will be carried out by the Purchaser through some other agency.

12.2.7 INFORMATION TO BE SUBMITTED AS PART OF THE TECHNICAL BID

If piles are envisaged in the structure, bidder shall submit the following information along-with the bid:

1. Number of the piling rigs proposed to be deployed.
2. Full Technical details of piling rigs and accessories in the form of catalogues, data sheets, etc.
3. Piling procedure, piling program and accessories to be mobilized by the contractor.
4. Complete Construction Methodology. However, work procedures and quality assurance plan (QAP) for the work will be required before start of the work. The contractor shall use only Ready mixed concrete from the batching plant for the proposed piling works.
5. All data sheets, rig register, test reports, Soil profile data.
6. Details of toe grouting to be done for all piles.

12.3 REQUIREMENTS

All work shall be carried out in accordance with this specification and contractor shall ensure meeting of all the requirements as laid down hereunder:

The work shall include supplying and providing necessary materials, mobilization / demobilization & operation of all necessary equipment, consumables providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labor etc. as required to carry out the complete piling work, and submission of records & reports as per schedule.

The Contractor shall confirm the "Safe Load" capacities by conducting both initial and routine load test on piles.

It is essential that all equipment and instruments are properly calibrated at the commencement of test so that they represent true values. The instruments shall be re-calibrated at the frequency as per manufacturer’s specification. Certificates to this effect from an approved institution/National Accreditation Board for Testing and Calibration Laboratories (NABL) shall be furnished to the Engineer. If the Engineer desires to witness such tests Contractor shall arrange to conduct the test in his presence.

The contractor shall assure the quality of piling work including cleaning of pile bore, quality of concrete, integrity of piles, etc.

Each pile shall be identified with a reference number. Sequence of piling shall be such that there is no damage caused to the concrete recently laid in the adjacent pile and as per approved drawings. Construction of piles shall be done in accordance with the priority of construction of various buildings. The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed pile. Sequence of piling shall be approved by the Engineer.

12.3.1 TERMINATION OF PILES

The casting of piles shall start from levels strictly as per approved construction drawings. In no case casting of piles should start from levels higher than those indicated in the approved drawings. The top of the pile shall be cast above the cutoff level so as to permit removal of all laitance and weak concrete before embedment into raft. The pile top shall be terminated at minimum 600mm above Pile cutoff level. The same will be chipped off up to cutoff level before the commencement of pile-raft construction to progress the job further.

12.3.2 SAFE LOAD CARRYING CAPACITY

The contractor shall conduct the tests as specified in the drawing or as per the direction of Engineer and determine the minimum safe load for the piles constructed for Vertical Compression/Lateral/Uplift.

12.4 MATERIALS

Materials shall conform to specifications for materials included in the specification of 'normal concrete', 'reinforcement' and 'coupler' in this tender document.

12.4.1 CONCRETE

The concrete shall be of M35 grade or as specified in the approved drawings. The minimum cement content shall be 350 kg/m^3 (including fly ash as defined in technical specifications for plain and reinforced cement concrete) and allowable slump shall be between 150mm to 180mm as specified in IS 2911 Part 1/Sec 2. The tests on concrete for piles shall be tested as per the relevant specification given in this tender. Suitable cylindrical cover blocks with center hole shall be used to maintain the specified cover as per the approved drawings. The re-steel ties used for holding cover blocks for re-steel.

12.4.2 REINFORCEMENT & COUPLERS

Reinforcement & couplers shall conform to relevant technical specifications given in this tender.

12.4.3 STABILISING MUD/BENTONITE/POLYMER

The drilling mud for stabilizing the borehole in bored piling work should have properties and quality control conforming to the requirements of IS 2911-(Part1-Sec-2). In case polymer is used, the specification and methodology for its use shall have prior approval from NPCIL.

The bentonite / polymer slurry and the cuttings, which are carried to the surface by the rising flow of the slurry, shall pass through setting tanks of adequate size to remove the sand and spoils from the slurry before the slurry is re-circulated back to the boring. The bentonite slurry mixing and re-circulation plant shall be suitably

designed and installed. The bentonite slurry shall be maintained at 1.5 m above the ground water level during boring operations and till the pile is concreted. When DMC (Direct mud circulation) or RMC (Reverse mud circulation) method is used the bentonite slurry shall be under constant circulation till start of concreting.

For tremie concreted piles, a sample of drilling fluid shall be taken from the base of the borehole by means of an approved sampling device in the first few piles and at a suitable interval of piles thereafter. The concreting operations shall not be taken up when the fluid density is more than 1.25g/ml.

After completion of piling work, area around piles shall be restored with compacted soil-cement mix after removal of bentonite slurry /muck, at no extra cost to NPCIL.

12.5 CONSTRUCTION

12.5.1 Construction of piles shall be carried out only after excavating ground up to the desired founding levels/levels as per requirement of ground improvement technique to be adopted and as per the approved drawings.

12.5.2 Pile shall be constructed by using temporary casing up to required depth as per site conditions. This is to ensure not only the stability of side soil and also to ensure good quality concrete in the entire length of pile. Adequate bentonite mud / polymer or any other suitable material (if required) may be used during the boring below temporary casing. The contractor shall ensure the stability of bore by adopting suitable combination of temporary casing pipe and bentonite/ polymer slurry for stabilization.

12.5.3 Immediately before placing of reinforcement and concreting, the bored hole shall be cleaned of all the loose material and debris. The pile tip zone shall be thoroughly cleaned by flushing the bore with fresh bentonite slurry/polymer to completely replace the old bentonite slurry / polymer used during the previous operations. This shall be carried out for about 45 minutes in two stages. Cleaning for about first 30 minutes shall be done before lowering of reinforcement cage & cleaning of about second 15 minutes after lowering the reinforcement cage.

12.5.4 The time interval between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs the pile bore shall be abandoned. However, the Engineer may allow concreting provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth and clean the pile bore.

12.5.5 The soil profile and design requirements shall dictate length of temporary casing pipe for construction purposes and shall be withdrawn during casting of the pile. The temporary guide casing shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

12.5.6 Cut-off level of the piles shall correspond to those given in the approved drawings. To ensure dense and sound concrete up to cut-off level, concreting shall extend minimum 600 mm above cut-off level. The vertical reinforcement shall project above the cut-off level as per the approved drawings.

12.5.7 In case the reinforcement cage is made up of more than one segment, the same shall be assembled by threaded couplers before lowering. Reinforcement as required shall be made into stiff cages with stiffener rings of appropriate diameter at suitable spacing to withstand handling without any damage or distortion.

Borehole shall be thoroughly cleaned to make it free from sludge or any foreign matter before lowering of reinforcement cage. The full length of reinforcement cage should be in place before start of concreting. Reinforcement shall be placed immediately after cleaning and inspection of the bottom of bore holes. The reinforcement should be supported away from the sides of the shaft by means of suitable spacer blocks to ensure concentric alignment in the shaft. Care shall be taken to preserve correct cover and alignment of reinforcement and avoid damage to it throughout the complete operation of placing concrete.

12.5.8 Concrete shall be so placed as to fill the entire volume of the tube or bore without the formation of voids caused by the faulty consolidation or entrapped air. Proper care shall be taken to ensure that the fluid alluvial soil does not penetrate the concrete.
Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS: 2911 (Part1-Sec2). Concrete shall be placed by means of tremie pipe, which will be suitably closed at bottom at the start of concreting. The tremie pipe must extend up to the bottom of the borehole at the start and may be withdrawn in sections as the level of concrete rises in the borehole; but its discharge end shall at all times be embedded in the concrete to a minimum depth of 2m. Placing of concrete should be continuous and the pile holes will be maintained full with the bentonite slurry where used throughout the concreting operation. Slurry displaced from the borehole by the concrete shall be channeled away or pumped into suitable mud pond for re-use or disposal to waste.

12.5.9 The record of volume of concrete poured in each of the piles shall be maintained. After concreting the actual quantity of concrete shall be compared with the average obtained from observations made in the case of a few piles already cast. If the actual quantity is found to be considerably less, the matter should be investigated and appropriate measures taken.

12.5.10 **Control of alignment**: Piles shall be constructed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS-2911 (part 1/Sec2).

12.5.11 **Preparation of pile head:** Before casting the piled raft, the excess concrete shall be cut off up to pile cut-off level as shown in approved drawings. In case sound concrete is not met with at such elevation the piles shall be cut up to an elevation where sound concrete is met. Care shall be taken not to damage the reinforcement or the concrete below cut off elevation during such stripping operations. Where chipping to be done to a level lower than the specified cut off elevation to obtain dense and sound concrete, the Piling Contractor shall build up the pile up to cut off elevation at his own cost.

The exposed part of concrete above the Cut off level shall be removed/chipped off and made square at cut off level not before seven days of casting of pile. The projected reinforcement above Cut off level shall be property cleaned and bent to the required shape and level to be anchored into the pile raft as shown in the drawing.

The pile top shall be embedded into the pile cap/raft by minimum 50 mm or clean cover to reinforcement, whichever is higher.

12.6 DEFECTIVE PILES

The Engineer reserves the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawing on account of load capacity, structural integrity, position, alignment, concrete quality, improper cleaning of borehole before concreting, etc. Piles that are judged defective shall be pulled out or left in place as decided by the Engineer without affecting the performance of adjacent piles. If the adjacent pile is affected, the contractor shall install additional piles to substitute the adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the EIC at no extra cost to NPCIL.

12.7 QUALITY ASSURANCE PROGRAMME

The Contractor shall submit and finalize a detailed Field Quality Assurance Program within 30 days from the date of award of the contract, according to the requirements of this specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of field quality plan, etc., the Engineer shall identify, customer hold points, on finalized field quality plan, beyond which work shall not proceed without written approval from the Engineer. The testing apparatus/equipment installed in the field laboratory shall be calibrated/ corrected by the qualified persons as per manufacturer’s instructions to give accurate testing results.

12.8 RECORDING OF DATA

Daily site records shall be maintained by the Contractor for the installation of piles against each Rig and shall contain the number and dimension of the pile, depth bored, time taken for boring and concreting. Contractor shall maintain field bore log. When drilling mud /polymer is used, amount of bentonite / polymer needed for stabilization of bore, specific gravity of the fresh supply and contaminated mud in the bore hole before concreting shall be checked and recorded regularly. Record of concrete volume actually cast per pile against required volume shall be maintained. Detail of any obstruction encountered its nature, depth and obstruction time. Any deviation from the designated location alignment or load capacity of any pile shall be noted. Typical data sheet in triplicate for facility of recording piling data to be prepared by the Contractor before starting of actual piling operation at site and information to be recorded against each pile in the data sheet shall be signed by the contractor and countersigned by NPCIL. One copy of the data sheet shall be retained by the

Contractor and the other two copies to be submitted to NPCIL for records & future reference.

A full record of pile load test results shall be submitted in triplicate to the Engineer immediately on completion of each test. The record shall also include the plots of load settlement (for various stages of loads) characteristics of pile and also the interpretation of the pile load test curve as per criteria for safe loads mentioned in the specifications for testing concrete piles forming a part of this tender. Any special observations shall be duly explained by the contractor.

Contractor's competent supervisor (geotechnical engineer) shall always be present to record the necessary information during the installation of piles. The data to be recorded shall include:

1. Pile number and location
2. Existing ground level, cut-off-level and level of top of the casting
3. Nominal shaft and inside diameter of casing
4. Data and time of setting up of rig at the pile location.
5. Data and time of start of boring.
6. Length of casing driven and depths bored vs time.
7. Description and thickness of various strata bored.
8. Details of any obstructions encountered (depth from existing ground level, thickness and time taken to penetrate through the same)
9. Chiseling depth and time.
10. Final depth of boring (founding level).
11. Standard penetration test at the bottom of the bore hole, if any.
12. Date and time of completion of boring.
13. Data and time of start and completion of flashing of the bore hole with fresh Bentonite fluid before Concreting.
14. Time of lowering Reinforcement cage and tremie pipes with total length thereof.
15. Date and time of start of concreting
16. Level of concrete inside the bore hole and tremie pipes at various stages of concreting.
17. Concrete grade, mix proportion, water cement ratio and slump test results.
18. Empty boring length and concrete length below cut-off-level.
19. Results of tests on Bentonite slurry used.

Typical data sheets of recording piling data shall be as given in Appendix-D of IS: 2911(Part I/ Sec.2).

Any deviation from the designed location, alignment or load carrying capacity of any pile shall be noted and promptly reported to the Engineer..

On completion of each pile construction, pile record in triplicate shall be submitted to Engineer-in-Charge within two days of completion of concreting of the pile.

On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Engineer, to ensure that it is free from pile bore

spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of Engineer.

12.9 PILE TESTING

The contractor has to prepare work procedure for conducting the tests in line with IS/ ASTM, Technical Specification herein under and get it approved from Engineer before start of test .

Pile Load Test: Both initial and routine load tests shall be conducted for all the types of testing i.e. vertical, lateral and pull-out. The load tests shall be carried out after concrete attains full strength.

Non-destructive testing of piles: NDT of piles (Low strain integrity test, high strain dynamic testing and cross-hole sonic logging test as per ASTM codes) shall be carried out by expert team or by engaging an expert agency. The staff of the team shall have experience of carrying out these types of tests and knowledge of analyzing the data. Credentials of expert team/expert agency shall be submitted for acceptance by NPCIL.

12.9.1 PILE LOAD TEST DETAILS

12.9.1.1 General

1. For pile load tests, the test set up shall be as per relevant BIS, ASTM standards and specifications for testing of concrete piles.
2. The testing shall be done by specified method of loading in successive increments as per the relevant clauses of IS: 2911 Part 4.
3. Tests shall be carried out at the cut-off level.
4. Maximum test loads for different types of piles shall be as per the approved drawings.
5. All the piles shall be provided sonic logging tubes to carry out Cross hole Sonic Logging Test.
6. The number of tests (other Cross hole Sonic Logging Test) required shall be as approved by the engineer.
7. A method statement for all the load tests shall be submitted to NPCIL and testing shall be carried out after approval of the same.
8. The details of tests to be carried out on piles are presented below.

PILE TESTING MATRIX

Tests on Piles		
Initial Load Tests	Routine Load Tests	Non-Destructive Tests (Both Initial and Routine)
1. Vertical Load Test	1. Vertical Load Test	1. Low Strain Integrity Test
2. Lateral Load Test	2. Lateral Load Test	2. High Strain Dynamic Test
3. Uplift Load Test	3. Uplift Load Test	3. Cross Hole Sonic Logging Test

12.9.1.2 INITIAL LOAD TEST

Initial load test shall be carried out on separately cast test piles following purposes:

1. Confirmation of estimated pile capacities at founding level.
2. To provide guidelines for setting up the limits of acceptance for routine tests.
3. To confirm suitability of piling system.
4. To have a check on calculated load by dynamic or static approaches.

The number of tests to be conducted for each mode (vertical compression, pull out and lateral) and each type of pile and maximum test load shall be as per approved drawings.

The following initial load tests shall be carried out as per IS 2911(Part 4):

1. Initial vertical load test.
2. Initial lateral load test
3. Initial pull-out load test.
4. Initial vertical cyclic test

12.9.1.3 ROUTINE LOAD TEST

Routine load tests shall be carried out on job (working) piles as per approved drawings. Routine load tests shall be carried out for following purposes:

1. To confirm the safe load of the pile.
2. Checking safe load and extent of safety for the specific functional requirement of the pile at working load
3. Detection of any unusual performance contrary to the findings of the initial test, if carried out.

The following routine load tests shall be carried out as per IS 2911(Part 4):

1. Routine vertical load test.
2. Routine lateral load test
3. Routine pull-out load test.

For routine lateral load test the loading shall be continued till one and half times the safe lateral load or 5mm deflection, whichever occurs earlier.

12.9.2 RECORDING OF DATA AND PRESENTATION

12.9.2.1 The initial and routine pile load test data essentially concerns three variables, namely, load, displacement and time. These are to be recorded sequentially for the tests under consideration and recorded in a suitable tabular form along with the information about the pile.

12.9.2.2 The initial and routine pile load test data may be suitably presented by curves drawn between the variables and safe loads shown on the graphs. Load-displacement curve should be an essential part of presentation.

12.9.3 REPLACEMENT OF DEFECTIVE/ REJECTED PILES

During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Engineer, fresh bore holes are to be executed at a suitable new position, as decided by the Engineer, which may demand for resizing of pile raft including possible increase in reinforcement quantity due to resizing of pile raft. In all such cases the abandoned bore holes are to be filled up with plain cement concrete of grade M15 so that no cavity remains in the bore hole of the abandoned pile. No extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile raft including increase in reinforcement quantity will be accepted and same is deemed to be carried out by the contractor at his own cost.

Piles showing unsatisfactory results as per load tests shall be treated as defective piles. Piles/boring/casing that are defective shall be left in place/ pulled out as directed by Engineer without adversely affecting the performance of the adjacent piles. In case the hole from which pile is pulled out is abandoned, the same needs to be filled up with concrete of grade M 15 at no extra cost to NPCIL. No payment shall be made for extra expenditure incurred in constructing alternative piles and implementing the changes in the design of raft on account of change in location of piles.

12.10 NON DESTRUCTIVE TESTING OF PILES

12.10.1 LOW STRAIN PILE INTEGRITY TEST

12.10.1.1 GENERAL

Low strain Pile Integrity Test (PIT) is a non-destructive integrity test method to establish the Integrity of the pile along its length and to identify the deficiency in quality of pile, if any.
In PIT the impact shall be made using small hand held hammer. The evaluation of PIT records shall be conducted according to the Pulse-Echo (or Sonic Echo – a time domain analysis) analysis method.

12.10.1.2 TEST METHOD AND REFERENCE CODE

The test requires the impact of a small hand held hammer on the shaft top and the measurement of motion of the pile top in terms of acceleration or velocity. The input compression wave from the hammer is reflected from pile toe (or a defect) and returns to the pile top at a time related to the speed of travel of the wave in the pile material. The test shall be performed as per ASTM D 5882 "Standard Test Method for Low Strain Integrity Testing of Piles".

The pile top velocity is displayed as a function of time with an exponentially increasing magnitude where high soil friction forces are present, such that the pile toe reflection is enhanced. Several records with consistent signals should be averaged. The averaged, amplified velocity shall be standard result of the Pulse Echo Method.

12.10.1.3 **TEST EQUIPMENT**

The test should be performed using digital data acquisition equipment. The signal conditioning and power supply must have very high signal-to-noise ratios to discern the reflected signals for long piles (and/or piles in high friction soils). The analog to digital resolution shall be at least 16 bits, and the sampling frequency at least 25,000 Hz. Data should be stored such that additional processing or further wave analysis is possible. The data must be displayed in the field for evaluations of preliminary data quality and interpretation. The apparatus shall include a graphic display of velocity. The equipment & software used for test and its data processing shall be compliant with ASTM D5882. The equipment shall have a provision of display of data on the field for preliminary evaluation and interpretation and the field print out shall also be feasible. The test agency shall deploy adequate number of equipment & spares to meet contingencies and achieve the desired progress of work to meet construction schedule.

12.10.1.4 **TEST PREPARATION**

Integrity testing shall be performed after the concrete has cured for a minimum of seven (7) days. The pile head shall have sound concrete, free from water, dirt or other debris and reasonably flat surface. The concrete at the pile top surface must be relatively smooth with sufficient space for both attachment of the motion sensing device 300mm away from the center and hammer impact area at the center of the pile.

Piles for integrity testing shall be selected by NPCIL.

The projecting re-bars need to be bent outside for easy access within core region. Safe and reasonable access to the pile is the responsibility of the contractor.

The data supplied to expert test agency at the time of test shall include length of the pile from testing level, cutoff level of the pile, pile diameter and pile reference as well as location. Soil information available for the location or in the vicinity shall be provided for valuable interpretation of test results. Additional data like pile installation records, load test results etc., shall also be supplied to the test agency.

12.10.1.5 **DATA PROCESSING**

The data collected using test equipment shall be processed using compatible software. To ensure that the signals are clearly visible for interpretation, data shall be processed in terms of Magnification (MA to enhance the energy lost), reduce reflections from soil to evaluate concrete (HI PASS Filter), and reduce reflections from reinforcement (Wavelet Filter). The MA shall be a factor of the length of the pile and normally must

be equal to the pile length. The magnification delay shall be default 20% to avoid errors in interpretation.

12.10.1.6 **RESULT PRESENTATION**

The testing agency shall submit test report within 2 working days, after performing the field test, clearly indicating the result of test results and Pile Integrity evaluation and further recommendations. For each pile tested, the averaged, amplified velocity versus time record shall be included in the report, with a table summarizing results and conclusions. On completion of field testing, a report shall be submitted and shall clearly describe the following:

- Uniformity of pile changes in cross-section qualitatively i.e. bulge or defect due to necking, etc.
- Sudden changes in soil stratum based on soil profile and graphs.
- Concrete quality in terms of wave speed.

12.10.1.7 **ACCEPTANCE AND REJECTION**

The report shall clearly indicate that tested piles are acceptable or questionable or needs to be rejected. The comments shall generally be based on the following guidelines.

1. Piles with toe response and no defect apparent shall be classified as acceptable.
2. Piles with no toe response and significant reduction or defect above the pile toe shall be rejected and replacement or any other remedial action may be considered. The test engineer should specify the approximate location of defect in such a case.
3. Piles with a sudden major increase in resistance or impedance may not show toe response and are termed as inconclusive and a typical such pile can be selected for static / high strain dynamic test at the discretion of the Engineer.
4. Piles that show toe response but some impedance reduction / defect maybe under-rated / replaced / repaired / or subjected to additional high strain dynamic or static testing at the discretion of the Engineer.

Acceptance / rejection of piles in 3 and 4 above shall also be based on construction records.

Construction records (concrete usage, grout pressure records, soil borings etc.) may be valuable in result interpretations. Based on the Expert agency recommendation, the decision to either reject and replace, or repair, any defective pile shall be taken by the NPCIL and replacement / remedial measure of such piles at no extra cost to NPCIL shall be binding on Contractor.

If the pile top appears questionable, further pile top cut-off and retesting may be advisable.

If a majority of piles diagnose as "inconclusive", partial or even complete pile excavation or another test method may be necessary for pile acceptance.

12.10.1.8 REMEDIAL ACTION

Rejected or questionable piles may be replaced or retested (e.g., static load testing, dynamic load testing, core drilling, ultra-sonic logging, etc.) based on the test results and recommendation of expert agency and as approved by NPCIL.

Remedial action may include pressure grouting through core holes wherever feasible as approved and accepted by NPCIL at contractor's own cost. The repaired piles shall be re-tested and accepted subject to qualifying the test. The cost of such re-testing shall be borne by the contractor.

12.10.2 CROSSHOLE SONIC LOGGING (CSL) BORED CAST-IN-SITU PILES

12.10.2.1 GENERAL

CSL testing shall be performed by sending ultrasonic pulses through concrete from one probe to another (probes located in parallel tubes). The CSL procedure inspects the structural integrity of the pile concrete between the tubes, and extent and location of defects, if any.

This work shall consist of furnishing all materials, equipment and labor necessary for conducting CSL tests on drilled and cast-in-place piles (hereafter each noted as test piles). The contractor shall be responsible for conducting the test through approved expert agency, including supply of material and labour as hereinafter specified and including prior to, during, and after the load test.

CSL testing is a non-destructive quick test and it is intended that the test pile be left in a condition, suitable for use in further construction and may be used as part of structure.

12.10.2.2 TEST METHOD & REFERENCE CODE

The Pile shall be instrumented & Tested as per recommendations of ASTM 6760 "Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross hole Testing" unless noted otherwise.

Both the time between pulse generation and signal reception ("First Arrival Time" or "FAT") and the strength of the received signal give a relative measure of the quality of concrete between transmitter and receiver. Dividing the distance between transmitter and receiver by the FAT value yields the approximate concrete wave speed which also is a relative indicator of concrete quality. For equidistant tubes, uniform concrete between the test tubes yields consistent arrival times with reasonable pulse wave speed and good signal strengths. Non-uniformities such as contaminated or soft concrete, honeycombing, voids and inclusions exhibit delayed arrival times with reduced signal strength.

12.10.2.3 TEST EQUIPMENT

The Contractor shall supply all materials and equipment required to prepare the test pile and restore the pile to a condition suitable for use in the permanent structure, wherever specified by the Engineer. Equipment required to perform the test includes but is not limited to following:

Provide a Cross Hole Analyzer (CHA) manufactured by Pile Dynamics, Inc., or equivalent CSL equipment. The equipment shall have the following minimum requirements.

1. A computer based CSL data acquisition system for display of signals during data acquisition, with a minimum 12 bit A/D converter with a sampling frequency of at least 250000 Hz, and recording of all pulse signals for full analysis and individual inspection. (Note: Converting signals with low noise using high A/D resolution and sampling rates is important to obtain quality data and allow proper full data interpretation.)

2. Ultrasonic transmitter and receiver probes with probe centralizer and signal transmission cables as per ASTM6760 capable of generating pulse with a frequency between 30,000Hz to 100,000Hz with good signal amplitude and energy through good quality concrete. The probes shall be less than 30mm in diameter and shall freely descend through the full depth of properly installed sonic logging tubes of at typically less than 50 mm diameter, in the piles.

3. Two depth sensors to independently determine transmitter and receiver probe depths.

4. Triggering of the recording system time base with the transmitted ultrasonic pulse.

12.10.2.3.1 Sonic Logging Tubes:

All Piles required to be tested shall be provided with sonic tubes for sonic logging tests cast into it. The tubes shall be manufactured from mild steel tubes. To form a single tube the pipes to be connected with Bell Mouth – push fit arrangement only. PVC or any kind of plastic material is strictly prohibited due to different coefficient of thermal expansion with respect to concrete which may affect the test result. The tubes should be of 50mm Internal Diameter and 1 mm thick.

Tests to be conducted for Sonic Tubes assembly and desired results.

The Sonic Tubes assembly should be tested for following tests:

a) External Pressure Test

The minimum 50 mm inside diameter tube, minimum 1 mm wall thickness should be applied with external pressure up to 5 Mpa . Following are the desired results:

Description	Pressure in Mpa	Hold Time	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 5 MPa	>= 60 Sec	No Leakages from Inner Surface of Tubes and No Distortion of Tubes

Minimum 3 test results should be obtained.

b) Pull Out Test for Tubes

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 0.5 KN	No Distortion / Elongation of Tubes till test load of 0.5 KN.

c) Pull out test for Joint

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick, Bell Mouth – Push Fit Joint.	>= 0.5 KN	Joint should withstand the Pull out load of 0.5 KN.

d) Pull Out Test for tubes 'Fixing Ears'

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 0.5 KN	Fixing Ears should withstand the Load up to 0.5 KN.

e) Crush Test

For 50 mm diameter and 1 mm tick Tube following is the criteria for Crush test.

Sr. No.	Descriptions	Test	Desired Results
1	Direction tube	1500 mm	No Cracks After test 30 mm Steel ball can go through the tubes.
2	Drop Weight	4000 + 150/-0g	
3	Diameter of Drop	m	

12.10.2.4 CSL ACCESS TUBE PREPARATION

Every drilled shaft shall be equipped with sonic logging tubes to permit possible inspection by CSL. Drilled shafts with different diameters at the same site may require a different number of sonic logging tubes. Sufficient number of sonic logging tubes shall be installed in all the Piles (minimum 2 nos.) prior to concreting as given in the drawing based on the Pile Diameter. The Number of tubes shall be generally one tube for every 0.3m of drilled shaft diameter unless specified otherwise, but not less than 2 nos. in any case.

The number of piles to be tested by CSL shall be as specified in drawings. If not specified in the drawing, minimum 20% of the piles shall be subjected to this test or as decided by Engineer.

The parallel steel tubes shall be supported and braced securely so that they maintain their position during the subsequent operations. The splice connection of parallel pipes shall be of good quality, easy installation and proven water-tight performance having Bell-Mouth Socket system with rubber gasket joint unless mentioned and approved otherwise.

The couplings locations shall be properly recorded. Tubes shall be installed by the Contractor in a manner such that the CSL probes pass through the entire length of the tube without bending. Ensure that the sonic logging tubes are in plumb and verify that unobstructed passage of the probes is achievable.

The Sonic logging tubes shall be fitted with a watertight shoe on the bottom and a removable cap on the top. Tubes shall be secured to the interior of the reinforcement cage at regular intervals not to exceed (1.0m). Tubes shall be installed uniformly and equidistantly around the circumference such that each tube is spaced parallel for the full length and at the maximum distance possible from each adjacent tube. Tubes shall be spaced as far as possible from the main axial reinforcing steel. The bottom end of the Tubes shall be kept approx. 100 mm above the bottom of the drilled shaft , and the top end shall be at least (1.0m) above the top of the concrete of the Pile, and to at least (0.6 m), but not more than (1.5m) above the ground surface. Tubes shall not be damaged during installation of the reinforcement cage.

The tubes should preferably be filled with water prior to concrete placement, in any case it must be filled with water within at most 1 hour after placing concrete to prevent de-bonding of the sonic logging tubes from concrete, due to differential temperatures. The top of the tubes shall be capped to prevent debris from entering the sonic logging tubes. Excessive torque, hammering or other stresses which could break the bond between the tube and concrete when removing caps from the tubes shall be avoided.

12.10.2.5 TIMING OF THE CSL TEST

The pile shall be tested no sooner than seven (7) calendar days after placement of all concrete (having minimum compressive strength as 2/3rd fck) and preferably within

90 days after casting of pile. The concrete strength and quality generally increases as the concrete cures, longer wait times are usually desirable. After all CSL testing has been completed, and after acceptance of the pile by NPCIL Engineer, the Contractor shall remove the water in the tubes, place grout tubes extending to the bottom of the access tube, and fill all sonic logging tubes in the pile with cement sand grout.

12.10.2.6 PROCEDURE

Prior to CSL testing, the Contractor shall provide the expert test agency with a record of all pile lengths with elevations of the top and bottom, and installation dates of all piles. The sonic logging tubes shall be clearly labeled for identification. The CSL testing shall be performed with the transmitter and receiver probes in the same horizontal plane in parallel tubes.

Using the labeling established for the tubes, CSL testing shall be performed between all adjacent perimeter access tube pairs and across at least all major diagonals within the pile.

Probes shall be lowered from the top, effectively measuring the access tube lengths. Probes shall be pulled simultaneously, with CSL measurements taken at intervals of 50 mm or less from the bottom to the top of the pile. Defects indicated by late pulse arrival times and significantly lower amplitude/energy signals shall be immediately reported to NPCIL Engineer. The equipment used for test shall be properly maintained and calibrated.

The tests shall be repeated for each pair of tubes, i.e. three runs for a pile with three tubes and six runs for a pile with four tubes.

12.10.2.7 REPORTING OF RESULTS

A report shall be prepared for each pile tested. The photographic record of the oscilloscope displays shall be analyzed in detail. Any deviation from the record to be expected from a pile constructed entirely of sound concrete and without defect shall be reported. The report shall indicate the nature, location and severity of the defect and recommendations shall be made for further testing. The implication of the existence of the defect on the performance of the pile shall be evaluated.

Results of the CSL shall be presented in a written report within five (5) working days of completion of testing. The report shall include presentation of CSL logs for all tested tube pairs including:

1. Presentation of the traditional nested signal peak (e.g. “waterfall”) diagram as a function of time plotted versus depth.
2. Computed pulse first arrival time (FAT) or pulse wave speed versus depth.
3. Computed relative pulse energy or amplitude versus depth.

A CSL log shall be presented for each tube pair. The rating of the shaft integrity considers the increases in "first arrival time" (FAT) and the energy reduction relative to the arrival time or energy in a nearby zone of good concrete. Pile is classified as satisfactory/ good provided the evaluation criteria for FAT increase and energy reduction are met. Pile is classified as having minor defect or poor concrete if either evaluation criteria of FAT increase or energy reduction are met. The criteria for evaluation of the concrete from the CSL test are given below.

Pile Classification	FAT Increase relative to good concrete	Energy reduction relative to good concrete
Satisfactory / Good	0-10%	<6 db
Minor Defect	11-20%	<9 db
Poor/Flaw	21 to 30%	<9 to 12
Poor/Defect	>31%	>12

Flaws must be addressed if they affect more than 50% of the profiles. Defects must be addressed if they affect more than one profile (a profile is the result of complete investigation from bottom to top between two tubes) at the same cross section. Flaws or Defects covering the entire cross section define a full layer concern requiring repair.

Immediately after testing, a signed copy of all the raw test data of a pile shall be handed over to the Engineer.

The piles with anomalous sonic logging results shall be rejected at the Engineer's discretion unless the contractor is able to demonstrate that the pile integrity is acceptable through proof coring.

12.10.3 HIGH-STRAIN DYNAMIC TESTING OF BORED CAST-IN-SITU PILES

12.10.3.1 GENERAL

High-strain dynamic testing shall be performed by obtaining and analyzing the records of pile force and velocity under drop weight impacts for evaluations of pile load carrying capacity, structural integrity, and load-movement and pile-soil load transfer relationships.

This work shall consist of furnishing all materials, equipment and labor necessary for conducting high-strain dynamic tests on bored cast-in-place piles (hereafter each noted as test piles). The contractor shall be responsible for conducting the test, including supply of material and labor as specified and including prior to, during, and after the load test.

High-strain dynamic testing is a non-destructive quick test and it is intended that the test pile be left in a condition, suitable for use in further construction and may be used as part of structure.

12.10.3.2 **TEST METHOD & REFERENCE CODE**

The Pile shall be instrumented & Tested as per recommendations of ASTM D 4945 'Standard Method of test for High Strain Dynamic Testing of Piles' unless noted otherwise.

12.10.3.3 **EQUIPMENT**

The test shall be conducted by the contractor through an approved expert agency. The Contractor shall supply all materials and equipment required to prepare the test Pile, dynamically load the Pile, and restores the pile to a condition suitable for use in the permanent structure, wherever specified by the Engineer. The test shall be conducted using Pile Driving Analyzer (PDA) to obtain and analyze the records of force and velocity under drop weight impacts. The field results shall be further analyzed with a signal matching technique such as CAPWAP (Case Pile Wave Analysis Program) or equivalent to refine the soil parameter assumptions.

In case of uncased pile – The Pile top shall be extended using a thin walled casing or equivalent, by a length equal to two pile diameters unless specified otherwise. This top length, shall be defined as the "test area" must be exposed and ready for test. Wherever the Pile top is below grade, the Contractor must remove surrounding soil (creating a safe working environment) so as to completely expose a test area of the Pile suitable for conducting the test to the satisfaction of expert agency engaged for the test. Windows on four opposite sides of the Pile have to be cut off in the steel casing to reach the concrete. The size of the windows shall be as suiting to the requirements of test agency and as approved by the NPCIL Engineer.

The pile top concrete shall be leveled above the casing. A drop weight shall be in the range of one to two percent (1 - 2%) of the anticipated pile capacity, or as determined by the expert agency and approved by the Engineer. A guide allowing variable drop heights typically between 3 and 13 ft (1 to 4 m), or as determined by the expert agency and approved by the Engineer shall be used for test.

Pile top cushion shall consist of new sheets of plywood with total thickness between 2 to 6 inches (50 to 150 mm), or as determined by the expert agency and approved by the Engineer.
A steel striker plate with a thickness of at least 2 inches (50 mm) and an area between 70 to 90% of Pile top area but not less than the area of the impacting surface of the drop weight to be placed on top of the plywood cushion.

Surveyors' transit, laser light, or equivalent for measurements of pile set under each impact.

12.10.3.4 **PROCEDURE**

a) The test Pile shall be constructed using the approved installation techniques.

b) If a permanent casing is not required, then the upper length equal to two Pile diameters, noted as the "test area", must be cased in a thin wall tube. Casing of this test area must be made as a continuation of the construction of the Pile.

c) Wherever, reinforcing bars are protruding out, the same shall either be encased within the concrete in the test area and on successful completion of the dynamic test, the surrounding concrete can then be removed to expose the bars using the same suitable for further construction, or a steel beam or pipe (cross sectional area approximately 20% of the Pile cross sectional area) shall be supplied with sufficient length such that the ram impact will not interfere with the reinforcing bars. Steel striker plates and plywood cushion must also be sized so that they cover as much of the impact area as possible. However, either of the above option shall be finalized in consultation with expert test agency with the prior approval of NPCIL Engineer.

d) There should not be any soil contamination or non-uniformities in the concrete located within or below the test area. Pile top shall be made level to the casing and smoothed.

e) Prior to testing time, the Contractor shall make the Pile test area length completely accessible to the suit the test.

f) Prior to the test four "windows" (approximate size of 6 by 6 inches (150 by 150 mm) diametrically opposite of each other shall be located and removed from the casing.

g) In cases where casing is not present, the circumferential area where transducer is to be fixed, shall be smoothened by grinding.

h) Gauges shall be attached to the exposed concrete or steel casing in a secure manner as to prevent slippage under impact.

i) Pile top should be examined to ensure that the concrete top is flush with or above the casing in any case it should not be below the casing level.

j) Apply plywood cushion and then striker plate to the Pile top.

k) At least two (2) hammer impacts should be applied to the pile top. First drop height should be minimal to assess the testing equipment, the driving system and pile stresses. Subsequent impacts can then be applied by utilizing higher drop heights.

l) Upon completion of the test, it is the Contractors' responsibility to return the pile to acceptable condition in a manner that the same can be used as part of structure.

12.10.3.5 **REPORTING OF RESULTS**

The Expert Agency shall submit a report of the field test results with its finding. In addition to the field results, results from at least one (1) set of wave equation analysis using CAPWAP or equivalent shall be submitted. The analysis shall be performed by same expert agency involved in the testing. The report must also provide the following:

1. Wave Equation analysis results obtained prior to testing.
2. Wave equation analysis results with a match quality preferably up to 5. If match quality is less than 5, reasons must be outlined for the same before acceptance by NPCIL.
3. For each impact, the maximum measured force, maximum calculated tension force, energy transferred to the gauge location, corresponding stresses, and the bearing capacity shall be tabulated.
4. Assessment of the test results both with respect to pile capacity and integrity.

The output from the test result shall provide:

a) Static capacity of the pile at the time of testing.
b) Simulated static load test curve
c) Total skin friction and end bearing of the pile
d) Skin friction distribution along the length of the pile
e) Compressive and tensile stresses developed in the pile during testing
f) Net and total displacement of the pile.
g) Pile integrity

12.10.4 EXPERT AGENCY TO PERFORM THE NDT ON PILES

The testing method and interpretation requires expertise and through understanding of wave mechanics. The agency employed for testing shall prove its competency by submitting previous reliability studies between static and high strain dynamic tests.

Contractor shall engage an Expert Agency of national repute and shall be approved by the NPCIL, to conduct the test. The Expert Agency shall be specialist having minimum of 5 years of experience in low & high strain integrity testing as well as sonic logging testing of the piles. The expert agency shall have sound knowledge of Wave Theory used for analyzing and interpretation of test results and at least performed minimum 5 nos. of correlation studies of Dynamic Pile Load Testing with conventional load test in various strata covering friction piles. The results of the correlation studies should have been accepted by the owners of the project, for whom tests were performed. Demonstration of case studies/correlation between CSL and HSDPT or PIT will be preferred. Performance certificates for completed projects shall be submitted.
The Expert Agency is required to perform wave equation analyses (using CAPWAP or equivalent) to determine the suitability of the proposed dynamic loading equipment and an acceptable range of ram drop heights so as not to cause damage in the pile

during the test. Performance certificates for completed projects shall be submitted. CV of the personnel carrying the test shall be submitted before performing the test.

The expert agency must possess, the following testing instrumentation in addition to that outlined in ASTM D 4945 Section 5: and other ASTM, in order to meet the project schedule and to maintain the redundancy. The test agency shall deploy adequate number of equipment & spares to meet contingencies and achieve the desired progress of work to meet construction schedule.

1. Pile Driving Analyzer (PDA)
2. Pile Integrity Testing Equipment.
3. Cross Hole Testing Equipment for Sonic Logging.
4. Required nos. of calibrated strain transducers.
5. Required nos. of calibrated accelerometers.

All other test equipment required for to conduct the above tests. The equipment and sensors shall be properly calibrated and the testing agency shall be able to obtain the calibration certificates upon request or prove the internal calibration of the system on site.

The Expert Agency shall study the Bore Log Data applicable to the test location, prior to perform the dynamic test, Pile installation records, concrete properties (strength, etc.) and submit the details regarding the anticipated dynamic loading equipment.

13 GROUT/ DRY PACK

13.0 General

Grout / Dry Pack shall be provided as specified on the drawings. The proportion of Grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage.

Concrete surfaces to be grouted / dry packed shall be thoroughly roughened and cleaned of all foreign matter and laitance. Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot strong caustic solution for this purpose may be permitted.

Prior to grouting/dry packing, the hardened concrete surfaces shall be saturated with water.

Forms around base plates shall be reasonably tight to prevent leakage of grout/dry pack. Adequate clearance shall be provided between formwork and base plate, to permit grout/ dry pack to be worked properly into place.

Grouting, once started, shall be done expeditiously and continuously to prevent segregation, bleeding and within the initial setting time. Grout shall be worked from one side to the other, to prevent entrapment of air.

Water in anchor bolt holes shall be removed before grouting is started.

Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least 24 hours after placing the grout. After the removal of forms and peripheral shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least after a minimum of seven days from the date of grouting. During this period, the grout shall be properly cured.

13.1 Dry Pack

The dry pack shall consist of 1:2.5 (Cement: Sand), sand passing through 1.18 mm square hole opening standard sieve. Only enough water shall be added to produce a mortar, which will stick together when moulded into a ball by a slight pressure of hand and will not extrude water but will leave the hands just damp. Dry pack material shall be placed and packed in layers having a compacted thickness of about 10mm. Each layer shall be solidly compacted over the entire surface by use of hardwood stick and hammer. Sand for this job shall be as pure as specified for concrete making.

13.2 Grout

13.2.1 Normal Grout

The contractor shall supply and place normal grout consisting of an approved mixture of cement, normal fine aggregate, water, admixture and when specified by the Engineer, a non-shrink agent. Normal grout shall be placed as shown on the drawings or specified by the Engineer.

Grouting through holes in base plates shall be, by pressure grouting. The pressure to be used for grouting shall be as directed by the engineer. The grout proportions shall be as follows:

Mix proportion	**W/C Ratio(max)**
Mix 1:1 Cement: Sand grout with anti shrink compound	0.44
Mix 1:2 Cement: Sand grout with anti shrink compound	0.44
Mix 1:1:2 cement: sand with 6mm down stone chips and anti shrink compound	0.44

Note: If the requirement arises, mixes other than the specified above, such as mix 1:1.5, 1:1.75, 1:2.25 etc. shall be used with the approval of the Engineer.

The W/C ratio shall be as per the manufacturer’s recommendation and in no case shall exceed the values specified above.

13.3 Inspection

All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Engineer

All materials supplied by Contractor and all works or construction performed by Contractor and rejected - as not in conformity with the specifications and drawings - shall be immediately replaced at no additional expense to NPCIL.

Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying grouting materials and or producing finished grout in accordance with the specifications and drawings.

All grouting shall be protected against damage until final acceptance by NPCIL or his representative.

Upon the completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

13.4 GROUT / DRY PACK FOR EQUIPMENT BASES

13.4.1 SCOPE

Scope of work covered in this specification includes supply and place normal free flow grout / dry pack at all places below equipment base plate, structural steel base plates / bearing plates, anchor bolts, pockets and other areas. Normal cement sand grout in various proportions with anti-shrink compound, non-shrink cementitious precision grout and dry pack with cement sand in proportion of 1: 2.5 are included in this specification.

13.4.2 GENERAL

13.4.2.1 Grout/ Dry Pack shall be provided as specified in the drawings. The proportion of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage.

13.4.2.2 Concrete surfaces to be grouted/ dry packed shall be thoroughly roughened and cleaned of all foreign matter and laitance. Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material.

13.4.2.3 Prior to grouting/ dry packing the hardened concrete surfaces shall be saturated with water.

13.4.2.4 Forms around base plates shall be reasonably tight to prevent leakage of grout/ dry pack. Adequate clearance shall be provided between formwork and base plate, to permit grout/ dry pack to be worked properly into the place.

13.4.2.5 Grouting, once started, shall be done expeditiously and continuously to prevent segregation, bleeding and within the initial setting time. Grout shall be worked from one side to the other, to prevent entrapment of air.

13.4.2.6 Water in anchor bolt holes shall be removed before grouting is started.

13.4.2.7 Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least 24 hours after placing the grout. After the removal of forms and peripheral shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least after a minimum of seven days from the date of grouting. During this period, the grout shall be properly cured.

13.4.3 DRY PACK

The dry pack shall consist of cement and sand in proportion of 1: 2.5. Sand passing through 1.18 mm square hole opening standard sieve shall be used in the dry pack. Only enough water shall be added to produce a mortar, which will stick together when molded into a ball by a slight pressure of hand and will not extrude water but will leave the hands just damp. Dry pack material shall be placed and packed in layers having compacted thickness of about 10 mm. Each layer shall be solidly compacted over the entire surface by use of hardwood stick and hammer. Sand for this job shall be as pure as specified for concrete work.

In case of heavy cement sand dry pack, heavy sand shall be used in place of normal sand.

13.4.4 NORMAL GROUT

13.4.4.1 The Contractor shall supply and place normal grout consisting of an approved mixture of cement, normal fine aggregate, water, admixture and when specified by the Engineer, a non-shrink agent. Normal grout shall be placed as shown in the drawings or as specified by the Engineer.

13.4.4.2 Grouting through holes in base plates shall be by pressure grouting. The pressure to be used for grouting shall be as directed by the Engineer. The grout proportions shall be as follows:

Mix Proportion		**W/C Ratio (Max)**
Mix 1:1	Cement: Sand with anti-shrink compound	0.44
Mix 1:2	Cement: Sand with anti-shrink compound	0.44
Mix 1:1:2	Cement: Sand with 6mm down stone chips and Anti-shrink compound	0.44

NOTE:

1. If the requirement arises, mixes other than the specified above, such as mix 1:1.5, 1:1.75, 1:2.25, etc. shall be used with approval of the Engineer.
2. The W/C ratio shall be as per the direction of Engineer and in no case shall exceed the values specified above.

13.4.5 NON-SHRINK CEMENTITIOUS PRECISION GROUT

Powdered non-shrink, high strength, free flow cementitious grout complying with the requirements of ASTM C348 & C109 that expands in two stages to counteract the plastic as well as the drying shrinkage normally associated with cement grouts. Mix proportion shall be as per manufacturer's recommendations. The compressive strength of the grout at optimum W/C ratio recommended by Manufacturer shall not be lesser than 55MPa, 65MPa & 75 MPa at 3days, 7days and 28 days respectively. It shall also possess following properties:

Property	**Acceptable Limit**	**Test Method**
Workability	Flowablility:	ASTM C 230
	Instantaneous, 240mm	
	After 20 mm, 220mm	
Setting Time	Initial Set, 4Hrs	IS 4031(Pt-5)
	Final Set, 5hrs	
Compressive Strength, 28 days	75 MPa	ASTM C 109
Tensile Strength, 28 days	8.1 MPa	ASTM C 1107
Flexural Strength, 28 days	9 MPa	ASTM C 378
Coefficient of Thermal Expansion	$11X\ 10^{-6}$ / ^{0}C	
Expansion in Plastic Stage	1.25%	ASTM C 940
Shrinkage	Nil	
Pullout Bond Strength	>17MPa	ASTM D4541

13.4.6 INSPECTION

13.4.6.1 All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer**.** Grout material shall be tested for cube compressive strength both for pre-qualifications and batch qualifications at no extra cost to NPCIL. No material exceeding the shelf life will be used and all such material shall be immediately removed from site.

13.4.6.2 All Materials supplied by the Contractor and all works or construction performed by the Contractor and rejected – as not in conformity with the specifications and drawings shall be replaced at no extra cost to NPCIL**.**

13.4.6.3 Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying grouting materials and or producing finished grout in accordance with the specifications and drawings**.**

13.4.6.4 All grouting shall be protected against damage until final acceptance by the NPCIL representative.

13.4.6.5 Upon completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

14 INJECTION GROUTING

14.0 SCOPE

14.0.1 The Scope of work covered under this specification is injection grouting at the following locations:

a) Where required impermeability of concrete is not achieved.

b) Where defective concrete is suspected and observed.

c) Where water seepage is observed.

d) Construction joints for all underground basements

e) Any other location specified in the drawing or as directed by the Engineer

14.0.2 The Grouting shall be carried out at specified locations as shown in the drawing or as directed by the Engineer

14.1 GENERAL

The injection grouting shall be carried out either through threaded GI nozzles of suitable length fixed in the area to be grouted or through non-return packer type nozzles either installed in the existing GI nozzles or in drilled holes. The nozzle length and spacing shall be as specified in the drawing or as directed by the Engineer. The diameter of the nozzle shall be as per site conditions and generally 16/12 mm diameter may be adopted for cement grouts (without non return valve) and 12 mm diameter (with non-return valve) for epoxy and polyurethane based hydrophilic grouting. The entire scheme shall be duly approved by the Engineer before commencing the work.

14.2 MATERIALS

The grouting material shall be epoxy, cement based with non-shrink additive or polyurethane based hydrophilic material as specified in the drawings, specifications

or as directed by the Engineer as per site conditions.

14.3 EPOXY GROUT

14.3.1 The epoxy grout shall comprise of an injectable solvent free, aggregate free, ultralow viscosity, free flowing, two-component epoxy injection resins, which shall be pumped through the nozzles (fixed prior to concreting or drilled after concreting) under pressure and rapidly cure to a high strength material. It shall comply with ASTM C-881-1987 Type I–Grade I Class (B+C) & class F as applicable. It shall be suitable for application in both dry and damp conditions,

14.3.2 The Generic name ‘epoxy resin’ covers a very diverse range of chemically and physically different polymers. To achieve durable repairs, careful selection of the resin composition appropriate to the application and service condition is essential.

14.3.3 The Proposed resin injection system is required to have following characteristics. The material shall comply with the requirement of ASTM C 881 Type I Grade I Class (B+C) & class F as applicable.

f) It should be two component (resin/hardener), low viscosity, solvent free, aggregate free, injection liquid based on high strength epoxy resin and suitable for deep impregnation. The epoxy and hardener system shall be able to cure in moist/wet conditions also.

g) It should rapidly cure to a high strength, shrinkage free hardening and without embrittlement.

h) It shall possess anti corrosion property, good adhesiveness and bond with the concrete with adhesive strength both under dry and damp conditions and should be capable for use under extreme ambient conditions and remain fluid during applications.

14.3.4 The proposed resin to be used shall be of two parts preferably supplied in different containers according to the manufacturers recommended proportions indicating identifications such as base hardener, recommended proportion, batch number, shelf life, date of manufacturing, grade, type, class, quantity, etc. Each batch shall invariably carry test certificates as per table 14.1 for tests conducted in NPCIL approved laboratory. The Engineer may at his discretion, appoint his representative to witness these tests at the laboratory. No separate payment will be made for testing. The chemical composition of epoxy resin constituent of component ‘A’ shall have an epoxy equivalent of 160-275 g/g mole and physical requirements shall be in line with ASTM C-881. A sample of proposed material intended to be used shall be supplied by the Contractor to the Engineer to verify the required parameters. The material shall be generally used within six months from the date of manufacture or date of expiry whichever is earlier.

TABLE - 14.1

LIST OF TESTS TO BE CONDUCTED AS PER ASTM C-881

SI. No	Property	Tested as per ASTM No.	Requirement
1.	Viscosity	D – 2393	2* poise (Max)
2.	Bond Strength		
	2 days (moist cured)	C – 882	10 N/mm^2 (Min)
	14 days (moist cured)	C – 882	14N/mm^2 (Min)
3.	Water Absorption (24 hours)	D – 570	1.0% (Max)
4.	Compressive strength 7 days	D – 695	70N/mm^2 (Min)
5.	Tensile strength 7 days	D – 638	50 N/mm^2 (Min)
6.	Flexural Strength	D – 638	55N/mm^2 (Min)
7.	Full Chemical Cure	7 days at 20 ^{0}C	
8.	Slant Shear Bond Strength 7 days	C-881	18N/mm^2 (Min)
9.	VOC Content	ISO11890-2	<1.5%
10.	Elongation at break	D638	2% (Min)

* Please note that requirement of viscosity is in variance with ASTM C-881.

14.4 CEMENT BASED GROUT

14.4.1 CEMENT AND WATER

The cement shall be Ordinary Portland Cement 43 Grade conforming to IS 8112. It shall be mixed with water to achieve required consistency for pumping. The quality standards of water to be used shall be same as that of RCC works.

14.4.2 ADMIXTURES

To achieve high consistency with low water cement ratio of around 0.3, suitable water reducing admixture as approved by the Engineer may be used. Suitable anti shrinkage compound shall be added in the mix if specified or as directed by the Engineer.

Proportion of cement & water shall be as directed by the Engineer. Quantity of admixture and type of mixing shall be as per manufacturer's instructions. Compatibility of admixture with the type of cement used shall be ascertained before

use of any admixture with cement.

Typically the properties of the resulting mix shall exhibit the following properties:

PROPERTY	ACCEPTANCE VALUE	TEST METHOD
Flow Cone test using Marsh Cone	23 secs at mix time	ASTM C 939
	34 secs after ½ hr	
	39 secs after 1 hr	
Specific Gravity	2.06	ASTM C 939
Setting time using Vicat's Apparatus	4 hrs for Initial Set	ASTM C 939
	5Hrs for Final Set	
Expansion	500 µm/m	ASTM C 878
Bleed Water	0.16%	ASTM C 232
Water Retention	96%	ASTM C 91

14.5 POLYURETHENE BASED HYDROPHILLIC GROUT

The material shall be one component high grade, low viscosity polyurethane injection foam resin which expands its volume to cure to very dense foam upon contact with water. This material shall be used to arrest excessive seepage of water through the concrete. Approval of the Engineer shall be obtained for the material, before use. The typical properties of the low viscosity polyurethane grouts are as follows:

PROPERTY	**ACCEPTANCE VALUES**
Density (at 20 ^{0}C)	1.16
Viscosity (at 23 ^{0}C)	320 mPa.s
Flash Point	180 ^{0}C
Application Temperature	+5 ^{0}C to 40 ^{0}C
Max foam expansion rate@10% accelerator dosage	25-30

14.6 GROUTING OPERATIONS

Grouting operations shall normally begin after six weeks of the last concrete poured. A high-speed mechanical mixer shall be used to mix the epoxy grout as per manufacturer's recommendation. The grouting shall be done by using hand pump and pressure will be decided based upon the nature of work and grade of concrete, or as directed by the Engineer. The grouting range can be achieved by injecting the grout with initial low pressure proceeding further with increasing pressure gradually. Slow and steady increase in pressure shall be followed to produce uniform impregnation of the zone under treatment. The injection pump shall be connected to the lowest tube and the injection allowed to proceed at gradually increasing pressures until grout appears at the adjacent/higher point or refusal of further grout entry at the operating pressure. Cement grouting shall be done normally starting with lean mix and slowly increasing the richness of mix. Cubes shall be cast to test the strength of the cement grout as directed by the Engineer. After successful completion of grouting the nozzles shall be cut and ground properly and finished with dry packing. Wherever specified in

the drawing, Contractor has to make suitable arrangements for placement of nozzles prior to concreting for its rigidity, thoroughness etc. complete with or without piercing through formwork. Contractor has to arrange adequate equipment/ manpower required for the work to carryout grouting in different areas simultaneously. Contractor at his cost may appoint a specialized agency to carry out grouting works. Detailed procedure of grouting shall be prepared by the Contractor and submitted to the Engineer for approval before commencement of work.

14.7 GROUTING AROUND PENETRATION EPs HAVING DIAMETER ABOVE 300 MM

Grouting is required to be done around penetration EPs having diameter above 300 mm and some special EPs. Procedure for grouting shall be generally same as above with the grouting pressure not exceeding the specified value in the drawing. The nozzles for grouting may be placed prior to concreting and the length and diameter of the nozzles shall be as given in the drawing.

15 CAULKING AND SEALANTS AROUND PENETRATIONS

15.0 SCOPE OF WORK

Scope of work covered under this specification is caulking of expansion joints, around embedded parts, penetrations and construction joints at various locations in all buildings as shown in the drawings and as directed by the Engineer.

- Caulking and sealing around penetrations.

15.1 MATERIAL

15.1.1 Polysuphide sealing compound shall conform to BS: 4254 and PP-M-400.

15.1.2 Epoxy quartz sand caulking compound shall be as per manufacturer's specifications.

15.1.3 Bituminous sealing compound (bitumen-polymer cold mastic) conforming to IS:1834-1984 Grade-B (working temperature 155°C to 165°C and density of 1200 kg/cu.m).

15.2 DESCRIPTION

Before proceeding with caulking, the grooves shall be cleaned for dirt, dust and grease if any. The grooves shall be finished to line and level.

15.3 CAULKING WITH POLYSULPHIDE SEALING COMPOUND

15.3.1 GENERAL

The work to be done under this specification covers the supply and applying of caulking polysulphide base sealing compounds and primer, all in accordance with the

requirements of this specification together with PP-M-400. Installation of the material will be done by the Contractor as per drawing, specification and direction of Engineer.

15.3.2 REFERENCES

ASA	:	116-1
ASTM	:	D676-59T
ASTM	:	1191-52
TTS	:	227 b
ASTM	:	E42-69
BS	:	4254
PP-M-400	:	NPCIL Specifications.

Wherever, this specification is at variance with the requirements mentioned in the above references, this specification shall govern.

15.4 DESCRIPTION

Materials covered under this specification are two-package system consisting of polysulphide base compound and an accelerator compound. The compounds shall be stable separately and when properly mixed, convert to a rubber like solid, which meets the requirements specified herein. The selection of base polymers, fillers and other components shall be optional with supplier, but shall be suitable for the application intended. Properties of base polymer should be similar to Thiokol and have low molecular weight. The consistency of the compound should be plastic.

15.5 INTENDED USE

The sealing compound is proposed to be used for caulking construction joints in RCC walls, slabs and expansion joints. The caulking may also be required around some embedded parts and concrete hatch covers. Size of 'V' groove to be caulked in construction may vary in size from 12 mm X 12 mm to 25 mm X 40 mm while the rectangular gap to be caulked in expansion joints may vary from 25 mm X 10 mm to 75 mm X 10 mm thick. The sizes given above are approximate only and intended to give general idea of work involved.

15.6 CLASSES OF MATERIAL

The sealing compound shall be applied in two classes as follows:

a) Class-A (Self-Leveling): shall be compound which when properly accelerated has sufficient flow to give a smooth level surface when applied in horizontal joints at ambient temperatures between 40°F & 120°F. The compound should also permit its application in joints sloped up to 1:10.

b) Class-B (Non-Sag): shall be compound which when properly mixed permits

application in vertical joints, without sagging at ambient temperatures between 40°F & 120°F.

15.7 COLOUR

The sealing compound may be supplied in any colour as agreed upon by the supplier and NPCIL.

15.8 MATERIAL REQUIREMENTS

Application life: A properly mixed compound shall be suitable for satisfactory application for at least 4 hours when maintained at a temperature of 77° ±2°F and relative humidity of 50% ±5%. It shall also be suitable for at least 1 hour when at a temperature of 110°F.

Stability: The base compound and accelerator in original unopened containers shall be stable for at least one year from the time of delivery when stored at a temperature not exceeding 110°F. When tested at the end of one year after the time of delivery, the compound shall meet the requirements specified herein.

Temp. Range performance: Continuous exposure 40 to 175°F
Continuous exposure 40 to 250°F

Recovery: The test assemblies shall be prepared and tested in accordance with ASA 116.1. The recovery of the compound in the test joint shall not be less than 25% within 1 hour at a temperature of 77°±2°F.

Resistance to crazing: The surface of compound of test panel prepared and tested in accordance with ASA 116.1 shall not craze more than 3 mils in depth.

Staining of concrete and masonry: The staining test shall be conducted on a test mortar in accordance with ASA 116.1 and there shall be no staining on the test mortar within 14 days. Staining on the test mortar indicates that the sealant is capable of staining.

Specific gravity: 1.6 to 1.7.

Toxicity: Safe lead content should not exceed 5%.

Properties required for Class A Compounds:

Hardness, Tensile Strength and Elongation

	Shore A Hardness	**Minimum Tensile Strength psi**	**Minimum Elongation %**
Original	35 ± 2	200	350
72 hrs. at 250°F	55 ± 3	325	150

Hardness shall be tested in accordance with ASTM D 676-59T, Tensile strength according to ASA 116.1 and Elongation according to ASTM 1191-.52.

Properties required for Class B compounds:

Sag: When tested in accordance with federal specification no. TTS-227b on a bead of ½" x ¾" there shall be no sag.

Hardness, Tensile Strength and Elongation:

	Shore A Hardness	**Min. Tensile Strength psi**	**Minimum Elongation %**
Original	22 ± 3	40	420
72 hrs. at 220°F	18	48	450
24 hrs. at 30°F	-	> 100	450

The testing method for these properties shall be same as specified for Class 'A' compounds.

Cohesive Strength: Surface-to-Surface Bond

	Aluminium	**Glass**	**Steel**	**Concrete**
Tensile (psi)	45	30	23	45
Elongation (%)	375	350	270	360

Cohesive strength shall be tested in accordance with ASTM 1191-52.

Durability:

Hours in weather-meter	**Equivalent in years**	**Shore A Hardness**	**Elongation %**
1440	5 years	23	340
2880	10 years	28	260

Durability shall be tested in accordance with ASMT E42-69.

The sealing compound shall be supplied separately in two parts the accelerator and the base compound. The quantities of the two component packs shall be such that when mixed they would readily produce the compound ready for application, giving the best performance.

15.9 CAULKING WITH EPOXY MORTAR

Epoxy mortar consists of epoxy resin and hardener mixed with quartz sand in the proportions as recommended by the manufacturer. The epoxy mortar shall be mixed thoroughly and shall be caulked in grooves. Epoxy primer consisting of epoxy resin and hardener without quartz sand shall be mixed as per the manufactures

recommendations and applied on the concrete surface prior to caulking of the epoxy compound. The top surface shall be finished smooth using trowel. It should be ensured that only such quantity is mixed which can be consumed before setting.

15.10 CAULKING WITH BITUMINOUS SEALANT

The joints shall be cleaned thoroughly and made free of debris. The bitumen based primer as per manufacturer's recommendations shall be cold applied prior to caulking with bituminous sealing compound, which shall then be hot applied. Care shall be taken that the working temperature of the sealant shall not exceed 155^0 to165^0 C since overheating of the sealant may lead to loss of its properties.

TABLE 15.1
PROPERTIES OF BITUMASTIC SEALANT

SI. No.	Characteristic	Unit	Characteristic Value
1.	Adhesion • To iron • To galvanized iron • To concrete (dry surface) • To concrete (hot humid surface)	MPa	 1.0 0.6 0.8 0.6
2.	Length development at breaking	%	>700
3.	Thermal stability	°C	110

All the sealant materials must be durable and retain their physical and mechanical characteristics and properties during its entire service life.

15.11 PROCEDURE

Before proceeding with the work, a detailed procedure shall be prepared by Contractor and submitted to the Engineer for approval. The materials shall be tested in approved test houses and each batch shall accompany with test certificates. Engineer may at his discretion, appoint his representative to witness these tests. Contractor shall also supply samples of materials to the Engineer for verification of specifications. No separate payment will be made for testing and supply of samples for testing/ verification.

All the sealant materials must be accompanied by following test certificates.

a) Chemical composition of the material
b) Compliance certificate
c) Fire-safety certificate
d) Certificate for health safety
e) Work instructions for usage

15.12 INSPECTION

15.12.1 All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer. Caulking material shall be tested for specified properties at no extra cost to NPCIL. No material exceeding the shelf life will be used and all such material shall be immediately removed from site.

15.12.2 All materials supplied by the Contractor and all works or construction performed by the Contractor and rejected – as not in conformity with the specifications and drawings shall be replaced at no extra cost to NPCIL.

15.12.3 Preliminary approvals of any materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying caulking materials and or producing finished caulking in accordance with the specifications and drawings.

15.12.4 All caulking shall be protected against damage until final acceptance by the NPCIL representative.

15.12.5 Upon completion of caulking work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the Engineer.

16 STRUCTURAL STEEL & EMBEDDED PARTS

16.0 SCOPE

This specification covers the technical requirements for supply of all steel items required for the work as per drawings including design of connections, preparation of fabrication drawings, fabrication, inspection, testing and painting after necessary surface preparation, transporting and erection at site at desired location of:

a) Main Structural Steelwork
b) Miscellaneous structural steelwork
c) Embedded parts (Standard/ Non-standard EPs)

The specifications given below are a general guideline and reference shall be made to PC-E-160 for detailed specifications and requirements on Embedded Parts. Additional requirements for fabrication and erection of critical and important Embedded Parts which are over and above these specifications are covered in NPCIL Specification PC-E-00034.

All the works shall be carried as per approved QA procedures.

16.1 MAIN STRUCTURAL STEEL

a) Beams, girders, monorails made of rolled section and / or rolled sections with cover plates, and/or compound girders, and/or plate girders, and / or box type sections.

b) Columns made of rolled sections with or without cover plates and / or compound sections battened / laced and / or built up sections from plates with or without grinding at ends and at splice locations,

c) Roof structure such as roof trusses, purlins, bracings, etc.

d) Base plates for columns including grinding (where specified) on top of base plates and underside of column shafts.

e) Any other item of structural steel framing, though not specifically mentioned but required for the building(s).

f) Sheet metal work of minimum 0.8mm thick.

g) Floor rails of IRST 18 grade.

h) Any other structures as shown in the drawings for fabrication

i) Rail section

16.2 MISCELLANEOUS STEELWORK

a) Platforms and walkways with chequered plates / gratings.

b) Ladders with or without cages.

c) Handrails.

d) Miscellaneous equipment supports, rails for equipment movement and their associated connections.

e) Steel enclosures for equipment or electrical instrument panels, rooms etc.

f) Any other miscellaneous structures shown in the drawings for fabrication.

16.3 EMBEDDED PARTS

16.3.1 GENERAL FUNCTION AND DESCRIPTION

Embedded Parts (EPs) are any structural member, angles, channels, plates, pipe sleeves etc. cast in the concrete and used to transmit the load from attachment to concrete structure. Eps fall into following two categories.

(i) Penetration Eps are opening through the concrete structure for the passage of process piping, ducts and cables, materials and personnel.

(ii) Non penetration Eps are used primarily as a means of supporting items such as piping, cable trays, ducts, equipment and platforms to the concrete structure or for edge preparation of concrete.

Penetration and non-penetration EPs are of different types and their descriptions are given below.

(a) Plate EPS

Plate Eps are used to support piping, cable tray, ladders and equipment. A typical plate EP consists of a plate and anchorage welded to it. Component supports can directly be welded or bolted to these EPS.

(b) Pipe Sleeves

Theses EPs are used for passage of piping, cables etc. from one side of concrete structure to other side. Pipe sleeve Eps consists of a pipe and one or more puddle flanges, provided through the length of pipe for anchorage and also for improving leak tightness. These pipes are either projecting out of the concrete surface or flush with it depending upon the requirement.

(c) Anchor bolts

Anchor bolts are used for anchoring equipment like pumps, motors, heat exchangers, tanks, pipes rails for cranes and hoists etc. The threaded portion of anchor bolt projection out of the concrete shall be suitably protected by caps/ sleeves from any possible damage to the threads till the equipment is erected.

(d) Threaded sockets/ embedded inserts

Threaded socket Eps are used for anchoring the equipment like heat exchanger, motors, pumps, tanks rails for cranes, hoists etc. The threaded portion remains below the concrete face. Suitable protective plugs shall be inserted to prevent damage to the threads during construction phase.

(e) Rectangular Box type penetration EPs

These Eps are generally used for passage of a bunch of piping or cables. It consists of a rectangular box made of plates and anchorage welded to it. The anchors help in transferring the loads from the EP to concrete structure and also improve leak tightness. These EPs are either projecting out of the concrete surface or flush to it depending upon the requirement.

(f) Expansion anchors

A post-installed anchor inserted into the concrete that transfers the loads to or from the concrete by direct bearing or friction or by both. Expansion anchors may be torque controlled where the expansion is achieved by a torque acting on the screw or bolt or displacement controlled where the expansion is achieved by impact forces acting on a sleeve or plug and the expansion is controlled by the length of travel of the sleeve of the plug. These anchors are used only if

(i) EPs are missed or misplaced from actual support location with respect to reference drawings during construction. Civil contractor shall substitute these EPs with suitable anchors meeting the design intent and cost for these shall be borne by them.

(ii) Additional requirement of anchors are arisen after concreting is done on account of design change.

Approved type of expansion anchors (for seismic/ non-seismic loads) for respective systems/ buildings/ structure from approved vendors shall be used.

(g) Grouted Anchors

Grouted anchor is an anchorage system which has the anchor rod, bolt or bar grouted or dry packed into pockets left in the hardened concrete.

(h) Embedded Piping

These are the part of the process system piping, which are embedded in the concrete and are projecting out of the concrete surface for joining with other part of the system piping while erection.

(i) Special EPs

The configuration of these EPs are different from the EPs described above and are designed to suit the particular requirement. These may have stringent tolerances depending upon the requirement of the equipment.

Different EPs used in the work and covered in these specifications are given below.

a) Anchor bolts of different sizes and Plate embedded parts (EPs)
b) Pipe sleeves with circumferential baffle plates of various diameters in carbon steel and stainless steel.
c) Electrical Canister EPs
d) Drain hubs and penetration in walls/slabs which are not joined to buried piping.
e) All Hatch frames both on the receiving hatch opening and hatch blocks/beams
f) All other embedded parts as shown on drawings released for fabrication.

16.4 APPLICABLE CODES, SPECIFICATIONS

IS : 102	Ready mixed paint, brushing, and red lead. Non-setting, priming.
IS : 800	General construction in steel- Code of Practice.
IS:801	Code of practice for use of old formed light gauge steel structural steel members in general building construction.
IS: 806	Code of practice for use of steel Tubes in General Building Construction.
IS : 808	Dimensions for Hot Rolled Steel Beams, Column Channel and Angle Sections.
IS :813	Scheme of symbols for welding

IS:819	Code of practice for resistance spot welding for light assemblies in mild steel.
IS:822	Code of practice for inspection of welds.
IS : 875	Code of practice for Design loads, For buildings & Structures (Part 1 to 5)
IS : 919	ISO systems of limits and fits. (Parts 1& 2)
IS : 1161	Steel Tubes for Structural Purposes- Specification
IS : 1200	Method of Measurement of Building and Civil Engineering Works (Part 1 to 28).
IS: 1239	Mild steel Tubes, Tubulars and other wrought steel fittings. (Parts 1 & 2)
IS :1363	Hexagon Head Bolts, Screws and Nuts of product Grade C (Part 1 to 3).
IS:1365	Slotted counter sunk head screws.
IS : 1364	Hexagon Head Bolts, Screws and Nuts of product Grade A & B.
IS : 1367	Technical supply conditions for threaded steel fasteners (Part 1 to 20)
IS : 1477	Code of practice for painting of ferrous metals in buildings. (Part 1 & 2)
IS: 1608	Metallic materials – Tensile testing at ambient temperature.
IS :1730	Dimensions for steel plate, sheets, strips and flats for structural and general engineering purposes.
IS : 1852	Rolling and cutting tolerances for hot rolled steel products.
IS : 1893	Criteria for earthquake resistant design of structures.
IS : 1977	Low tensile Structural Steels – Specification.
IS : 1978	Line Pipe
IS : 2002	Steel plates for pressure vessels for intermediate and high temperature service including boilers.
IS : 2016	Specification for Plain washers.
IS: 3502	Steel chequered Plates – specifications.
IS : 2062	Hot rolls low, medium and high tensile structural steel.
IS : 3589	Steel Pipes for water and sewage.-Specification
IS : 3757	Specification for high strength structural bolts
IS : 5372	Taper washers for channels.(ISMC)
IS : 5374	Taper washer for I beams (ISMB)
IS : 5620	Recommendation for structural design criteria for low head slide gates.
IS: 5624	Foundation Bolts – specification.
IS : 6005	Code of practice for phosphating of iron and steel.
IS: 6623	High strength structural nuts - specifications.
IS: 6533	Code of practice for design and construction of steel chimney Part 2-Structural Aspects
IS: 6639	Hexagon Bolts for steel structures – specifications.
IS :6649	Specifications for Hardened and tempered washers for high strength structural bolts and nuts.
IS : 7205	Safety code for erection of structural steel work.
IS : 7215	Tolerances for fabrication of steel structures.
IS : 8500	Structural steel - micro alloyed (medium and high strength qualities)-Specification
IS : 8629	Code of practice for protection of iron and steel structures from atmospheric corrosion (Part I-III)
IS: 9537	Conduits for electrical installations – General requirements.

IS: 10842	Evaluation procedure for Y-groove weld crack-ability test in structural steel.
IS : 11855	Guidelines for design and use of different type of rubber seals for hydraulic gates.
IS : 12843	Tolerances for erection of steel structures
SP:6(1)	ISI Hand Book for structural engineers –1, Structural Steel Section
BS : 3139	High strength friction grip bolts for structural engineering.
BS: 4395 (I)	High strength friction grip bolts and associated nuts and washers for structural engineering.
BS : 4592	Industrial type flooring and stair treads –Metal open bar gratings
BS : 4604	The use of high strength friction grip bolts in structural steel work.
AWS D1.1.	Structural Welding Code-Steel
AERB/SS/ CSE-2	Design, Fabrication and Erection of Steel Structures Important to Safety of Nuclear Facilities
ASME Sec II, Part C	Specification for Welding Rods, Electrodes and Filler Material
ASME Sec V	Non –destructive Examination.-
ASME Sec VIII, Div 1	Rules for Construction of Pressure Vessels.
ASME Sec III, Div 2	Code for concrete Reactor vessels and containments
ASME Sec IX	Qualification standard for Welding and Brazing procedure welders, brazers and welding and brazing operators
ASTM A-36	Specification for Structural Steel
ASTM A 167	Standard specification for Stainless and Heat Resisting Chromium Steel Plates, Sheet, Strip
ASTM A 262	Standard practice for Detecting Susceptibility to Intergranular attack in Austenitic Stainless Steels
ASTM A 380	Standard Practice for Cleaning and descaling Stainless Steel Plates, Equipment and Systems
ASTM A 516	Standard specification for Pressure Vessel Plates, Carbon Steel for Moderate and lower Temperature Service.
ASTM E 94	Standard Guide for Radiographic Testing
ASTM E 165	Standard test method for Liquid Penetrant Examination
ASTM E 709	Standard Guide for Magnetic Particle Examination
PC-E-160	NPCIL Specifications for Embedded parts
British Standard	EN Series carbon steel materials like EN8, EN24

The pertinent clauses and sections of the above codes, standards and specifications (latest revision), shall apply to the material, design, detailing, fabrication and inspection of the work covered by this specification as specified in the other sections of this specification.

In the event that certain requirements of this specification, applicable drawings and above standards & codes conflict with each other. The following priority shall govern in descending order.

i) Requirement given in the drawing
ii) Requirement given in specification No. PC-E-160, for EPs, PC-E-0034 for critical and important EPs and this specification for other steel structures.
iii) Requirement given in ASME/ ASTM
iv) Requirement given in Indian standard

16.5 DRAWINGS

16.5.1 ENGINEERING DESIGN DRAWINGS

Design drawings shall show all the dimensions and if necessary, clearances of the structure, typical connection details including size & length of the weld, weld arrangement, number of bolts, size of bolts and types of bolts, size of each member, definite location of openings, to various levels, and all other information necessary to prepare drawings for fabrication and erection.

16.5.2 Fabrication Drawings

16.5.2.1 Contractor shall prepare all fabrication and erection drawings in metric units for the entire work based on the design drawings. Shop detail drawings shall show all shearing, punching, drilling, bevel cutting, bending, and all welding / bolting in complete detail. All connections and splices shall be detailed by the Contractor and clearly shown on the drawings.

EPs shall not be welded to the main reinforcement. Bill of material shall show number, size, length, weight and assembly work of each erection piece. Bill of material for each drawing shall include fasteners/ bolts, nuts, washers and other accessories complete with specification, size, length and number etc. for each erection mark and proper identification for each joint.

Bill of material shall be prepared erection mark wise, showing weight of each component part and total weight of each erection mark. All revisions after initial issue of a drawing shall be clearly indicated with issue number and date of revision. Details shown in the drawings shall be clear and legible.

16.5.2.2 Contractor shall not commence shop detailing from information on Engineering design drawings unless such drawings or part of such drawings are officially released with the stamp bearing “Released for Construction”. Contractor shall be responsible for the correctness of all shop drawings. Six (6) prints of shop drawings shall be submitted to the Engineer for scrutiny and approval. The fabrication drawings shall be revised by the Contractor to reflect all revisions in design drawings as and when such revisions are made by Engineer. Six (6) prints of the revised fabrication drawings shall be submitted to the Engineer for approval.

16.5.2.3 No detailed shop drawings will be accepted for examination by the Engineer unless they are complete and checked and approved by Contractor’s qualified Structural Engineer and accompanied by an erection plan showing the location of all pieces detailed.

16.5.2.4 Contractor should check for erection clearance and ensure that detailing of connections is carefully planned to obtain ease in erection of structures including

field-welded connection and bolting. Field connections/ splices may be welded or bolted type, as specified in drawings.

16.5.2.5 Fabrication shall not be started until Contractor has received copies of such drawings upon which Engineer has endorsed his approval. Approval by Engineer of any of the drawings shall not relieve Contractor from the responsibility for correctness of engineering, workmanship, fit of parts, details, material, errors or omissions if any and all work shown thereon. Any work done prior to approval of shop drawings will be at the Contractor's risk. The Contractor shall make such changes in the design when so directed, which are considered necessary to make the structures conform to the provisions and intent of the specifications, without any additional cost to the NPCIL. Engineer’s approval shall not invalidate any claim for damages of any kind for incorrectly detailed/ fabricated steel, notwithstanding any approval of such drawings by Engineer.

16.5.2.6 Contractor shall submit design calculations, for each and every connection detail proposed by him and also for any substitution for members, desired by him and approved by the Engineer. Fabrication drawings not accompanied by calculations for the connection design are liable to be rejected.

16.5.2.7 Each lot of drawings sent by Contractor for approval shall contain a limited number of drawings and shall be in an order and manner which follows erection sequence or as required by Engineer based on priorities allocated.

16.5.2.8 Engineer will return one copy of Contractor's drawing marked with Engineer's approval/ comments. Contractor shall furnish the Engineer, Six (6) prints of all approved final drawings for field use and record purpose. Contractor shall also furnish the Engineer with one reproducible of each drawing. These reproducible shall incorporate all modifications, field changes substitutions etc. affected and shall reflect the status "as built". It should be noted that so-called sepia or similar process reproducible are not acceptable. All these reproducible are not acceptable. All these reproducible shall be submitted rolled (not folded) on the outside of regular mailing tubes.

16.5.2.9 All these drawings will remain the property of the Engineer (NPCIL). Engineer reserves the right to use them in any manner whatsoever.

16.5.2.10 Two sets of soft copies of all final approved Contractor’s drawings in the form of CDs shall be furnished by the Contractor for Owner’s use after incorporating the as built status.

16.5.2.11 Time consumed by the Contractor in securing approval of drawings should not be added to the time allowed for completion of contract. A period of four (4) weeks from the date of receipt of drawings by the Engineer should be anticipated for this item of procedure in the schedule.

16.6 MATERIALS

16.6.1 STEEL SUPPLY

All steel shall be procured and supplied by the Contractor, from reputed sources as

approved by Engineer and shall conform to the following:

16.6.1.1 Contractor shall use materials for fabrication as specified in the approved drawings. All materials supplied by the Contractor shall be in sound condition, of recent manufacture, free from defects such as loose mill scales, slag intrusions, laminations, pitting, flaky rust etc. The lengths/sizes of steel sections and plates shall be as supplied by the steel mills and conform to the latest issue of the relevant IS /ASME specification.

16.6.1.2 All materials required for the work shall be correlated with manufactures test certificates. In the absence of test certificates, materials shall be tested by Contractor through an approved laboratory for establishing conformance to specification's requirement at Contractor's cost, and as directed by the Engineer. All tests shall be witnessed by owner's representative.

16.6.1.3 The Contractor shall supply the mill test certificate for the materials being supplied by him.

16.6.1.4 Material supplied against these Test Certificates (TCs) should have identification stamped or stenciled on them. All such identification markings shall be authenticated by the inspection agency, which has inspected and approved the material.

16.6.1.5 The Engineer shall have the right to test random samples to prove authenticity of the test certificates produced by the Contractor at the Contractor's cost. Any material found not meeting the specification requirement would be rejected. In the absence of material specification in the drawing following guidelines are given for structural steel members:

a) Rolled sections and Bars

Rolled steel sections supplied by the Contractor shall be of following quality.

Rolled Section	: IS 2062 E 250-Quality. A
Plates below 12mm	: IS 2062 E 250-Quality. A
Plates 12mm and above	: IS 2062 E 250-Quality. B0
Plates for crane girder	: IS-2062 E 250-Quality. C

Rail section:

The Y- Groove crackability test shall be performed in accordance with IS 10842 for material of Grade E 250Quality C, having thickness 12mm and above.

b) Pipes and Pipe fittings

For pipes and pipe fittings the following standards shall apply

For pipes up to 150 mm diameter IS: 1239 Part I and II,

For pipes beyond 150m to 2000mm diameter IS: 3589.

16.7 SUBSTITUTIONS

Whenever the Contractor desires to substitute structural members, shown on the drawings, due to non-availability of requisite materials, such substitutions shall be made only after authorization in writing by the Engineer.

Engineer may also direct to make substitution, when he considers such substitution is necessary.

16.8 FABRICATION OF STRUCTURAL STEEL

16.8.1 GENERAL

All workmanship and finish shall be of the best quality and shall conform to good engineering practice and the best-approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Standard fabrication clearances as detailed in American Institute of Steel Construction Manual and IS Codes shall generally be followed unless otherwise directed/ approved. For EPs specific requirements given in para titled 'EMBEDDED PARTS' and 'PAINTING' of this specification shall be followed in case found to be in variation with other clauses of this section. Materials at the shop shall be kept clean and protected from weather. In addition

a) All care should be taken to avoid undue welding distortions.
b) Complete layout shall be prepared and got approved by the Engineer before actual fabrications are started. If needed mock-ups may also be prepared.
c) All fit ups shall be got approved from the Engineer.
d) Standard tolerances as per relevant IS specifications shall be followed in case they are not provided in relevant drawings and specifications.

16.8.2 ELECTRODES

All Electrodes and welding shall be of low hydrogen type conforming to ASME Sec II Part C. Brands approved by NPCIL shall only be used. The bidders shall submit the list of venders and seek approval of NPCIL.

16.8.3 CONNECTIONS

16.8.3.1 All connections shall be designed (In case these are to be designed by the contractor) for forces indicated on the design drawings. The contractor shall be responsible for selection of standard connections from AISC, "Manual of Steel Construction" unless specified in drawings. Where standard joints are not available,

contractor shall design connections and shall get Engineer's approval prior to fabrication.

16.8.3.2 Connections shall be effected either by welding or bolting or as specified on the drawings. Type and quality of weld/bolts shall be in accordance with relevant IS Codes and as specified in the drawings.

16.8.3.3 Where necessary, tapered washers, flat washers or spring washers shall be used with bolts. The length of the bolt shall be such that at least one thread of bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be at least three times the thread pitch.

16.8.3.4 In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, even if a longer grip bolt has to be used for this purpose.

16.8.3.5 Wherever applicable, all connections and splices shall be designed for full strength of members or loads indicated unless otherwise approved. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice. Unless otherwise specified, beam end connections shall be designed for 60% of the shear capacity of rolled sections and 80% of shear capacity for built-up sections plus additional axial forces, if any.

16.8.3.6 All members likely to collect rainwater shall have drain holes provided.

16.8.3.7 Shop connections shall be generally welded. Field connections shall be made with bolts or HSFG bolts or welding as specified on the drawings.

16.8.3.8 In general, splice joints are not permitted except where standard length of the section under consideration is not sufficient to build the full length of the member. However, under exceptional condition, not more than one shop splice shall be permitted to make up the full length of a member with prior approval of Engineer at no extra cost to NPCIL. Shop splices to make the full member lengths shall be of full penetration butt-welded type and radio-graphically tested.

16.8.4 STRAIGHTENING

16.8.4.1 Rolled material, before being worked, shall be straightened, unless otherwise required/specified. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Long plates shall be straightened by passing through a mandrel or levelling rolls and structural shapes by the use of mechanical or hydraulic bar/section straightening machines. Heating or forging shall not be resorted to without the prior approval of the Engineer in writing. In case of site fabrication, the Engineer shall approve the straightening methods in writing before commencing the work.

16.8.4.2 Checking of the straightness of the structural members like angles, channels, beams etc. shall be done by using the thread. For checking of the straightness of the column sections piano wire shall be used. The sections, which are twisted beyond repairs, shall not be used for fabrication. Heating or hammering shall not be permitted. After removal of bends, structural members shall be submitted for inspection and approval of Engineer.

16.8.5 CUTTING

16.8.5.1 Cutting may be done by shearing, chopping, sawing or machine flame cutting. All re-entrant corners shall be shaped notch free to a radius of at least 12-mm. Sheared or cropped edges shall be dressed to a neat workmanlike finish and shall be free from distortion and burrs.

16.8.5.2 Hand flame cutting shall be undertaken, only if so permitted by the Engineer and shall only be carried out by an expert in such work. Hand flame cut edges shall be ground smooth and straight, for minimum 2mm in depth to remove the oxide layer.

16.8.5.3 Edges of flange cover plates and plates used to form any sections shall be ground smooth/planed.

16.8.6 PUNCHING AND DRILLING

16.8.6.1 Holes for all connections shall be drilled accurately and the burrs removed effectively. Where several parts are to be connected, such parts shall be first assembled, tightly clamped together and drilled through. Holes in secondary members such as purlins, girts, lacing bars etc. may be punched full size through material not over 12 mm thick. Holes should be clean cut, without burr or ragged edges.

16.8.6.2 ub-punching may be permitted before assemble, provided the holes are punched 3 mm smaller in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not in such cases exceed 16 mm.

16.8.6.3 When match drilling is carried out in one operation through two or more separate parts, these parts shall be separated after drilling and the burrs removed.

16.8.6.4 Holes for turned and fitted bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to HB tolerance specified in IS: 919.

16.8.6.5 Where reamed members are taken apart for transporting or handling the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. Poor matching, over drilling and ovality in holes shall be a cause for rejection. Burning holes with gas is strictly prohibited.

16.8.6.6 Holes may be required to be drilled by the Contractor at site for installing equipment or steel furnished by other agencies. The information for this will be supplied to the

Contractor by the Engineer before or after erection of the steel. Holes should be by drilling or other machining process and not by gas cutting sets.

16.8.7 ROLLING AND FORMING

Plates, channels, RSJ, etc., for circular bins, crane girders, gantry girders etc shall be accurately laid off and rolled or formed to required profile/shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field. In the case of stainless steel materials while rolling care shall be taken to avoid direct contract of MS/CS rollers with SS material in view of iron contamination to SS materials. A detailed rolling & forming procedure shall be prepared by the contractor and Engineer approval shall be obtained prior to execution.

16.8.8 GRINDING

Column ends bearing on each other, resting on base plates, compression joints designed for bearing, base plates coming in contact with column end and cap plates shall be ground smooth to ensure 90% contact with local gap not exceeding 0.10 mm (filler gauge shall be used to check this gap), unless mentioned and approved otherwise. All ground surfaces shall be protected from dirt and mechanical damages till the assembly is completed. However the underside of base plate bearing on cement grout need not be ground smooth.

16.9 GRATINGS

All gratings shown and/or listed in the drawings shall be fabricated as a complete unit as detailed or as necessary for connections to structural steel framing. The gratings shall be capable of sustaining a safe live load of 500 kg/sq. metre of plan area unless otherwise specified on the Engineer's design drawings. Treads and landings shall be suitable for the prescribed loading and be furnished complete with a one-piece standard non-slip abrasive nosing of approved type.

16.9.1 ELECTROFORGED GRATINGS

Electro forged Gratings shall be of custom fabricated/ cut to size in shapes (rectangular/ circular etc.) as required with serrated bearing bars. Gratings shall be fixed at all elevations with clamps, siddle clip & slotted clamps including drilling, providing and fixing screws. It shall be hot dip galvanized as per IS 4759 but in no case it shall be lesser than 610GSM. Wherever, due to functional requirements Galvanizing is not acceptable the grating shall be painted with high build epoxy with minimum DFT of 200 micron (excluding primer) over 75 micron zinc silicate primer etc. The gratings shall be capable of sustaining a safe live load of 500 kg/sq. meter (unless specified otherwise) of plan area. Treads and landings shall be suitable for the prescribed loading and be furnished complete with a one-piece standard non-slip abrasive nosing of approved type. The Contractor shall submit the design and fabrication drawing to NPCIL for approval prior to procurement of gratings.

16.10 HANDRAILS

Handrails shall be provided on open sides of platform, stairways and around all openings as shown in drawings. Handrails shall be of SS/mild steel pipe as specified in the drawings of flush welded construction and ground smooth. Unless specified otherwise the handrail shall be fabricated using 32mm nominal bore medium class pipe provided with double rail, top rail about 1 meter above platform / walkway level and the intermediate rail 450 mm below top rail and pipe posts spaced not more than 1.5 metres apart and 150 mm high 6mm thick toe plate. All MS handrails shall be painted as per requirement given in the drawings.

Smooth uniform curves and bends shall be provided at stair returns and also where so ever required /specified. Posts connected to curb plates shall have a neat closure at the bottom and a 6mm thick plate nearly welded to posts for attachments to curb plate/ toe guards. All necessary fittings including inner dowels at splices, brackets, bolts, bends, flanges and chains, shoes for removable type handrails where required shall be furnished by the Contractor. Open ends of all the pipe posts shall be plugged and welded. A minimum radius of 3 times the pipe diameter shall be provided at all points of direction changes in the handrail.

16.11 CHEQUERED PLATE

Chequered plates used shall be minimum 6mm thick or as indicated in the drawings and shall be capable of carrying a minimum live load of 500 kg/sq.m unless otherwise specified in the design drawings. Chequered plate shall be fixed by 8mm diameter cadmium plated M.S. screws with countersunk heads at a maximum spacing of 400mm. Members supporting the chequered plate shall have matching holes tapped in them. Chequered plates may also be required to be welded to the structural steel framing. The decision in this regard will be given by the Engineer wherever required/ specified.

Thickness of zinc coating shall be as per IS: 4759 for structural steel plates, angles, channels etc. and as per IS: 4736 for pipe sleeves.

16.12 WELDING

16.12.1GENERAL

16.12.1.1 Welding procedure specification (WPS) shall be established and Qualification of weld procedure (QWP) shall be done in accordance with the requirements of ASME Sec IX, or AWS D 1.1 as and where specified. Welders employed shall also be qualified as per above standards prior to taking up fabrication.

Following pre-qualified welding process shall be employed for fabrication, erection and repair by:

a) Submerged Arc Welding (SAW).
b) Shield Metal Arc Welding (SMAW).
c) Gas Metal Arc Welding (GMAW).

d) Gas Tungsten Arc Welding (GTAW)

16.12.1.2 All welds shall be free from defects like blowholes, lack of penetration, undercutting, cracks etc. All welds shall be cleaned of slag or flux and show sections, smoothness of weld metal, featheredges without overlap and freedom from porosity.

16.12.1.3 50mm on either side of the surfaces on which weld metal is to be deposited shall be smooth, uniform, free from fins, tears burrs cracks and absolutely free from grease, paint, loose scale, moisture or any other substance which would adversely affect quality and strength of weld.

16.12.1.4 Machining, thermal cutting or grinding may be employed for joint preparation or removal of unacceptable work or metal. The weld edges shall be smooth & regular surface free from cracks & notches. Flame cut material above 50mm thick shall be pre-heated to 100°C prior to flame cutting.

16.12.1.5 All weld fit-up shall comply with tolerances specified in the design drawing. The parts to be joined by fillet welds shall be brought into close contact as practicable. The root gap in no event shall be greater than 3 mm for SMAW process and 1.5mm for SAW process. If the separation is greater than 1.6mm the leg of the fillet weld shall be increased by the amount of root opening. This shall apply only in the case of continuous welds. Abutting parts to be butt-welded shall be carefully aligned and correct root gap shall be maintained throughout the weld operation. The fit up of joints at contact surfaces that are not completely sealed by welds shall be close enough to exclude water entry after painting. The separation between laying surfaces of lap joint and butt joints with backing plate shall not exceed 1.5mm. Abutting parts to be butt-welded shall be carefully aligned and the correct root gap maintained throughout the welding operation. Misalignments greater than 25% of the thickness of the thinner plates or 3mm, whichever is smaller, shall be corrected and in making the correction, the parts shall not be drawn into a slope sharper than 2 degrees.

16.12.1.6 All tack welds shall be made using qualified procedure and qualified welders. Any preheat requirement specified in the welding procedure shall also apply to tack welds. All tack welds shall be examined visually for defects and if found defective, shall be removed.

16.12.1.7 Welding of temporary attachment/fixtures to retain fit up is allowed in case the parts have a nominal thickness of at least 6mm. Temporary attachments are welded to at the distance of at least 30 mm from the weld seam for construction of CS and least 60mm for welding austenitic steel. Welding of temporary attachments/fixtures into the joint slot is not allowed. All temporary fixtures to be

removed after welding by grinding them to weaken the welded portion and hammering thereafter, followed by grinding the portion of any weld remaining on the base metal. A dye check at the discretion of the quality surveyor shall be done to detect any crack/defect at the point of fixture temporary weld.

16.12.1.8 It is not allowed to turn over and carry over heavy assemblies in tacking condition in order to control the geometric dimensions to the requirements of the drawings.

16.12.1.9 Non-flatness of the facing sheets being assembled into the subassemblies in the longitudinal and transverse direction is allowed within 10mm for 1m of the length.

16.12.1.10 During the installation of the structural steel members care shall be taken to prevent damage of the sheets and of the welding seams. The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided as far as possible.

16.12.1.11 In the joints of the parts with dissimilar thickness smooth transition of one part to the other must be provided by way of the gradual decreasing of the thickness of the thicker part with the slope of the surface not exceeding 15 degree.

16.12.1.12 Welding shall not be done when the surface of the members are wet or exposed to rain or high wind velocities unless the welding operator and the work are properly protected. In joints connected only by fillet welds, the minimum size of fillet weld to be used shall be as shown in the following table unless otherwise specified in the drawing.

Material thickness of Thicker part joined (mm)	Minimum size of fillet weld (leg dimension of fillet weld) (mm)
Up to 6	3
Over 6 to 12	5
Over 12 to 18	6
Over 18 to 36	8
Over 36 to 56	10
Over 56 to 150	12
Over 150	16

16.12.1.13 Fillet welds 5 mm or larger in size for SMAW and 10mm for SAW shall be made with two or more passes. Welding rods shall be 3.15 in diameter maximum for root passes, and 4mm and above in diameter for subsequent passes. Complete penetration butt weld shall be terminated at the ends of the joint in a manner that will insure their soundness. Where abutting parts are 20mm or more in thickness,

suitable run-on and run-off plates with similar edge preparation and having a width not less than the thickness of the thicker part shall be used. These extension pieces shall be removed after completion of weld and the end of the weld made smooth and flush with the abutting parts.

16.12.1.14 In case of full penetration butt welds without backing , root weld shall be back gouged to sound metal before second side welding for complete fusion throughout the entire cross section. However, in case of square butt welds done in flat position from both sides and with thickness of parts joined less than 8mm and root opening not less than half the thickness of the thinner part, gouging can be dispensed with, if approved by the engineer.

16.12.1.15 All welded shop splices in each component part of covered plate beam or built up member shall be made before the component part is welded to other parts of the member. Long girders or girder section may be made by welding sub assemblies each made in accordance as explained above. When making these sub assembly splices, whether in the shop or field, the welding sequence should be reasonably balanced between web and flange welds. Where weld reinforcement interferes with the proper fit-up between components to be assembled for welding, these welds shall be ground flush prior to assembly.

16.12.1.16 Preheating for welding of steel shall conform to ASME Section VIII Div 1

16.12.1.17 Post weld heat treatment (PWHT) shall be carried out if the weld size is more than 50mm, unless specified otherwise. The procedure for PWHT shall conform to ASME Section VIII Div 1. No stress relief using oxyacetylene flame is permitted.

16.12.1.18 In assembling & joining parts of a structure or a built-up members and in reinforcing parts to members, the procedure and sequence shall be such as to minimize distortion and shrinkage. The fabricator shall prepare a welding sequence for a member or structure which in conjunction with WPS and overall fabrication method, will produce members or structure meeting the quality requirement specified. The welding sequence and distortion control programme shall be submitted to Engineer for comments and information before start of welding such program shall include, besides other appropriate details, full particulars in regard to the following:

a) Proposed pre-bending in components such as flanges and flange cover plates and pre-setting of joints to offset expected distortion.
b) Make up of sub-assemblies proposed to be welded before incorporation in final assembly.
c) Proposed joint forms, classification of wire and flux or covered electrodes, welding process including fit up and welding sequence with directions in which freedom of movement is to be allowed.
d) Proposed number, spacing and type of storage backs and details of jigs and fixtures for maintaining proper fit up and alignment during welding.

e) Any other special features like assembling similar members back to back or stress relieving procedure.
f) If so desired by the Engineer, mock up welding shall be carried out at Contractor's cost to establish the efficiency of the proposed programme, with any modification suggested by the Engineer in limiting distortion or /and residual stress to acceptable levels.
g) For sections made of rolled sections with cover plates, the ends of the plate shall be seal welded or alternatively flange cover plate terminated 25mm short of the full length and welded across to the beam for proper end sealing and/or as directed by the Engineer.

16.12.1.19 Welds shall be defect free and surfaces shall be thoroughly cleaned to remove all visible weld defects and extra material. All welds shall be stamped/identified with System/Joint No/Welder punch etc. as per approved procedure at a distance of 30-35 mm from the weld seam.

16.12.2 WELDING CONSUMABLES

16.12.2.1 Electrodes, filler wires and flux used for welding shall be from approved manufacturers/Suppliers. When requested by the engineer, the contractor shall furnish certification that electrode or electrode flux combination will meet the requirements of classification. The classification and size of electrode, arc length, voltage & amperage shall be suited to type and thickness of material, type of groove, welding positions and other circumstances attending work.

16.12.2.2 Electrodes, filler wire and consumables shall conform to the requirements of ASME Sec. II Part C.

16.12.2.3 Only low hydrogen electrodes to AWS E7018 shall be used for welding for all Carbon Steel material. Whenever high tensile welds are required to be employed than E-8018 electrode are to be used of approved make. These electrodes shall be purchased in hermetically sealed containers or baked by the user as recommended by electrode manufacturer. Electrode flux coating shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. SMAW electrodes shall be properly stored. Before welding, the electrodes shall de dried in a holding oven as per manufacturer's recommendations. Only limited quantity shall be issued to the welders. The electrodes shall be kept in "carry ovens" and shall not be exposed to the atmosphere.

16.12.2.4 The filler wire and flux combination for submerged arc welding shall conform to the requirements of ASME Section II, Part C. The weld metal deposited by the submerged arc process shall have mechanical properties not less than that of base material specification. The flux used for SAW process shall be dry and free of contamination from dirt, mill scale or foreign material. The flux purchased in packages shall be stored in dry place. Flux shall be dried in case of damaged package at a temperature of 260° C for 1 hour prior to welding operation. Flux shall be placed in dispensing system immediately upon opening a package.

16.12.2.5 Welding plants and accessories shall be of adequate capacity and shall satisfy appropriate standards and be of the approved make and quality. Proper safety rules shall be followed and adequate means to measure the current shall be provided.

16.12.2.6 Wet magnetic particle inspection in accordance with ASME Sec. V may be performed.

16.12.2.7 For other magnetic materials dry power magnetic particle inspection in accordance with ASME Sec V.

16.12.3 WELD REPAIR

Whenever weld repair is required, Contractor shall give prior intimation to the Engineer and permission before the repairing is taken up. When a defect is detected in a weld, it shall be removed by cutting/grinding and smooth blending of the area with parent metal without sharp edges, corners. If welding is required, the same shall be done using the qualified procedure/welder and stage inspection as per the original weld. Correction of defect in the same portion of the weld shall not be allowed more than two (2) times. Portion of the welding seams, which have been subjected to repair, must be indicated in the weld inspection reports.

16.13 ERECTION

16.13.1 GENERAL

16.13.1.1 The Contractor shall supply all erection bolts, permanent bolts and electrodes as required for the job. At all times the Contractor shall be responsible for the safety and protection of fabricated material, from loss or damage of any nature until the completion of erection work.

16.13.1.2 Structural steel work will involve the erection of columns, beams, bracing, crane girders, purlins, trusses, monorails, ladders, platforms, gratings, chequered plates etc.

16.13.1.3 The Contractor shall complete all preliminary works at site, including post concrete survey wherever required well before the arrival of fabricated structural steel, such as keeping in readiness electrical winches, mobile cranes, gin poles, compressors, all tools and tackles, welding sets, torque wrenches, impact wrenches, etc., as part of this contract and any other work that may be necessary so as to start erection immediately after the arrival of fabricated steel at site.

16.13.1.4 The Contractor shall arrange for such quantum of erection equipment, supervision staff, labour and other arrangements so as to carry out the work efficiently. The equipment and services provided by Contractor shall include but not be limited to, the supply of labour, transport vehicles, crane derricks, gin poles, winches, welding equipment and tools, compressed air if required, blocking, scaffolding, locked storage for tools, welding rods, positioners, cables etc required for site fabrication assembly and erection of the structure. If found necessary the Contractor shall also provide at hisown cost arrangements for inspection and

testing of material used in erection. He shall satisfy the Engineer regarding arrangements for various types of work to be undertaken by him.

16.13.1.5 No dragging of fabricated structural steel shall be permitted.

16.13.1.6 All fabricated structural steel shall be stored 150mm above ground on suitable packing, to avoid damage during the monsoon. Steel shall be stored in the order of erection with erection/identification marks visible. Storage areas shall be prepared and maintained by the Contractor. Any steel stored near excavations shall be removed immediately to a safe distance to avoid burial under debris.

16.13.1.7 The Contractor shall protect all existing plants, embedded parts, all permanent and temporary structures, piping, conduits, equipment and facilities against damage during erection. The Contractor shall perform his work in a manner, which in no way endangers the operations of any existing plant or structures or hinders other construction activities.

16.13.1.8 The Contractor shall arrange at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after the completion of the job. The Contractor shall also provide necessary passageways, fences, safety belts, helmets, safety shoes, lights and other fittings to the satisfaction of the Engineer and for protection of his men and materials.

16.13.1.9 All structures shall be erected as shown in drawings. The Contractor shall carry out all erection work in the sequence required/ approved by the Engineer. The methods of erection and complete erection scheme shall be subject to the approval of the Engineer and shall be modified wherever required by the Engineer. This, however, will not relieve the Contractor of the responsibility for safe and expeditious completion of the work, its quality and accuracy.

16.13.1.10 Drifts should be used only for drawing the members into position and must not be used to such an extent so as to destroy the holes. Drifts of a larger size than the nominal diameter of the hole shall not be allowed. Any damaged holes or burrs must be rectified to the satisfaction of the Engineer. Correction of minor misfits and reasonable amount of reaming, if any, shall be considered as a part of erection. Any error in shop work, which prevents proper fit even after a moderate amount of reaming and slight chipping or cutting shall be immediately reported to the Engineer. The Contractor's work shall also include straightening and repairing of materials slightly damaged and drilling some holes in members where required. This is deemed to have been included in the unit rate quoted and nothing extra shall be payable for the above operations. Non Conformance Report (NCR) shall be raised and got approved for all repairs and modification required.

16.13.1.11 In case of any faulty erection, all such dismantling and re-erection required will be at the Contractor's cost. Shim stock of mild steel plates, required for erection will be set, leveled and prepared for grouting / dry packing.

16.13.1.12 Where flat bearing beams occur, bearing plates shall be set, levelled and prepared for grouting/dry packing.

16.13.1.13 Structural Steel frames shall be erected plumb and true to tolerance indicated in the relevant clause. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracing shall be introduced wherever necessary to take care of all loads to which the structures may be subjected including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety. Proper size steel cables, slings etc shall be used to avoid any damage due to accidents.

16.13.1.14 As erection progresses, the work shall be securely bolted to take care of all dead load, wind and erection stresses. No final welding or bolting shall be done until the structure has been properly aligned and approved by the Engineer.

16.13.2 CODE

Unless specified in the relevant drawing and specification, all erection work shall be carried out in accordance with the latest edition of Indian Standard Code of Practice for use of Structural Steel in General Building Construction IS-800 & AISC code wherever applicable.

16.14 ANCHOR BOLTS & FOUNDATIONS

16.14.1 The Contractor shall carefully check the location and layout of anchor bolts embedded in foundation constructed to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/foundation shall be reported to the Engineer.

16.14.2 Anchor bolts shall be provided with two nuts of approved grade of materials as per relevant IS or ASTM standard codes on upper threaded portion, one of which may be used for levelling the column base to the required elevation and one will be a lock nut. All shim stock, required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good MS plates and shall be supplied by the Contractor at his cost .Required no of washers shall also be provided by the contractor at his cost.

16.14.3 Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. The Contractor shall carry out all grouting under column base plates or beam bearing plates, unless the grouting is specifically excluded from the scope of work.

16.14.4 HIGH STRENGTH FRICTION GRIP BOLTING

16.14.4.1 High strength friction grip bolts and nuts shall conform to IS: 3757 and/or BS: 3139/ or ASTM A325.

16.14.4.2 Installation of high strength friction grip bolts in joinrs shall comply with IS : 4000 and / or BS : 3294 and or specification for structural joints using ASTM A 325 or A490 Bolts by Research council on Rivetted and Bolted Structural Joints.

16.14.4.3 The diameter of the bolt holes will not be more than 1.5 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the bolt heads, nuts and washers shall be free of scales, burs, dirt and other foreign matters tending to inhibit uniform sealing of the joint components. However, tight mill scale and the light residual oil coating on bolts, nuts and washers need not be removed.

16.14.4.4 All fasteners in a joint shall be tightened to a tension equal to greater than the specified proof load .either by the calibrated wrench method or the turn –of- nut method.

16.14.4.5 Tightening may be achieved by use of pneumatic powered impact winches , long handled manual torque wrenches with or without torque multiplier or electric wrenches . A hardened washer shall be placed under the element being turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges.

16.14.4.6 When using the calibrated wrench method, adjustable power impact wrenches and manual torque wrenches shall be calibrated to induce the bolt tension of 5% in excess of the proof load values, for each size of bolt to be used in the installation. Every wrench shall be calibrated by having it tighten a minimum three bolts of the same diameter, in a hydraulic tension measuring device. Calibration shall be repeated whenever a wrench is required to tighten a different size bolt or at least once each working day if there is no change in the bolt size. Impact wrenches shall be set so as to stall or cut at the torque effort corresponding to the prescribed fasteners tension. When manual torque wrenches are used the torque indication corresponding to the calibrating tension shall be determined and taken as the job standard. Torque measurement shall be read while the turned element is in the tightening motion. As subsequent tightening of bolts in particular assembly is liable to loosen bolts already tightened, all bolts must be ‘Touched up’.

16.14.4.7 If finger tight condition is used as a string point an extra full turn shall be taken to correspond to one half turn from the snug- tight position.

16.14.4.8 Load indicating bolts or load indicating washers may be used if so approved by the engineer in writing.

16.14.4.9 Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method and type of bolt used .

16.15 ERECTION PROCEDURES

16.15.1 The structures shall be erected by assembling in sections on the ground and hoisting successive sections into place, or they may be built up in place by individual

members at the option of the Contractor. The staging in different sections already erected shall be self-sufficient in stability for all conditions or stresses including those caused by wind. If erected by assembling in sections, not less than 50% of all bolting in place shall be done in each section before starting another section.

16.15.2 All bolts shall be drawn up tight but not to such a degree as to endanger the strength of the bolts and nuts shall be locked in place with lock nuts. Only wrenches approved by the Engineer shall be used on the work and the use of any wrench, which may deform the nut, will not be permitted. At least ten percent of the bolts in each connection as directed by Engineer shall be tested for tightness by calibrated wrenches or other approved methods free of charges. If any bolt in any connection is found to be not sufficiently tightened, all bolts in that connection shall be re-tightened and tested again without claiming any extra.

16.15.3 The Contractor shall take all precautions for the safety of labourers at the time of erection. Safety belts shall be provided to workers while working at all levels for the erection of tower. The erected structure shall be well secured and protected at the close of the day to avoid any damage to the structure and workman.

16.16 TOLERANCES

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852 for indigenous steel. The tolerances for fabrication of structural steel shall be as per IS: 7215. Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb. The tolerances specified below do not apply to steel structures where the deviations from true position are intimately linked with and directly influence technological process. In such cases, the tolerances of process technologists//suppliers which will be indicated in the drawing.

16.16.1 **Columns**

Deviation of column axes at foundation top level with respect to true axes

(a)	In longitudinal direction	:	± 5 mm
(b)	In lateral direction	:	± 5 mm

16.16.2 **Deviation in the level of bearing surface of columns at foundation top w.r.t. true level : ± 5 mm**

Out of plumbness (verticality) of column axis from true vertical axis, as measured at column top:	
(a)For columns up to and including15 meters in height:	± 1/1000 of column height inmm
(b)For columns exceeding 15 meters in height:	± 1/1000 of column height inmm or ± 20 mm whichever isless
Deviation in straightness in longitudinal and transverse planes of column at any point along the height:	± 1/1000 of column ht in mm or ± 10 mm.

Difference in erected position of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance.	± 10 mm
Deviation in any bearing or seating level with respect to true level	± 5 mm
Deviation in differences in bearing levels of a member on adjacent pair of columns both across and along the building	± 10 mm

16.16.3 **Connection of Members**

Beams up to 600 mm in depth - 1.5 mm
Beams over 600 mm in depth - 1.5mm every 600mm depth to a max. of 3mm.

Where abutting parts are to be joined by bolting through cleats or end plates, the connection requires closer tolerance.

Permissible deviation from the squareness of the end is
For Beams - 1 mm per 600 mm of depth up to a max. of 1.5 mm.

16.16.4 **Depth of Members**

Acceptable deviation from the specified overall depth is
For depth of 900 mm and under - +/- 3 mm
For depth over 900 mm and under 1800 mm- +/- 5 mm
For depth of 1800 mm and over - +8 & - 5 mm

16.16.5 **Trusses and Beams**

Shift at the centre of span of top : ± 1/250 of height of truss in mm

Chord member with respect to the : ± 15 mm whichever is less
Vertical plane passing through the centre of bottom chord.

Lateral shift of top chord of truss at the : ± 1/1500 of span of truss in mm

Centre of span from the vertical plane or : ± 15 mm whichever is less
passing through the centre of supports of the truss.

Lateral shift in location of truss from its : ± 10 mm
true vertical position

Lateral shift in location of purlin true
position : ± 5 mm

Deviation in difference of bearing : i) ±20 mm for trusses
levels of trusses or beams from ii) for beams :

the true difference	Depth < 1800 mm : ±6mm Depth > 1800 mm : ±10 mm
Deviation in sag in chords and diagonals : of truss between node points	1/1500 of length in mm or 10mm whichever is smaller
Deviation in sweep of trusses, beams etc.: in the horizontal plane	1/1000 of span in mm subject to a max. of 10 mm

16.16.6 **Crane Gantry Girders & Rails**

Shift in the centre line of crane rail with respect to centre line of web of crane gantry girder	: ± 5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	: ± 5 mm
Difference in alignment of crane rail in plan measured between any two points 2 metres apart along rail	: ± 1 mm

Deviation in crane track with respect to true gauge

(a) For track gauges upto and including 15 metres	:	± 5 mm
(b) For track gauges more than 15 metres	:	± [5 + 0.25 (S-15)] where S in metres is true gauge
Deviation in the crane rail level at any point from true level	:	1/1200 of the gauge distance or ± 10mm whichever is less
Difference in the crane rail actual levels between any two points 2 metres apart along the rail length	:	± 2 mm

Difference in levels between crane track rails at

(a) Supports of crane girders	:	± 15 mm
(b) Mid span of crane girders	:	± 20 mm

Relative shift of crane rail surfaces at a joint in plan and elevation	: 2 mm subject to grinding of surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in mm	: 1/1000 of track gauge S in mm subject to maximum of 20 mm

16.16.7 **Towers:**

Out of plumbness (verticality) from the true vertical axis	:	1/1000 of the height of the chimney or tower in mm .

16.17 MARKING OF MEMBERS

16.17.1 After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The match mark shall be punched on both sides of the member and the erection mark on the face of the member. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

16.17.2 All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

16.17.3 Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

16.17.4 In case of embedded parts, identification mark shall be visible on the exposed surface after embedding in place.

16.18 STORAGE

16.18.1 The Contractor shall have proper arrangements for storage. He shall identify the storage area where raised platform will be constructed by him. The materials will be identified area-wise and quantity-wise with proper identification marks.

16.18.2 Covered storage (Storage of fabricated materials): The Contractor shall make storage arrangements category-wise for storing fabricated materials and these materials shall be available for erection whenever called for. Fabricated materials should be stored separately according to different categories viz. embedded parts, pipe sleeves, angle frames, gratings and fabricated structural shapes. All the above materials when stacked should have proper access for inspection either by the Engineer or his authorized representatives.. The fabricated materials should be properly identified by giving identification marks. Similar precautions shall be taken to prevent the above material from rusting or any damage during the storage. Any fabricated EPs/material damaged/rusted during storage shall be rectified/repaired at Contractor's own cost.

16.19 INSPECTION, TESTING & REPORTS

16.19.1 Contractor shall give due notice to Engineer in advance of the materials or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for Engineer's approval/inspection. The fact that certain material has been accepted at Contractor's shop shall not invalidate final rejection at site by Engineer if it fails to be in proper condition or has fabrication inaccuracies which prevents proper assembly. No material shall be painted or dispatched to site without the inspection and approval by Engineer unless such inspection is waived in writing by the Engineer.

16.19.2 Shop inspection by Engineer or his authorized representative or submission of test certificates and acceptance thereof by Engineer shall not relieve Contractor from the

responsibility of furnishing material conforming to the requirements of these specifications, nor shall it invalidate any claim which the Engineer may make because of defective or unsatisfactory material or workmanship.

16.19.3 Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified. Contractor's inspection work shall be under the control of competent Chief Inspector whose primary responsibility is inspection (reporting to Management) and not to production department.

16.19.4 For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. The inspection and testing shall be conducted in a manner satisfactory to Engineer. Fit ups shall be examined by the quality surveyor as per the approved QA plan prior to welding the joint .All welds shall be inspected for flaws by the method described under the relevant Clause The inspection and testing on structural steel members shall be as set forth below:

16.20 MATERIAL TESTING

16.20.1 All materials conforming to a particular Indian/ASTM or any other standard as called for shall be tested as required by such standard. Proof in the form of certified test reports or mill certificates indicating the required tests have been carried out as per specification at the source as acceptable. In case these are not available, then the Contractor at his cost shall perform these tests.

16.20.2 Engineer has option to specify additional inspection or testing as he deems necessary and the additional cost of such testing will be borne by the Engineer.

16.20.3 The Contractor shall maintain records of all inspection and tests, which shall be made freely available to the Engineer and shall be submitted to the Engineer at completion of each stage of work.

16.20.4 If mill test reports are not available for any steel materials, the same shall be got tested by Contractor to Engineer's satisfaction to demonstrate conformity with the relevant specification at his own cost.

16.20.5 The tests are restricted to as per Indian/ASTM or any other standard for a particular material as required by such standard. If any additional tests are required to be done actual expenses shall be reimbursable.

16.21 INSPECTION OF WELDS

The following methods are used for the quality control of welded joints. All weld shall be grinded and thoroughly cleaned before taking up the inspection

16.21.1 Visual Inspection

Visual inspection shall be performed prior to and during and after non-destructive testing. The completed welds should be checked for correct size and profile. All weld surfaces shall be free from slag, creators, abrupt ridges and vallies, arc strikes. Prior to fabrication proper included angle, route opening, route face, alignment and cleanness of joint shall be checked and ensured. All weld shall be visually inspected to ensure the welding performed are within the acceptable limits.

16.21.2 Magnetic Particle Test (MPT)

Wherever specified, all MPT shall be as per ASTM- E709. Defects if found, shall be repaired and retested.

16.21.3 Dye Penetrate Inspection

MPT may be substituted by Dye Penetrate Inspection where the former is not feasible due to configuration. All surfaces of the welds to be inspected by DPT shall be free from scale, flux, ridges etc. The testing should be in accordance with ASTM-E165. Defects, if found, shall be repaired and retested. The cost of demagnetizing after testing shall also deemed to be included in the quoted rates of the Contractor.

16.21.4 Radio-graphic Examination

Wherever specified, Full penetration butt welds shall be radio-graphed or spot radiographed as shown in drawings /QA plans in accordance with ASTM: E-94 and as specified.

16.21.5 Ultrasonic Testing

Wherever built up sections for crane runways girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing as per ASME, Sec-V, Article 5.

16.21.6 Acceptance Standard

The acceptable standards for weld inspection shall be as per ASME Sec VIII - Div I.

16.22 DIMENSIONS, WORKMANSHIP AND CLEANLINESS

All the fabricated embedded parts of Structural Steel members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment and surface finish are in accordance with the requirements shown on the approved Contractor's shop drawings and/or Engineer's drawings.'

16.22.1 The dimensions of the fit ups shall be maintained as specified in the fabrication drawings.

16.22.2 Raw material with cracks, seams, laps, lamination and heavy pitting are not acceptable. Ultrasonic testing of plates above 50 mm thick or as per the material specification shall be carried out for the soundness of material.

16.22.3 The cut edges of plates more than 25 mm for fillet weld, butt welds, and the plates used for tension flanges and webs -100 % MPT / DPT shall be carried out.

16.22.4 Welding shall be carried out as per approved WPS and QWS by qualified welders.

16.22.5 Macro etch test on welds shall be carried out 1 per structures for built up girders, columns and other heavy structures for penetration.

16.22.6 For 100% weld length, MPT / DPT on root & final pass for thickness equal to or greater than 25mm for butt welds.

16.22.7 For 100% weld length, RT shall be carried out for thickness equal to greater than 32 mm butt welds.

16.22.8 For 100% weld length RT for butt welds of rolled sections having a depth greater than 600 mm shall be carried out.

16.22.9 Minimum 10% of Fillet welds length, for either plate thickness is up to and inclusive 25 mm or fillet size is less than 10 mm (inclusive 10mm), root & final pass MPT /DPT shall be carried out.

16.22.10 On 100 % weld length, MPT/DPT shall be carried out on root & final pass, for either plate thickness greater than 25mm or fillet welds is more than 10 mm size.

16.22.11 Dimensions of all the assemblies and sub-assemblies shall be as per fabrication drawings within the tolerances specified in IS 7215.

16.22.12 For full penetration welds, DPT shall be carried out after back gouging before second side welding.100% MPT shall be carried out on low alloy steel, flame cut edges for thickness greater than 12mm.

16.22.13 Wherever built up sections for crane runways girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing as per ASME, Sec-V, Article 5,

16.22.14 The contractor shall maintain records of all inspection and tests, which shall be made freely available to the Engineer or his authorized representative and shall be submitted to the Engineer at completion of each stage of work.

16.22.15 The contractor shall ascertain that materials conforming to the requirements of this specification only are used.

16.22.16 The contractor shall check that the welding procedures (including the electrodes, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

No	Type of defect	Acceptance criteria	Remarks
1	Cracks	Not acceptable (NA)	
2	Incomplete or lack of fusion	Not acceptable (NA)	
3	Misalignment of butt welds	0.25 x T maximum of 3 mm	T: Thickness of thinner plate

4	Reinforcement	Max reinforcement of 2 mm for t < 10 mm 3 mm for t > 10mm < 15 mm. 4 mm for 15 mm and greater	
5	Undercut	0.25 mm deep max	
6	Sharp edges	Min radius of 2 mm	

16.22.17 **Inspection of Test Failure**

In the event of any failure of structural, steel members to meet inspection or test requirements, the Contractor shall notify the Engineer or his authorised representative. A Non Conformance Report (NCR) has to be made and got approved from the Engineer or his representative before repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by Engineer. Contractor shall maintain records of all inspection and testing which shall be made available to the Engineer or his authorized representative, for three years from the date of completion of the contract.

16.23 EMBEDDED PARTS

16.23.1 General

The details furnished below are in addition to general requirements of material supply, fabrication, inspection, testing etc specified in the earlier clauses of this specification. In general, reference shall be made to PC-E-160 for detailed specifications and requirements on Embedded Parts.

16.23.2 Material

Contractor shall supply/ use materials for fabrication as specified in the drawings. In the absence of material specification in the drawing, following guide lines are given.

Design	**Spec**	**Remarks**
Plates for pipe sleeves of wall thickness less than 20 mm	IS-2062Grade E-250, Quality –B0	
Flanges and plate EP's and threaded fasteners of 20 mm thk/ dia and more	IS-2062, Grade E-250, Quality – B0	
C.S Pipes up to 150 mm NB	1S-1239 Heavy Grade	
C.S. Pipes of sizes 200 mm NB and above	IS-3589 Grade FE 410	
Stainless Plates	ASTM-A-240 type 304L	IGC tested
Stainless pipes	ASTM-A-312 type 304L	Seamless or seam welded by automatic or manual

		process. Inspection as per specification.

Rolled sections and Bars

Rolled steel sections supplied by the Contractor shall be of following quality.

Rolled Section	:	IS 2062 E 250-Quality. A
Plates below 12mm	:	IS 2062 E 250-Quality. A
Plates above 12mm	:	IS 2062 E 250-Quality. B

16.23.3 Electrodes

All electrodes and welding wire shall be low hydrogen type conforming to ASME Sec II Part C. Brands approved by NPCIL shall only be used.

16.23.4 Material test certificate shall be in original.

16.23.5 Material supplied against these TC's should have identification stamped or stenciled on them which can be correlated with the TC's

16.23.6 All such identification markings shall be authenticated by the inspection agency which has inspected and approved the material.

16.23.7 The contractor shall furnish to the Engineer duplicate copies of all purchase order copies covering the material ordered by him for this project and also test reports.

16.23.8 The Engineer shall have the right to test random samples to prove authenticity of the test certificates produced by the Contractor.

16.23.9 Fabrication of EPs

Fabrication of EPs shall be done as per the relevant drawings and specification to avoid any possible damage to the threading on the anchor bolts before erection of the equipment, suitable protective plugs are inserted. In some cases, internally threaded sockets are embedded with top of the socket kept flush with the concrete face.

16.23.10 Welding

All welding procedures and welder performance qualification shall be carried out as per ASME Section IX supplemented by ASME Sec. VIII Div 1 / Div 2 or ASME Sec.-III as and when specified. The welding and other fabrication requirements shall be as per PC-E-160.

16.23.11 Inspections and Testing

All fabricated EP's shall be inspected as per approved QA plan. The inspection shall cover visual examination, MPT, LPT, RT and UT such that these EP's are free from burrs, cracks, nicks and surface irregularities as per previous clauses of this specification. . The DP and Radiography examination and Air Hold Test shall be carried out as per specification No. PC-E-160.

16.23.12 Air hold test / Vacuum box test

All pipe and sleeve EPs of safety systems meant for sustaining pressure or otherwise specified shall be tested for leak tightness. The test pressure/holding time shall be as per the approved Drawings. Air pressure/vacuum shall be held minimum for 10 minutes to detect leakage and pin holes.

16.23.13 Rectification

Any rework / rectification on the EP's required due to improper placement after concreting shall be carried out by the Contractor to the satisfaction of Engineer without any extra cost. This shall also include any additional inspection requirements as decided by Engineer.

16.24 PAINTING

16.24.1 Contractor shall follow the best method of surface preparation and painting system. In order to achieve the maximum durability, one or more of the following methods of surface preparation shall be followed, depending on condition of steel surface and as instructed by Engineer. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system:
Manual or hand tool cleaning
Mechanical or power tool cleaning
Blast cleaning.

16.24.2 Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. The minimum acceptable standards in case of manual or hand tool cleaning shall be St2 or equivalent, in case of mechanical or power tool cleaning it shall be St3 or equivalent, in case of blast cleaning it shall be Sa 2 ½ or equivalent as per Swedish Standard SIS-055900 / ISO-8501-1.Where highly corrosive condition exists, then the blast cleaning shall be Sa3 as per Swedish Standard. Prior to surface preparation all other contaminants, oil, grease etc. Blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceeding 85%. Engineers reserve the right to instruct the type of surface preparation depending upon the condition of material.

16.24.3 Irrespective of the method of surface preparation, the first coat of primer must be applied on dry surface immediately and in any case within 4 hours of cleaning of surface. However at times of unfavorable weather conditions, Engineer shall have the liberty to control time period, at his sole discretion and /or to insist on recleaning, as may be required, before primer application is taken up. In general during unfavorable weather conditions, blasting and painting shall be avoided as far as possible.

16.24.4 Surfaces shall not be coated in rain, wind or in environment where injurious airborne elements exist, when the steel surface temperature is below 5^0C and the humidity is greater than 85%.

16.24.5 To the maximum extent each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spot or areas missed in the application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet & dry film thickness.

16.24.6 Paint manufacturer’s instructions shall be followed strictly at all times. Particular attention shall be paid to the following.

16.24.7 Instructions for storage to avoid exposure as well as extremes of temperature.

16.24.8 Surface preparation prior to painting, Mixing and thinning, Application of paints and the recommended limit on time intervals between coats.

16.24.9 Painting shall be carried out preferably by spraying. Brushes may be used sparingly at certain locations only and the brushes used for painting shall be of a style and quality that will enable proper application of paint. Type of brush shall be chosen according to its application and there shall be a minimum of brush marks left in the applied paint. Engineer reserves to instruct type of application of paint.

16.24.10 Joints to be site welded shall have no shop paint for at least 50 mm from the welding zone. Similarly steel surfaces shall not panted in areas where connection is by use of friction grip bolts. On completion of joint the surfaces shall receive the painting as specified.

16.24.11 Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling. As such it is recommended that the primer and finish paint shall be from the same manufacturer.

16.24.12 Contractor shall furnish all the characteristics of paint material along with the test certificates. All paint material shall be of first quality.

16.24.13 All Structural steel surfaces except EPs shall be given the first coat of primer at shop and the second coat after it is erected in position. Further, any abraded surface of the first coat during transport from shop to site and during erection shall be provided with a touch-up coat of the primer. The field primer shall be compatible with the shop primer.

16.24.14 The surface of steelwork to be painted shall be thoroughly cleaned of all loose mill scale, rust, grease, dirt and other foreign matter by grit blasting to white metal in accordance with IS 1477 –Parts I & II./ Swedish Standard SIS 05-5900. At places where grit blasting is not feasible, one coat of suitable approved anti-corrosive paint shall be applied.

16.24.15 The paint treatment specified shall be applied soon after completion of pre-cleaning or pre–treatment in order to prevent contamination of the surfaces in any way, either by brushing or by spraying on the thoroughly cleaned and dry surface as desired by the Engineer. Airless spraying shall be carried out unless specified otherwise by the Engineer.

Sl. No.	Structure	Surface preparation	Primer	Finish coat
1	All steel structure	Clean off dirt, rust, weld spatter & loose mill scale by shot blasting	1 coat of epoxy based approved zinc silicate primer to a film thickness of 75 microns	Hi-build Epoxy paint conforming to relevant specifications to a DFT of 200 microns

SS members shall be painted with the peel able paint, which shall be removed at the time of passivation.

16.24.16 Acceptance Criteria

a) All painted surfaces shall be uniform & pleasing appearance.
b) All epoxy and enamel painted surfaces wherever finish paint is specified shall be of uniform texture and high glossy finish.
c) All storms, splashes & spatters of paints shall be removed.
d) Surfaces shall meet the minimum specified DFT for their respective systems.

16.25 SPECIFICATION FOR FABRICATION OF STAINLESS STEEL EMBEDDED PARTS

16.25.1 SCOPE

This specification covers the requirements for the supply fabrication, inspection, testing and transportation of stainless steel embedded parts.

16.25.2 SPECIFICATION

Mechanical Engineering Drawing Standards - IS 696 (latest)
Assessment of surface roughness - IS: 3073 (latest)
Liquid penetrant inspection of metallic surfaces – ASME SEC V.
Ultrasonic Inspection of Metallic Surfaces – ASME sec V
ASME Boiler and Pressure Vessel Code Section IX Welding (Qualifications)

16.25.3 a) MATERIAL AND WORKMANSHIP

Materials which are not specifically covered & which are necessary for fulfillment of this specification shall be procure by the contractor. He shall be responsible for the correct procurement and performance of these materials, & shall replace at no extra cost to NPC any material failing to meet the requirements of the drawings & specifications.

b) WELDING ELECTRODES

Use of S.S. 308L or S.S.347 electrodes for welding SS 304L is recommended. Electrodes used on the work are to be approved by the Purchaser.

c) WORKMANSHIP

Workmanship shall be in accordance with high standards and adequate, to achieve accuracies and surface finish as shown on the approved drawings and this specification is to ensure satisfactory operation and service life of the liners.

16.25.4 WELDING

Weld shall be made by the weld procedure and welders qualified by tests in accordance with IS: 817 & 1181 and ASME Section IX as specified by the Purchaser. Welding procedure shall be prepared by the Contractor and submitted to the Purchaser for approval before the start of welding.

16.25.5 a) INSPECTION OF WELDS

All services and facilities related to testing and inspection to be provided by the Contractor. The inspection work shall be under the control of a competent Chief Inspector whose primary responsibility is Inspection and reporting to Management. Inspection by NPC or their authorised representative shall not relieve the Contractor of any of the inspection duties called for herein.

All welds including fillet welds shall be subjected to Liquid Penetrant Test.

b) OTHER INSPECTION

The Contractor shall conduct 100% inspection & maintain record for all components and final grids system in accordance with the Approved drawings & Specification. This shall include inspection of the following:

Dimensional accuracy, surface finish, hardness, fit and alignment, workmanship, cleanliness and lubrication, completeness.

16.25.6 TRANSPORTATION

After completion of segmented fabricated line grid, it shall be thoroughly cleaned, protected from dirt, corrosion and damage and suitably braced and packed for transportation**.**

16.26 QUALITY SURVEILLANCE FOR STRUCTURAL STEEL & EPS

16.26.1 General

The Engineer shall subject all works and materials covered by this specification to inspection.

The Contractor shall provide free access in his shop during working hours for the inspection staff, designated by the Engineer, at all phases of the work and assist them where necessary in conducting the inspection. The Contractor shall expeditiously furnish all gauges, instruments and other necessary measuring equipment required for inspection of the work in the shop. The shop inspection by the inspector is intended to ensure that the material and workmanship are in accordance with this specification, but it will be not relieve the Contractor of any of his responsibilities for the product. The inspector’s inspection will include, but not

be limited to, the following:

16.26.2 Material

The inspector will ascertain that only materials conforming to the requirements of this specification are used.

16.26.3 Dimension and Tolerances

The Engineer will ensure and check that the structural members conform to the dimensions and tolerances as set out on the drawings and as required by the specification.

16.26.4 Welding Procedure

The Engineer will witness the welding and testing of any procedure qualification tests that are required by this specification. The Engineer will also check that welding procedure (including the electrode, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

16.26.5 Welding Equipment

The Engineer will check the welding equipment to be used for the work to ensure that it is in such condition as to enable qualified welders to follow the procedures.

16.26.6 Welder & Welding Operator Qualifications

The Engineer will permit welding to be performed only by welders and welding operators who are qualified by tests in accordance with ASME – Section IX.

When the quality of a welder or welding operators' work, appears to be below the requirements, the Engineer may require testing of his qualifications by necessary tests.

16.26.7 Welds

The Engineer will ascertain that the sizes, length and the location of all welds conform to the requirements of this specification and the approved fabrication drawings. Temporary welds used for the works shall be removed and ground flush with the original surface.

The Engineer will identify with a distinguishing mark of all parts of the joints that has been inspected and accepted.

The Contractor shall comply with all the demands of the Engineer to correct improper workmanship and to remove and replace, or correct as instructed, all welds found defective or deficient.

In the event of faulty welding or its removal for rewelding results in damage to the base metal in the judgement of the Engineer, or its retention is not in accordance with the intent of the plans and specification, the Contractor shall remove and replace the damaged materials at his own cost.

17 FIRE PROOFING OF STRUCTURAL STEEL MEMBERS USING INTUMESCENT PAINTING

17.0 SCOPE

This specification covers the requirements in general that needs to be followed for thin Intumescent Coatings used as Passive Fire Protection measure on Steel Structures of defined fire ratings, wherever applicable. The specification in general covers the requirements for selection of coating, testing, application & quality control measures which shall be followed to use the Thin Intumescent Coatings. Wherever Intumescent Paint is proposed to be used in radiation area, the adequacy of same shall be established prior to its use.

17.1 INTUMESCENT COATING SYSTEM

The system shall comprise the 3 layers i.e primer, basecoat and seal top or decorative coat. The Primer & Seal/Top coat shall be compatible with base coat. The product proposed for use shall be manufactured by a reputed & experienced company having In-house R&D & fire test facility, unless approved otherwise.

The Coating shall be certified from reputed agencies like UL (USA) & Warrington (UK) etc. The certifying agency shall be well recognized and acceptable to NPCIL.

Unless approved otherwise, the Primer, Intumescent base coat , seal coat or decorative top coat should be sourced from the same manufacturer, to assure their compatibility.

The coating system should be such, where recoating of the coating shall be feasible if required, with approved top / seal coat for asthetic reason. It shall also be feasible to repair the same as per approved procedure from Manufacturer in case of damage to Intumescent coating.

17.1.1 PRIMER

A protective coating, usually anti-corrosive, is applied to the substrate prior to application of the basecoat. It shall also provide adequate adhesion to base coat in case of fire.

For site applied Intumescent coatings, the primer is the only part of the total system that would normally be applied in shop and balance base coat & Seal Coats are applied a site.

17.1.1.1 PRIMER SELECTION

The choice and thickness of primer shall depend on

- the In-service environment, which affect the degree of anti-corrosive protection required.
- where the primer is to be applied, and subsequent Intumescent basecoat application requires a significant delay between steel preparation in shop and final erection and completion of coating at site, the primer needs to have suitable weathering properties and durability, it must be suitable for over-coating with the intumescent coating after the appropriate time interval, and it should be sufficiently tough to be transported with minimum mechanical damage. In such cases the primer may be applied in 2 stages, if recommended, by coating manufacturer.
- the primers having poor heat resistance, and likely to have a detrimental effect on the performance of the intumescent in a fire shall not be used.
- primers based on weaker solvents than the (solvent based) intumescent, may exhibit defects such as rivelling and/or wrinkling when over-coated, and therefore shall be avoided.
- the primer shall be compatible with base coat and generally manufactured by same manufacturer, In case primer from different producer, if used with prior approval, before application of the Intumescent basecoat, the confirmation from the Intumescent manufacturer shall be obtained in writing, such that the primer and Intumescent basecoat are compatible in both ambient and fire conditions. In such case the technical data sheet for the primer, the actual primer thickness and information regarding the length of time the primer has been applied should be shared with base coat material supplier, who should then be able either to give approval for use of the primer, or to provide alternative advice.

17.1.1.1.1 COMPATIBILITY OF INTUMESCENT COATINGS WITH ZINC RICH PRIMERS

Wherever Zinc rich primers, are used to avoid problems of inter-coat adhesion. It is essential that the zinc salts, if exist due to prolonged exposure prior to application of base coat, are completely removed by washing down with clean fresh water. Where full removal of zinc salts cannot be guaranteed, the option to remove the zinc coating and re-prime the steelwork shall be followed.

Formation of Zinc salts can be prevented by applying a tie-coat over the primer at the fabrication stage. The Intumescent coating can then be applied to the tie-coat.

The application of water based intumescent coatings(if approved to use) directly over zinc rich primers is not recommended.

In all cases, the intumescent coating manufacturer should be consulted to confirm the compatibility of the priming system with the intumescent system and, where applicable, the tie coat.

17.1.1.1.2 COMPATIBILITY OF INTUMESCENT COATINGS WITH EXISTING PAINT LAYERS

Steelwork requiring refurbishment will usually be treated with an existing coating system. The existing paint coatings are likely to be old and their adhesion to the substrate, or between layers of the system, may be poor.

In such cases earlier coating shall be completely removed and the application of a primer/primer system compatible with the new Intumescent system shall be applied. The old paint shall be preferably blast cleaned to Sa 2½ standard as defined in BS EN ISO 8501-1. The blasted surface provides a suitable base for the application of the new priming system.

In situations where site conditions may make abrasive blast cleaning impractical or unacceptable, the use of manual cleaning methods may be considered. Impact tools such as chipping hammers, needle guns are reasonably effective in removing old paint coatings . Power rotary wire brushes may also be used to remove the existing paint, where a compatible surface tolerant primer is used. When using power tools care should be taken to avoid polishing the surface, and to achieve an acceptable profile or anchor pattern.

The Intumescent system manufacturer should be consulted to provide advice about surface preparation standard, with appropriate supporting evidence.

Where a manufacturer wishes to demonstrate that compliance can be achieved by the application of an Intumescent system over existing painted surfaces of known generic type and thickness, fire test evidence should be available to provide a technical justification. Agreement should be reached with NPCIL about the applicability of the test data to the circumstances which prevail on the specific site.

17.1.2 BASE COAT

The base coat shall be Solvent based Intumescent Coating of approved Dry Film Thickness, unless approved otherwise.

The Intumescent coating (Base Coat) shall be fit for use for given "In service environment exposure condition". The coatings proposed to be used in exterior condition shall be specifically certified for its suitability for exterior use. Wherever, coatings of interior members needs to be left exposed, while erection for a reasonable period of time prior to completion of enclosure, the same shall be adequately protected with suitable seal coat to avoid any damage to base coat from moisture etc.

Wherever unusual conditions given below are likely to arise, the advice of the coating manufacturer about suitability of coating, should be sought:

- If environment change in the foreseeable future.
- If some form of local pollution present. For example, high levels of sulphur dioxide could produce acidic conditions and this in turn may influence the type of seal coat required.

- If conditions vary within the building. For example, roof spaces (of an air conditioned building) subjected to periodic condensation.
- If some elements of the construction particularly vulnerable to impact damage.
- If any unusual processes likely to cause localised special conditions, such as splashing, water pooling, localised high temperatures etc.

17.1.3 SEAL COAT OR TOP COAT

A Polyurethane coating of specified thickness shall be applied over the basecoat to prevent the basecoat from environmental degradation and abrasive damage as seal coat.

17.1.4 FIRE TESTING OF COATING

Fire protection systems for steel structures are tested for their ability to retard the rate at which the steelwork heats up in a fire.

If desired by NPCIL, the coating system (Inclusive of all 3 coats, as proposed to be used) shall be independently evaluated by performing the fire testing in independent approved laboratory, before acceptance of product. The number of test samples shall be decided based on variability of coating thickness proposed to be used in the project and with mutual consent of NPCIL & Contractor. Generally, for a given fire rating and coating thickness the member having highest Hp/ A (Heated Perimeter/ Cross-sectional Area) shall be most critical and selected for testing. The cost of testing upto 2 samples are deemed to be included in the coated rate . In case if it is decided to test more than 2 samples, the cost of such additional tests (Beyond 2 Samples) including materials & labour shall be reimbursable to the contractor on actual expenditure, If the product is successfully tested and qualified. However, in case of failure of coating on testing, the cost of testing shall be compulsorily borne by the contractor.

17.2 FIRE RATING

It is defined as the ability of an element of building construction/ component for structure to fulfill, for a stated period of time, the required stability, fire integrity and or thermal insulation and/ or other expected duty in a standard fire resistance test.
The fire resistance requirement for a building is defined in terms of the fire resistance period and stated in terms of minutes (15, 30, 45, 60, 75, 90 or 120 minutes) based on standard time temperature curve as per ISO 834 / IS 3809.
The fire rating of the members shall be derived, based on relevant codal provisions or from Fire Hazard Analysis. The fire rating for each member shall be as specified and approved by NPCIL.
Wherever specified, the ability of a component or material to achieve the required fire resistance period is demonstrated by subjecting it to a standard fire test as defined in BS 476-20 /21 or BS EN 1363-1 or ASTM E119 as approved from NPCIL.

In case of Intumescent Coating the adequacy of the system under test, shall be decided based on the fulfillment of requirement, that the substrate temperature does exceed the critical temperature when heated for rated duration as per standard time temperature curve given in IS 3809.

17.3 CRITICAL TEMPERATURE

Unless specified otherwise, the critical temperature for member with 4 side exposure & 3 side exposure shall be 550 deg C and 620 deg C respectively.

17.4 FILM THICKNESS OF INTUMESCENT SYSTEMS

Primer, Base Coat and seal coat / decorative top coat thicknesses shall be as specified and approved by NPCIL.

Unless specified otherwise, the thickness of primer & seal coat shall not vary with size of member, for a given fire rating. However, the thickness of base coat may vary as per its Section Factor, fire rating, critical temperature & exposure condition etc.

17.4.1 PRIMER FILM THICKNESS

The thickness of primer shall be as specified and approved by NPCIL. In no case, the primer thickness shall exceed the upper limit, if any, specified by the coating certifiying agency or by the coating manufacturer, above which the performance of the intumescent may be impaired in a fire situation.

Wherever, steelwork delivered to site is treated with a primer applied elsewhere in shop, the compatibility of the primer applied shall be ensured with Intumesecent coating by the coating manufacturer. The correct thickness of the primer applied in shop shall be properly documented and informed to Base coat applicator, to work out the thickness of base coat from combined thickness measured after application of base coat. In case, such records are not available, the site applicator must conduct a primer thickness survey prior to commencement of intumescent application to the satisfaction of NPCIL.

17.4.2 BASE COAT THICKNESS

Unless specified otherwise, the DFT of base coat shall be derived based on charts of proposed coating material, certified from the reputed agencies like UL (Under Writer Laboratories, USA) & Warrington, UK etc. The base coat thickness shall be derived based on critical temperature of the member, its desired fire rating, its section factor , no of sides exposed to fire etc. using above certified charts. The correct film thickness must be determined for each section, in order to produce a list of section sizes with their associated film thicknesses for the entire project.

The contractor shall prepare a painting schedule of primer, intumescent coating & seal coat thicknesses required to provide fire protection to each of the steel sections to achieve the specified fire resistance periods. This schedule shall be submitted to the NPCIL for review and approval, prior to commencing the works. The schedule must include, but not be limited to, the following.

(i) Fire resistance period(s) required.
(ii) Steelwork references as noted on general drawings.
(iii) Steelwork section sizes and section factors.
(iv) Details of any partial fire protection, if provided by concrete floor slabs etc.
(v) Name of intumescent product(s) specified / selected.
(vi) Method used to determine required coating thicknesses.

The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

17.4.3 SEAL COAT FILM THICKNESS

The coat thickness shall be as specified and approved by NPCIL.

17.4.4 PAINT THICKNESS ON BOLT HEADS AND STEEL TO STEEL CONNECTIONS

Where structural steelwork is treated with intumescent in shop and erected in finished condition, special provision has to be made for the coating on site of bolt heads and other surfaces not previously fire protected. As per recommendations of BS 5950 Part 8, the protection coating thickness on bolt heads and connections should be the same as that on adjacent steel sections.

Where the coating operation is delayed for any reason or where the bolts/ connections are made of a special material proper cleaning prior to coating shall be carried out. In such case a special adhesion primer may be required before application of the intumescent in consultation with coating manufacturer and approval of NPCIL.

17.4.5 FILM THICKNESS DETERMINATION

The correct thickness of intumescent coating system applied on the members shall be confirmed before proceeding to application of the decorative topcoat, as any deficiency in intumescent thickness can be best corrected at this stage.

The average DFT of the primer coat shall be properly recorded and verified in the shop. If same is not available it shall be measured physically at site. prior to application of Base Coat. After application of the intumescent basecoat, the average primer thickness should be subtracted from measurements taken on the basecoat, to establish the true intumescent thickness.

The thickness of topcoat must be confirmed in the same way as for the intumescent basecoat above.

Where decorative appearance is important and requires additional coats of finish, or where additional topcoat thickness is required to protect from severe environmental

conditions, the intumescent manufacturer should be consulted to confirm that the additional thickness will not inhibit the fire resistance of the system.

17.5 IN-SERVICE ENVIRONMENT

The nature of the environment to which the coatings will be exposed may affect their durability or their performance in a fire situation, and must therefore have a major influence on the properties required of them. Environment may have a significant bearing not only on the choice of intumescent basecoat, but also on the type and thickness of anticorrosive primer and on the type and thickness of seal coat.
For steel protection generally, BS EN ISO12944-2:1998(7) defines a number of environments in terms of 'corrosivity', based on relative corrosion rates of carbon steel, as follows:
Category C1 Very low
Category C2 Low
Category C3 Medium
Category C4 High
Category C5-I Very high (Industrial)
Category C5-M Very high (Marine)

ISO 12944 relates these categories to the composition and thickness of different protective coating systems required to provide short, medium or long term protection against corrosion, but only categories C1 and C2 would be considered typical of most thin film applications.

Examples of typical environments for each category are given in Table 17.1 below.

For C1 environments (the most common for fire protection) corrosion protection may not be strictly necessary but for site-applied intumescent coatings an anticorrosive primer may still be specified to provide temporary protection .

For all other environment categories some degree of corrosion protection would normally be included, but the specifier must also consider the type and thickness of seal coat that may be necessary to prevent degradation of the intumescent by moisture from humid atmospheres, condensation etc.

TABLE 17.1: CLASSIFICATION OF ENVIRONMENT TYPES

Corrosivity Category	Corrosion/ Exposure Rating	Examples of typical environments in a temperate climate (information only)	
		Exterior	Interior
C1	Very low	N/A	Inside heated or air-conditioned buildings with clean atmospheres. Low relative humidity and no likelihood of damp or condensation e.g. offices, schools, shops, hotels.
C2	Low	Atmospheres with low level of pollution and fairly dry climate. Mostly rural areas. Intumescent use mainly in sheltered locations e.g. under canopies.	Occasional damp or wet conditions. Unheated buildings where water leakage or condensation may occur, e.g. unheated warehousing, sports halls, plant rooms etc and in roof voids.
C3	Medium	Urban and industrial atmospheres, moderate sulphur dioxide pollution. Coastal areas with low salinity. Examples would include exposed car parks.	Constant damp atmosphere, but may be warm and well ventilated. Production rooms with high humidity and some air pollution, e.g. food processing plants, kitchens, laundries, breweries, dairies.
C4	High	Industrial areas with high sulphur dioxide pollution and coastal areas with moderate salinity. Typical areas include tank farms, petrochemical installations etc or exposed exterior surfaces of any structure in a polluted environment.	Interior of chemical plants subject to continual injection of chemical vapours or steam in the atmosphere. Constant warm and high humidity conditions such as in swimming pools. Coastal ship and boat yards.
C5-I	Very high	Industrial areas with high humidity and aggressive atmosphere. Thin film intumescents should only be used with manufacturer advice.	N/A
C5-M	Very high	Coastal and offshore areas with high salinity. Thin film intumescents should only be used with manufacturer advice.	N/A

17.6 STORAGE

The storage of all material(s) should be strctly in accordance with the manufacturer's recommendations . As a general guide, the storage temperature for all material(s) will be within the range of 5 -30°C, and any water based materials in particular should always be protected from frost. Material containers should remain unopened until needed and should be used in date order (FIFO).

All materials delivered to site must be used within the manufacturer's stated shelf life, or otherwise be approved in writing by NPCIL, if declared suitable for use by the original manufacturer.

17.7 APPLICATION OF COATING SYSTEM

17.7.1 PREREQUISITES

Application must not proceed, if the prevailing environmental conditions are outside the limits set out in the manufacturer's technical data sheets.

As a general rule, environmental conditions – air and steel temperatures, humidity and dew point – should be determined before commencement of work in the morning, afternoon and evening (if appropriate), and at other times if conditions show a noticeable change (e.g. if it starts raining). All measurements should be logged and be available for inspection at all times.

Prior to site application, all surfaces to be coated should be in a clean, dry condition and any areas not requiring fire protection or which may be exposed to overspray should be appropriately protected by masking.

The applicator should ensure that all equipment required to carry out the surface preparation and application of all components of the intumescent coating system, according to technical specification, are available and in good working order.

The applicator must ensure that all relevant Health and Safety data sheets, application instructions and method statements are available and are fully understood.

Where required, mixing should be carried out in accordance with the manufacturers' instructions. Materials taken from store should attain the temperature recommended for use before being applied.

The scheduling of the works should be such that sufficient areas are made available, allowing free access for the applicator of the intumescent coating system to apply the material to the required specification.

All work should be scheduled to ensure that the conditions required by the manufacturer (temperatures and humidity, over-coating times etc) can be met.

It is particularly important that where application is to be carried out in a partially clad building (i.e. not theoretically open to the elements), the contractor ensures that the building is water-tight and that areas where coatings are to be applied are not directly exposed to external weather conditions at any time.

17.7.2 MONITORING OF ENVIRONMENT CONDITIONS

No application should take place on site when environmental conditions – air and steel temperatures, relative humidity, dew point – are outside the limits laid down by the coating supplier, to avoid any detrimental effects on both film formation and integrity of the coating (especially water based systems) as well as on long term performance.

Typically, steel temperatures should be more than 30 C above the dew point to ensure that no (visible or invisible) moisture or condensation is present on the surface during application.

The applicator's shall monitor these conditions in accordance with the specification, and to maintain auditable records to demonstrate compliance.

17.7.3 SURFACE PREPARATION

Steel surfaces should be prepared by removing scale and rust using abrasive shot blasting to a minimum standard of Sa2½ as defined in BS EN ISO 8501-1: 2001 "Preparation of steel substrates before application of paints and related products"

Prior to the commencement of blast cleaning all steel surfaces should be clean and dry. Oil and grease contaminants, if present, should be removed by the use of suitable emulsifying degreasers, suitable clean organic solvents or steam cleaning before the commencement of blasting.

A surface profile shall be within the range of 35 – 75 micron in general suiting to primer and as specified by the Coating Supplier and shall not exceed 100 microns.

All dust and spent abrasive must be removed from the prepared steelwork by blowing down with clean dry compressed air.

17.7.4 APPLICATION OF PRIMER

The primer of specified thickness should be applied before the blast cleaned surface deteriorates.

Where the steel sections are (more normally) blasted and primed in shop, the same surface preparation standards as above would be specified, but after transportation and site storage further measures need to be included to ensure cleanliness of the primer prior to over-coating with the Intumescent basecoat. In such case the primer may be applied in 2 stages, if recommended, by coating manufacturer. The first stage primer shall be applied in shop to protect the shot blasted surface till final painting, and second coat of primer shall be applied prior to application of

Intumescent Coating in consultation with coating manufacturer. The necessary surface preparation at each stage shall be carried out in line with coating manufacturer recommendations. The next stage of coat shall be applied after minimum curing time of previous coat and shall also be completed before the end date if specified by the coating manufacture.

The coating manufacturer shall ensure and certify that the primer & process followed in such a way shall not adversely affect the performance of the coating.

The primer should be applied to the specified dry film thickness and the thickness measured in accordance with the approved procedure.

When thicknesses are found to be outside the specification, the advice of the designer and/or primer and intumescent coating manufacturer should be sought and remedial action carried out as necessary.

Because different structural steel sections may require different intumescent basecoat thicknesses, it is important to ensure that all sections are correctly marked or otherwise identified for application and record purposes. Marking is best carried out after completion of priming and should not interfere with the application or operation of the intumescent coating system.

Where unprotected elements meet fire protected elements in a structure, it is normally considered good practice to overlap the fire protection onto the adjoining 500mm of ‘unprotected’ structural steel to limit heat transfer into the protected substrate.

17.8 QUALIFICATION OF APPLICATOR

The fire performance of a product, component or structure is dependent on satisfactory site application and maintenance. Competence in application requires an understanding of the importance of such factors as surface preparation, data sheet limitations for conditions during applications, achievement of film thickness etc. Such competence is important for any coating operation, but for intumescent paints the potential consequences of coating failure make the standard and control of application quality even more critical. Therefore, these coating shall be applied by experienced persons who know and understand not only the practicalities of coating application, but also the importance of attention to detail in the installation process. The applicator shall be certified by the Intumescent Coating Manufacturer, which shall provide confidence in the appropriate standard of workmanship being provided.

17.9 APPLICATION METHODS

The application of all coatings should be carried out fully in accordance with manufacturers’ technical data sheet requirements and the applicator’s method statement approved by NPCIL. These in turn must reflect fire test and assessment conditions.

While airless spray is generally the preferred method of application for most coatings, the use of this method on site may be restricted, in such cases either provision to protect adjacent buildings and the surrounding environment from

overspray shall be made, or brush/ roller application may be followed if permitted as per coating manufacturer recommendations.

Where spray is not possible, a larger number of coats by brush or roller may be required, and minimum and maximum over- coating times must be observed. In such case he recommended thicknesses provided on manufacturer's data sheets, along with the maximum achievable thickness per coat by the different methods may be used as basis of application.

17.10 THINNING AND EQUIPMENT CLEANING

Thinning of Intumescent product may be permissible to aid application characteristics with prior approval of NPCIL, particularly where ambient temperatures affect product viscosity and make a good quality finish difficult to achieve. However, excessive thinning can create sagging, drying and film formation problems, particularly where high film thicknesses are involved, so all thinning is subject to approval by the manufacturer in writing. Only thinners approved by the manufacturer may be used, if approved.

Wherever, solvent is used for equipment cleaning, the same should be approved by the coating manufacturer as being compatible with the coating system, as incompatible gun-washes left in equipment overnight can give rise to film formation defects if mixed in with the coating.

It should be noted that thinning with solvent will invalidate the wet to dry ratio given on the product data sheet and may significantly affect the VOC (Volatile Organic Compound) content of the coating, and hence its use should be limited so that it does not adversely affect compliance with environmental legislation and does not causes any health hazard to the applicator and surroundings.

17.11 HANDLING, TRANSPORTATION AND STORAGE OF SHOP-PRIMED STEELWORK

The primers used for the shop priming of structural steelwork shall be fairly tough ,resilient, and shall be resistant to mechanical damage . Further, the contractor is required to implement protective measures and appropriate care during the transport, storage and erection of steel structures.

Coatings should be sufficiently dry before handling and members should be lifted at designated lifting points or by using lifting brackets where available. The use of lifting chains in contact with coated steel is preferred to strops/webbing slings as the former cause only minimal damage that is normally easy to rectify. Member shall be preferable lifted in single lift.

The loading of trailers should be carefully planned, with timber supports positioned, where possible, in uncoated contact areas (e.g. areas to receive bolted connections). Where contact of supports with coated areas is unavoidable, members should be supported on their toes to minimise the contact area. Where thin-film prefabrication primer only has been applied in shop, members which may fill with water should be

prevented from doing so by the use of covers to avoid premature breakdown under immersion. Loads are best secured with the careful use of clean chains and it is advised that the loaders wear overshoes and where possible avoid walking on coated surfaces in order to minimise contamination.

Where site storage is unavoidable, similar care should be taken in the handling and support of the coated steel using the same lifting and support points as those used in transportation. Where possible members should not be stacked and water ponding should again be avoided using localised protection where necessary. The contractor should be made fully aware of the importance of good handling practice and storage areas should be roped off with signage clearly explaining the need to avoid contamination and mechanical damage to the coating finishes.

Similar care should be taken during the erection phase, with any lifting activities making use of strategically positioned holes, lifting lugs and brackets etc to minimise damage to the body of the paintwork.

17.12 TREATMENT OF SHOP-PRIMED STEELWORK AT SITE

17.12.1 REPAIR OF TRANSIT DAMAGE

Despite the contractor's efforts to be careful, some damage to the coating will inevitably occur during handling and transportation. Further damage may occur as a result of site modifications, welding etc prior to the application of the intumescent basecoat.

The nature and extent of primer repair required will vary, dependent on

- The scale of damage incurred.
- The degree of deterioration of the damaged surface.
- The type of exposure – i.e. the service environment and the importance of the primer in providing long-term anticorrosive protection.

Even where damage to the primer is extensive, provided that the exposed steel surface has not badly corroded it may be sufficient to re-prepare the surface to an acceptable standard prior to application of the intumescent basecoat overall i.e. without reinstating the primer. This might be acceptable, for example, where conditions during application are acceptable and subsequent exposure is to an environment of corrosivity category C1, provided the intumescent coating manufacturer agrees.

17.12.2 Repair of weld damage area

In cases where on-site welding, cutting or grinding has been necessary, all affected areas must be re- prepared to a standard agreed with the intumescent manufacturer, and cleaned down to remove any resultant contamination.

In general, site welding would be carried out prior to application of the intumescent basecoat, and the welds and heat-damaged areas then re-prepared by suitable mechanical means such as power discing and/or grinding prior to reinstatement of the

primer. Where welding is carried out after application of the intumescent basecoat, any heat-damaged coating should be cut back to a sound coating (distance) prior to re-preparation and reinstatement of all coats in the area of repair.

Where subsequent service is to be in an environment subject to damp or wet conditions – e.g. humid buildings without air conditioning, swimming pools etc – the anticorrosive coating may be important to the long term performance of the system and a good standard of surface preparation and reinstatement of the full anticorrosive primer thickness may be necessary. In all cases, the advice of the intumescent manufacturer should be followed.

17.12.3 Contaminated and corroded primer

Where a thin coat of primer is specified to provide protection of the blast cleaned steel during the transport and erection stages only, any delays in the build programme may result in some breakdown of the coating and consequent corrosion (rust rashing) of any exposed steelwork. In such cases if decided by the Engineer, re-preparation shall carried out by the contractor. Depending on the extent of corrosion and the nature of the intended service environment, the decision may range from no re-preparation to manual re-preparation of affected areas followed by immediate application of the intumescent basecoat overall, or manual preparation to BS EN ISO 8501-1 St3 standard, followed by re-application of primer prior to completion of intumescent coating. Wherever, the primer forms a functional part of the long term protective system and to be used under severe exposure environment re-preparation at site shall be required.

Where the primer is in good condition but in a contaminated state, it be cleaned using suitable methods such as washing using detergent and/or fresh water pressure washing and allowed to dry before application of the intumescent basecoat. The decision of NPCIL in this regard shall be final.

17.13 SEALING OF INACCESSIBLE AREAS

If some gaps are present in structures, where moisture ingress may occur and if not sealed may cause problems such as blistering or degradation of the intumescent coating after application. Such areas need to be sealed prior to application of the intumescent basecoat, with a moisture resistant intumescent mastic or equivalent, prior to the application of intumescent basecoat.

Areas like interface between the top flange and concrete decking, may allow moisture to penetrate and this will take a long time to dry out, even if environmental conditions are satisfactory for paint application.

17.14 REPAIR PROCEDURE

During the application process and after completion of the work, repairs may be necessary to ensure that the standard of fire protection, surface integrity and finish is in accordance with the original specification. The cause of the damage or degradation should be addressed prior to carrying out the repairs, to avoid any repetition.

Before carrying out on-site remedial works, a written Method Statement for repair procedures shall be prepared by the contractor and submitted to the NPCIL for review and approval.

The contractor shall be responsible for identifying all areas requiring remedial works and for rectification in accordance with the coating manufacturer's recommendations. Issues such as compatibility, effectiveness and adhesion of combined thicknesses etc shall be considered while taking the decision.

In case, where the intumescent coating has detached due to mechanical damage, or suffered localised degradation due to water ingress, the normal repair procedure of mechanical removal of the damaged or denatured coating to a firm (unaffected) edge, followed by reinstatement of the system to the original, specified thickness shall be followed.

17.14.1Repair of film thickness deficiencies

If the dry film thickness of the intumescent basecoat or topcoat, does not comply with the nominal dry film thickness stated in the schedule of thickness, work shall be undertaken to bring the affected area up to the required thickness.

Where a decorative finish has been specified, the contractor shall make provision for the removal of all visible dirt from the surface of the coating, following erection of the steelwork.

17.14.2 Repair of damage to completed Intumescent coating systems

Remedial work on complete fire protection systems will depend on both the extent of the damage and whether or not a seal coat was applied to the original coating.

Minor damage, such as chips and scrapes, will not normally affect the performance of the material unless the service environment is wet or exposed, in such case damage may allow moisture ingress and lead to degradation of the intumescent. It is therefore recommended that minor damage should be repaired with the approval of NPCIL at the earliest opportunity, following the procedure given below:

a) In cases of damage to the basecoat, the damaged area should be cut back to a firm edge. If the primer coat is damaged, any corrosion products which may have formed should be removed and the steelwork "patch primed" using a suitable compatible primer.

b) If only the basecoat is damaged, fresh basecoat or approved repair material should be applied to match the existing thickness, taking care not to excessively overlap onto the surrounding intact seal. When the dried intumescent material matches the surrounding thickness, the recommended seal coat (if any) should be applied either to the patch repair or overall.

c) If only the seal coat is damaged, fresh seal coat should be applied, either to the localised area, or over the whole section.

In the unlikely event that major repairs are required (i.e. due to water or chemical attack), the intumescent coating manufacturer should be consulted for expert advice and repair shall be carried out as per approval of NPCIL.

17.15 HEALTH AND SAFETY PROVISIONS

Products used on site shall comply with the recommendations of manufacturers' health and safety data sheets, and that the safety of all personnel in the vicinity of the application is protected. During and throughout the application process, full compliance with all relevant Health and Safety and Environmental legislation must be demonstrated. As a minimum this includes

- Observance of all precautions and conditions for use of the coating system, as defined in the manufacturer's Product Safety Data Sheets.
- Compliance with relevant Site Storage Regulations.
- Compliance with all applicable relevant Waste Disposal Regulations, in particular for the Hazardous Waste.

17.16 DESIGN LIFE AND LIFE TO FIRST MAINTENANCE

In general the intumescent systems along with seal coat should not require maintenance before 15 years, other than for decorative purposes or where mechanical damage has occurred and shall be guaranteed for same. The thickness of the seal coat shall be decided according to above requirements.

The Coating shall be regularly and frequently inspected of the condition of the fire protection. A schedule of regular maintenance shall be prepared in service. Wherever, there is any doubt about the capability of a thin film intumescent system to provide the required long term durability, a thick film system may be advised.

17.17 QUALITY PLAN, INSPECTION CRITERIA AND METHODOLOGY

17.17.1 QUALITY PLAN

Competent contractors and applicators shall have in-house systems in place to control site work and to demonstrate compliance with specification requirements. The quality plan shall cover the sequence of activities required to deliver the specified quality of finish. This plan shall also identify the inspection stages and hold point in the process, and shall be submitted to NPCIL for approval prior to commencement of the work.

17.17.2 Measuring Equipment

The following fully calibrated and certificated measurement equipment to be available on site

- Where steel surface preparation is to be carried out at site, pictorial standards for blast cleaning and for manual / mechanical surface preparation as supplied with EN ISO 8501-1:1988 should be available to ensure the correct standard is being achieved.
- Comparator plates or Testex tape and micrometer are required to determine the blast profile, where relevant. EN ISO 8503-1:1988 and EN ISO 8503-5:2004 apply.
- Ambient temperature thermometer.

- Minimum – maximum thermometer.
- Steel temperature gauge, preferably electronic.
- Whirling hygrometer, together with a relative humidity and dew point calculator as included in EN ISO 8502-4:1999, or electronic equivalent.
- Instruments which provide ambient and substrate temperatures, relative humidity and dew point calculations automatically.
- Tape measure to check steel section sizes, if necessary.
- Wet film thickness gauges.
- Dry film thickness gauges having a measurement range appropriate to the specified dry film thickness. Ideally the instruments used should have the capability to record thickness readings in batches, and it would aid the completeness of records if the readings were also downloadable to computer.

17.17.3 Site inspection criteria

Typically, the inspection criteria shall include the following

1. Surface preparation

- Surface preparation standard – as specified, usually against EN ISO 8501-1 or equivalent
- Surface profile minimum and maximum – as specified (EN ISO 8503-2) or equivalent
- Dust or other contamination – visual or EN ISO 8502-3

2. Application

- Air temperature, substrate temperature, relative humidity and dew point (throughout the application process) – as specified or as manufacturer's data sheet.
- Batch numbers of all products used
- Dates and times of application and compliance with recommended over-coating times from manufacturer's data sheets
- Wet film thickness checks

3. Dry film checks

- Dry film thickness survey and records
  (i) at primer stage
  (ii) after application of intumescent basecoat and
  (iii) on completion of coating

  Thicknesses at each stage should be in accordance with the specification.
- Visual appearance – as specified or in accordance with agreed standard.

  NB: Dry film thicknesses should always be checked against the approved film thickness schedule, which defines the required thickness for each individual steel

member. Drawings or tables showing the correct thickness for each member must therefore be available to the inspector (contractor's QA representative or NPCIL representatives) prior to a dry film thickness survey.

17.18 INSPECTION METHODOLOGY

17.18.1 WET FILM THICKNESS

Wet film thickness measurements should be taken during application using a wet film gauge. These readings will provide a guide for the applicator to ensure that the required dry film thickness of the primer/basecoat/seal coat will be achieved. Wet film thickness measurements indicate the thickness of an individual coat. Care should be taken when applying subsequent coats, as readings may be misleading due to the gauge sinking into a softened previous coat.

Information on the wet film thickness necessary to give a specified dry film thickness should be obtained from the relevant intumescent manufacturers' technical data sheet(s).

17.18.2 Dry Film Thickness (DFT)

17.18.2.1 MEASURING GAUGES

The method of Dry Film thickness determination shall use a gauge employing the electro-magnetic induction principle. Such instruments shall have a range appropriate to the specified dry film thickness and shall be calibrated on a smooth plate prior to use. Calibration should use shims appropriate to the specified film thickness.

If feasible, the instruments should be capable of storing data. Ability to print and/or download to computer.

17.18.2.2 Thickness measurement

Primer thickness may be determined either after application in shop, or on site prior to commencement of application of the intumescent basecoat.

Allowing for the thickness of primer applied, the total dry film coating thickness of the intumescent basecoat should be determined prior to the application of any specified protective/decorative topcoat(s). Measurement at this stage will more easily facilitate any subsequent corrections which may prove necessary.

If the total intumescent dry film coating thickness, allowing for the underlying primer, is found to be within specified tolerances, application of the next coat (usually a decorative and/or protective coat) can proceed.

If the total intumescent dry film coating thickness is found to be outside the specified tolerances, the procedure outlined in section 19.4 should be followed.

Indentation of the coating by the measuring instrument probe indicates insufficient hardness of the coating and measurements should be deferred. However, if programming requires coating to precede urgently, with prior approval of NPCIL,

a shim of known thickness can be used to spread the load of the probe tip on the coated surface, allowing measurement to proceed before the coating has fully hardened. The dry film thickness of coating and shim together can then be measured and the shim value deducted to give the coating thickness.

Application within the specified tolerances shall also be ensured by careful monitoring of material usage and the elimination of surface defect prior to application.

When taking dry film thickness readings, it is recommended that no readings are taken within 25mm of the edge of an I section or within 25mm of the join of flange to web of an I section.

Taking the above into account, readings should be taken randomly over the remaining areas of the section with a frequency as described in clause 19.3 below.

17.18.3 Frequency of measurement

Sections should be measured in accordance with the following guidelines

A) For first 10% members or till consistent performance to the satisfaction of NPCIL is achieved, whichever is later, the thickness measurement shall done as per following frequency.

(i) I Sections, Tee Sections and Channels
Webs: Two readings per metre length on each face of web
Flanges: Two readings per metre length on the outer face of each flange
One reading per metre length on the inner face of each flange.

(ii) Square and Rectangular Hollow Sections and
Angles: Two readings per metre length on each face.

(iii) Circular Hollow Sections
Eight readings per metre length evenly spread around the section

Where members are less than 2m in length, three sets of readings shall be taken, one at each end and at the centre of the member. Each set shall comprise the number of readings on each face given by (i), (ii) or (iii) above, as appropriate.

Following guidelines for setting out a film thickness survey shall be followed.

- The contractor must provide suitable and adequate means of access, including to difficult and / or partially inaccessible areas. It is therefore important that surveys are scheduled when the fullest possible access is still available on site.
- All equipment used must be correctly calibrated, and if more than one party is carrying out thickness checks, agreement regarding calibration of all instruments must be reached before commencing.
- At least 10% of steel sections should be measured in accordance with the frequency set out in 19.3 A) above. These should include a representative mix of section sizes, and difficult access sections as well as those that are easiest to access.

- All other sections should be measured with reduced frequency with prior approval of NPCIL, unless the detailed survey (of 10% of sections) identifies a recurrent problem of thickness.
- If the detailed survey reveals a trend of unacceptable thickness, this should be taken into account when planning the remainder of the survey.
- In the worst case scenario, a full and detailed survey according to 18.3 A) above may be adopted.
- If certain faces of the sections are repeatedly found to be unacceptable (e.g. top flange or one face known to be difficult to access), the remainder of the survey should include detailed measurements of that face as well as random measurements of other faces.
- Where no unacceptable trends are identified, the remainder of the survey should consist of random readings taken at a frequency of 4-5 readings per metre length.
- Unacceptable low areas should be marked up for remedial coating by the inspector.

17.18.4 Acceptance criteria

The coating thickness acceptance criteria shall be as follows, assuming that the specified thickness is a nominal value:

(i) The average dry film thickness applied to each element shall be greater than or equal to the specified nominal value.

(ii) The average measured dry film thickness on any face of any member shall not be less than 100% of the specified nominal value.

(iii) Dry film thickness values less than 80% of the specified nominal value are acceptable, provided that such values are isolated and that no more than 10% of the readings on a member are less than 80% of the specified nominal value.

Where any single thickness reading is found to be less than 80% of the specified nominal value, a further two, or where possible three, readings shall be taken within 150 to 300 mm of the low reading. The initial reading may be considered isolated if all the additional readings are at least 80% of the specified nominal value. If one or more of the additional readings are less than 80% of the specified nominal value, further readings shall be made to determine the extent of the area of under thickness. In such cases, low thickness areas identified should be brought up to the required thickness before proceeding to the next application stage.

(iv) The average measured dry film thickness of any face of any member should not exceed the manufacturer's recommended maximum thickness for the particular member shape and orientation.

17.19 CORRECTION OF DEFECTIVE OR INADEQUATE COATINGS

17.19.1 THICKNESS CORRECTION

Wherever inadequate thickness is identified, the deficient area shall be identified and further coat(s) of intumescent product to bring the overall thickness up to acceptable standards shall be applied, prior to application of the final seal coat / decorative top coat.

However, if low thickness is not detected until after the seal coat / decorative top coat has been applied, detailed guidance must be sought from the intumescent coating manufacturer. In some circumstances – and with supporting test evidence – it may be possible to remedy the situation by the application of further coats of intumescent paint, but in the other extreme it may be necessary to remove previous coatings in order to build up the necessary fire protection from scratch.

Wherever the intumescent coating thickness exceeds the limits stated in the manufacturer's recommendations, guidance should be obtained from the manufacturer.

17.20 RECORDS AND REPORTS

Where appropriate, site records should contain the following information

17.20.1 VERIFICATION OF PRODUCT AND SPECIFICATION

Confirmation of product testing and certification, preferably in accordance with a third party certification scheme.
In addition, any contract specific requirements regarding product or specification should form part of the site records. For example, where appearance of the finish is important, and where sample paints or panels have been approved by the NPCIL, these should form part of the product dossier.

17.20.2 Contract documentation covering the fire protection product and its installation

- Substrate type (i.e. section sizes and shape, orientation, Hp/A value, etc.)
- Substrate location
- Surface preparation (i.e. degreasing, blast cleaning, etc. and standard)
- Identification of any primer and information concerning compatibility with intumescent coating.
- Evidence of third party product certification, including proof of specific testing for cellular beams and fire-engineered situations, giving relevant report reference etc.
- Declarations of Supply covering the fire protection products used.
- Batch numbers of products supplied.
- Thickness of intumescent coating required for the specified fire resistance period.
- Any variations or concessions agreed during the course of the contract.

- Design review to confirm any design changes and their effect on the specification, prior to commencement of application.

17.20.3 Quality Control Records

- All records should identify the areas inspected with reference to the relevant drawings, and should include
- Environmental conditions – air and substrate temperature, relative humidity and dew point.
- Dry film thicknesses per coat and for the full fire protection system, for each element of the structure. Measurements should include

- the member identification mark
- the number of readings taken
- maximum coating thickness recorded
- minimum coating thickness recorded
- average coating thickness
- any supplementary readings taken to establish if low readings (below 80% of specification) are limited and isolated areas.

- Variations, corrective actions or concessions carried out in relation to environmental conditions or dry film thicknesses.

17.20.4 Site Remedial Work

Where dry film thicknesses are checked after application of each coat, it is a fairly simple procedure to correct low thickness as this can be achieved by simply applying an additional coat (or part coat) before proceeding to the next stage of the specification.

If film thicknesses are not carried out with the required regularity, or if low thicknesses are not detected until the application process has been completed, it will be necessary to seek the manufacturer's advice regarding the best method of bringing the coating up to the required level of protection.

Advice may vary from complete removal of applied coatings, to selective removal of seal coat or, if supporting test evidence is available, to building up the thickness of the intumescent base coat (on top of the seal coat) followed by re-application of further seal coat.

In all cases, records must show the nature of defect, source of remedial advice and the full extent of remedial work carried out at site.

18 PRECAST CONCRETE

18.0 GENERAL

All concrete for precast concrete work shall comply with specifications for general concrete work and with the following additional requirements.

18.1 TOLERANCES

All units shall be cast as per detailed drawings furnished by the Engineer and to the tolerances indicated thereon. In the absence of any such indication, the dimensions shall not vary by more than ± 3 mm.

18.2 PLATFORM

All precast units shall be cast on a suitable yard, bed or platform with firm foundation and free from wind. The platform shall be fenced and shall have a curing tank of adequate size. The Contractor shall be responsible for the accuracy of the level or shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or printed on each unit. Each unit shall be concreted in one operation.

18.3 FORMS

The forms shall be steel forms with rigid steel frames or plywood forms if specifically approved by the Engineer. All component parts of formwork shall be so held that during concreting, there is no deformation of the form resulting in the concrete units not conforming to dimensions indicated on the drawings.

18.4 STRIKING FORMS

Side shutters shall not be struck in less than 24 hours for ordinary Portland cement after depositing concrete or as specified by the Engineer.

18.5 IDENTIFICATION MARKS

The surface of the underside or upper side, which is reinforced, shall be distinctly marked.

18.6 CURING

The blocks shall be kept at not less than 90% humidity immediately after manufacture for 24 hours and thereafter wet cured for a period of 10 days at a temperature of not less than 16°C. Rapid drying at the end of curing period shall not be permitted. Therefore they shall be stored under a safe and shaded enclosure/area. During this period, the blocks shall be handled carefully without causing any damage to corners, edges, surfaces etc.

18.7 HOISTING

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal

takes place, the Contractor shall satisfy the Engineer or his representative that the methods he proposes to adopt for these operations will not overstress or otherwise affect seriously the strength of the precast units. Lifting hooks shall be embedded in correct position of the unit as shown in the drawings to facilitate erection. These shall be burnt off and finished after erection if directed so, by the Engineer. The units shall be incorporated in the work in accordance with details shown on drawings or as directed by the Engineer. Cracked or damaged precast pieces during, before or after erection shall be removed and replaced with good ones at the Contractor's expense.

18.8 JOINTING

The joints shall be filled in with cement mortar 1:3 unless otherwise specified on the drawings. After jointing, the joint shall be cured for a minimum period of 10 days. All sharp and abrupt ridges and marked depressions shall be removed by grinding or filling with cement mortar properly bonded to the concrete.

18.9 PRECAST CONCRETE HATCH COVERS

All concrete for hatch covers shall comply with specifications for general concrete work and with following additional requirements.

18.9.1 All Hatch covers shall be cast as per detailed drawings furnished by the Engineer and to suit the openings as built. The tolerances in dimensions shall be + 0 or – 3 mm unless otherwise noted on drawings. No two adjacent hatch covers shall differ by 2 mm in elevation. However, before concreting hatch covers, site measurements of actual openings at the final location of hatches shall be taken. Clearance around hatch covers shall be maintained, if required, by adjusting their overall dimensions to suit actual size of opening.

18.9.2 As far as possible these hatch covers shall be cast very near to their final locations to minimize handling of these hatch covers.

18.9.3 Each Hatch cover cast for a particular location/opening shall be properly identified by use of metal plates as indicated in drawings.

18.9.4 Each Hatch cover shall have MS edge protection angle frame along its perimeter, and vertical connecting angles, as given in detailed drawings. The frame shall be fabricated taking into consideration, the actual size of opening at its final location.

18.9.5 Care shall be taken while concreting to ensure that this framework does not get distorted during/after concreting.

18.9.6 All Formed surfaces of the hatch cover shall have F3 finish and unformed surfaces shall have U3 finish.

18.9.7 The Hatch covers/blocks will have to be transported and placed in final location by the Contractor. Rectification of hatch covers or blocks will have to be carried out by the Contractor if tolerances as specified are not achieved. The unit rate for this item

shall include casting, curing, transporting to final location, erection, rectification and re-erection after painting at final location. Hoisting shall be done as per relevant clause for precast concrete given above.

18.10 SAMPLING, TESTING AND STRENGTH

Prior to manufacture trial mixes shall be prepared. When suitable mixes have been established, a sufficient number of blocks shall be cast to permit the Engineer to check the density and surface finish. If accepted these shall be standardized for all blocks to be manufactured. Provisions of IS: 1199 (Method of sampling and analysis of concrete) shall apply in addition to the requirement of this specification. The compressive cube strength of cured concrete blocks shall not be less than the specified strength at 28 days after casting.

19 MASONRY AND ALLIED WORKS

19.0 SCOPE

This chapter includes concrete block masonry, brick masonry, stone masonry, plastering, rubble soling for floors on grade, expansion and separation joints, sealing of joints, PVC/ GI water stops, flooring, skirting and dado, general area painting, steel doors, fire doors, sewer and plant drains, sanitary and plumbing items and other finishing works of the main plant structures.

19.1 APPLICABLE CODES

19.1.1 INDIAN STANDARD CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

IS: 277 Galvanized steel sheets (plain and corrugated)-specification

IS: 383 Specification for coarse and fine aggregates from natural sources for concrete

IS: 513 Cold reduced low carbon steel sheet & strip

IS: 702 Specification for Industrial bitumen

IS: 712 Specification for Building Limes

IS: 777 Glazed earthenware wall tiles

IS: 782 Specification for Caulking Lead

I.S: 1038 Specifications for Steel Doors, Windows and Ventilators

I.S: 1200 Methods of measurement of building and civil engineering works

IS: 1081 Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators

IS: 1443 Code of practice for laying and finishing of cement concrete flooring tiles

IS: 1834 Specification for hot applied sealing compounds for joints in concrete

IS: 1838 Specifications for Preformed Fillers for Expansion Joint in Concrete Pavement and Structures(Non-Extruding and Resilient Type)

Part I Bitumen Impregnated Fiber

IS: 2116 Specifications for Sand for Masonry Mortars

IS: 2185 (part-1) Concrete masonry units — specification; part 1 hollow and solid concrete block

IS: 2212 Brick Works - Code of Practice.

IS: 2508 Specification for low-density polyethylene films

IS: 2645 Integral waterproofing compounds forcement mortar and concrete— specification

IS: 2932 Enamel, synthetic, exterior a) Undercoating b) Finishing - Specification

IS: 2933 Specification for Enamel exterior a) Undercoating b) Finishing

IS: 3462 Specification for Unbacked flexible PVC flooring

IS 3495 Methods of tests of burnt clay building bricks

IS: 3614 (Part-1)Fire-check Doors, Part I: Plate, Metal Covered and Rolling type

IS: 4351 Steel door frames - Specification

IS: 4671 Specification for expanded polystyrene for thermal insulation purposes

IS: 6248 Specification for Metal rolling shutters and rolling grills.

IS: 9862 Specification for ready mixed paint, brushing, bituminous black, lead-free, acid alkali, water and chlorine resisting.

IS: 12894 Pulverized Fuel Ash-Lime Bricks - specifications

IS: 14811Rolled copper plate, sheet, strip and foils for general engineering purposes - specification

19.2 CONCRETE BLOCK MASONRY

In general, concrete block masonry shall be used in the work. Concrete block masonry shall be of solid concrete blocks having minimum average compressive strength of 5 $N/MM^2$and density shall not be less than 1800 kg/m^3.Precast concrete block masonry shall be constructed in various sizes in cement mortar 1:4 by volume with blocks manufactured as per IS: 2185 (part-1) and as per drawings and direction of engineer using standard equipment.

If Contractor proposes to cast concrete blocks at plant site, they shall submit a detailed procedure for casting of concrete blocks and submit it for the approval of the Engineer. Work shall start only after approval of the procedure. Concrete blocks shall be tested in accordance with the provisions given in IS: 2185. Contractor shall submit inspection and test plan for approval of the Engineer. Contractor shall develop proper casting yard with curing facilities for casting concrete blocks as per direction of the Engineer.

For construction of concrete block masonry, code of practice for brick works i.e. IS 2212 shall apply.

19.2.1 MATERIAL

The following are the materials to be used in the concrete block masonry work.

19.2.1.1 CEMENT

Cement shall be as covered in per specification titled ‘Plain and Reinforced Concrete’.

19.2.1.2 SAND

The sand shall consist of natural sand from an approved source. The sand shall be hard, durable, clean and free from adherent coatings, mica, shale organic matter and appreciable amount of clay. The sand shall not have deleterious impurities such as iron pyrites, alkalis, salts, coal, mica, shell etc. Sand for masonry mortars shall have particle size grading conforming to IS: 2116 – latest edition. The grading of sand for use in mortar for unreinforced and reinforced brickwork shall be within the specified limits for respective works. The fineness modulus of sand for mortar used in brickwork shall be between 2.9 and 2.1. Where grading of the sand falls outside the specified limits due to excess or deficiency of coarse or fine particles may be processed to comply with the standard by screening and or blending.

19.2.1.3 WATER

Requirement of water shall be as covered in the specification for 'Plain and Reinforced Concrete'.

19.2.2 STORAGE, HANDLING OF MATERIALS, CONCRETE BLOCKS, CEMENT, SAND, ETC.

Concrete blocks shall not be dumped at site & they shall be stacked in regularities, even as they are unloaded to minimise breakages and defacement of blocks. The supply/ manufacture of blocks shall be so arranged that at least fifteen days requirements of blocks are available at site at any time. Blocks selected for different situation of use in the work shall be stocked separately.

Cement, sand etc. shall be stored as stated in specification for 'Plain and Reinforced Concrete'.

Concrete shall be as per the specification for 'Plain and Reinforced Concrete'.

19.2.3 MORTAR

Mix for mortar shall be as specified in Schedule of Quantities. The cement and sand shall be mixed dry in specified proportion and then thoroughly mixed to proper consistency. No mortar that has stood for more than half an hour shall be used.

19.2.4 LAYING AND WORKMANSHIP

a) Blocks of same dimensions will be used on the same work except otherwise specially permitted by the Engineer. All blocks shall be sufficiently soaked but not excessively wet before laying. All blocks shall be soaked in water for a period of two hours before use and no blocks shall be used until there is complete cessation of bubbles when immersed in water. Concrete surfaces in contact with block masonry shall be hacked to remove the laitance and the surface roughened to the satisfaction of the Engineer for proper bonding.

b) All dirt and dust shall be removed from the block and the surfaces shall be moist at the time of laying.

c) No bats or cut blocks shall be used in the work unless absolutely necessary around irregular openings for adjusting the dimensions of different courses and for closers, in which case full block shall be laid at corners, the bats being placed in the middle of the courses.

d) The blocks shall be laid on a full bed of mortar and to line, level and shapes shown on the drawings. When laying, the blocks shall be slightly pressed so that mortar can get into all the pores of the brick surface to ensure proper adhesion. Cross-joints and wall joints shall be properly flushed in packed with mortar so that no hollow spaces are

left. Blocks shall be handled carefully so as not to damage their edges. They should also not be thrown from any height to the ground but should be put down gently.

e) All courses shall be laid truly horizontal and all vertical joints made truly vertical. Vertical joints in one course and the next below shall not come over another and shall not normally be nearer than 1/4 of block length. Fixture, plugs, frames etc. if any, shall be built in at places shown in the drawing while laying courses only and not later by removal of the blocks already laid.

f) Care shall be taken during construction to see that edges of blocks at quoins, sills, heads etc. are not damaged. All block work shall be tightly built against columns, floor slabs, or other structural members around door and window frames with proper distance to permit caulked joints. In case of very dry weather, the surface of the block shall be kept wet to prevent drying of mortar. At the end of days work, provision shall be made to keep the surface of block work wet with water. Block work shall be added uniformly throughout so that no portion of the work shall be left more than 900 mm lower than other. Verticality of walls and horizontality of the courses shall be checked very often with plumb bob and spirit level respectively.

g) Block work shall be laid out and arranged such that a minimum of cutting and shaping is required. Where necessary to trim block work units, they shall be cut, trimmed or broken at kerbs, or where required to a neat true line without chips on exposed faces.

h) Block work one and half blocks thick or more shall have both faces in true plane. Block work of lesser thickness shall have one selected face, in true plane.

i) Bond used shall be English bond and shall be carried throughout the work. At all corners alternate courses of brickwork shall be laid header and stretcher-wise as seen in the face so as to secure good bonds. The arrangement of bonds at quoins shall be symmetrical.

j) Blocks shall be laid in joints not exceeding 10 mm in thickness and this thickness shall be uniform throughout. Joints shall be struck flush with the face at the time of laying.

k) All joints on face shall be raked to minimum 10 mm depth while the mortar is still green to provide bond for plaster or pointing.

l) The rate of laying masonry may be up to a height of 1000 mm per day or as approved by the Engineer.

19.2.5 ENCASING OF STRUCTURAL MEMBERS

Where drawings show that structural steel columns and spandrel beams are to be partly or wholly covered with block work, the blocks shall be built tightly against all flanges and webs with all spaces between the steel and the block work filled solid with setting mortar and this mortar shall not be less than 12 mm thick.

19.2.6 REINFORCEMENT AND ANCHORAGE

a) For the walls, anchors in the form of M.S. flats or rods from columns and/or beams and embedment and any other anchoring and reinforcements, shown on drawings, shall be adequately embedded in the block work.

b) For reinforced blockwork, the reinforcements shall be as specified in the schedule of quantities. All reinforcements shall be thoroughly cleaned and fully embedded in the mortar. The thickness of the joints in blockwork containing steel bars shall be increased so as to have a minimum mortar cover of 6 mm around the bar interposed between the block and the reinforcement. Overlap in the reinforcement, if any, shall not be less than 50 times the diameter of the bar. The reinforcements shall be lapped with dowels left in R.C. columns or welded to steel stanchions. Where reinforced concrete bands are provided in the block walls, such bands shall be to the full width of the wall and the concrete of grade not lesser than M-25 shall be used. Such band will be measured separately under respective items of concrete in the Schedule of Quantities.

c) All half-block partition walls shall have M.S. reinforcing bars at every fourth course of the block work and they shall be securely anchored at their ends where the partitions bond.

d) All sash and door frames, louvers and other connections requiring weather proofing, shall be built in and the outside frames shall be cleaned out to uniform 20 mm depth and filled solidly with an approved elastic caulking compound applied with a caulking gun.

e) Scaffolding will generally be double but may be single if warranted for the particular work as approved by the Engineer. Scaffolding shall generally be erected with steel pipes. The Contractor shall take all measures to ensure safety of work and the working people.

f) Contractor shall be entirely responsible for any damage to property or injury to persons resulting from defective scaffolding, ladders and materials or otherwise arising out of default in this respect. Proper scaffolding shall be provided to allow, easy approach to every part of the work. Overhead work shall not be allowed.

19.2.7 CURING

All block work shall be kept constantly wet for at least 7 days from the date of laying of block work.

19.2.8 CLEANING

Upon completion of the masonry installation, all exposed block shall be cleaned of all mortar and cement grout incrustations and concrete stains. Protruding mortar joints shall be chipped off. As the cleaning progresses, all masonry work shall be examined

and all imperfect jointing, nail holes, cracks, etc. shall be carefully pointed up and filled with mortar where required and the horizontal rakings left tooled and clean.

19.3 PLASTERING

19.3.1 WATER AND CEMENT

Water and Portland cement shall be as specified for masonry work.

19.3.2 SAND

Sand shall consist of natural sand, crushed stone sand or crushed gravel sand, from an approved source. The sand shall be hard, durable, clean and free from adherent coatings and organic matter, and shall not contain any appreciable amount of clay balls or pellets. The sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal, mica, shale or similar laminated or other in such form or in such quantities as to affect adversely the hardening, the strength, the durability, or the appearance of the plaster or applied decoration, or to cause corrosion of any metal in contact with the plaster. Total of all deleterious substances shall not exceed 5% by weight. The sand shall be properly graded and of medium size with a fineness modulus of 2.0 to 2.2.

19.3.3 STORAGE OF MATERIALS

Cement and sand shall be stored as specified in specification for ‘Plain and Reinforced Concrete’

19.3.4 MIX

The Mortar for plastering shall be mixed in suitable mechanical mixer in the proportion as indicated in the schedule of quantities. Water proofing compound conforming to IS: 2645 of approved manufacturer shall be added to the mortar mix for external plastering and finishes in the proportion as specified in the specification or in accordance with the manufacturer’s instructions. Cement and sand shall be mixed in a dry state and then wetted and mixed thoroughly to obtain the required consistency, including machine mixing if desired by the Engineer. The mortar shall be consumed within half an hour of mixing. Any mortar for plaster, which is partially set, shall be rejected and removed from the site. Machine mixed mortar shall be prepared in an approved mixer as approved by Engineer-in-charge. Mixing for 1-1/2 to 2 minutes is normally sufficient. Only cement sand mortar shall be used in the plastering works. Cement mortar for plastering shall have a mix in the proportion of 1 part of cement and 3 parts of sand by volume unless otherwise specified in the schedule of quantities.

19.3.5 PREPARATION OF SURFACE

All joints in the masonry shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Surface on which plastering is to be applied shall be clean and free from all dust, loose materials, grease etc. and be well wetted for at least 6 hours before plastering. Brick/ block work shall be brushed down with a steel wire brush to remove all loose dust from the joints and thoroughly washed with water. All laitance shall be removed by chipping and roughening from concrete surfaces, which are to be plastered.

19.3.6 APPLICATION OF PLASTER

In all plaster work, mortar shall be applied with somewhat more than the required thickness and well pressed into the joint and on the surface and rubbed and levelled with a flat wooden rule to give required thickness. Plaster, when more than 15 mm thick, shall be applied in two coats, a base coat followed by the finishing coat. Thickness of the base coat shall be just sufficient to fill up all unevenness in the surface. No single coat, however, shall exceed 12 mm in thickness except in foundation / plinth work. The lower coat shall be thicker than the upper coat. The overall thickness of the coats shall not be less than the minimum thickness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat of plaster. The under-coat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be “thrown on” rather than “applied by trowel”.

To ensure even thickness and true surface, patches of plaster about 100 mm to 150mm square or wooden screed 15 mm wide and of the thickness of the plaster shall be fixed vertically about 2000 mm to 3000 mm apart, to act as gauges. The finished wall surface shall be true to plumb, and the contractor shall, without any extra cost to NPC, make up any irregularity in the brickwork with plaster. All vertical edges of brick, pillars, door jamb etc. shall be chamfered or rounded off at no extra cost to NPCIL as directed by the Engineer. After the plastering work is completed all debris shall be removed and the area left clean. All corners must be finished to their true angles or rounded. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

19.3.7 CURING

All plastered surfaces after laying shall be cured for a minimum period of seven days, by an approved method, and shall be protected from excessive heat and sunlight by suitable approved means. Moistening shall be commenced as soon as the plaster has hardened sufficiently and is not susceptible to damage. Each individual coat of plaster shall be kept damp continuously, for at least two days, and then dried thoroughly, before applying the next coat.

19.3.8 FINISH

In any continuous face of a wall, finishing treatment of any type should be carried out continuously and day break made to coincide with architectural break in order to avoid unsightly patches at junctions.

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

19.3.8.1 STANDARD FINISH

Where punning is not indicated, the interior plaster shall be finished rough, otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

19.3.8.2 NEAT CEMENT FINISH

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg per sq.m and rubbed smooth with a trowel.

19.4 RUBBLE SOLING FOR FLOORS ON GRADE

The rubble shall be of approved quality. Thickness of soling shall be as shown on the drawings/schedule of quantities. The rubble soling shall be carefully hand packed as close as possible and bedded firmly with their largest side placed vertical, the broader faces downward, the smaller surface at top and voids and interstices filled in solidly by wedging with hard chips and small stones but of largest size possible to fit interstices finished with cement sand mortar 1:10 min. and thickness as indicated on drawing.

No stone shall be less than 80 mm in thickness or less than 2.8 kg in weight or more than the depth of soling in thickness and not to exceed in length or breadth twice its thickness.

When a sufficient length of soling has been laid, this shall be compacted with a three wheeler power roller and the surface shall be evened by blinding uniformly with sand not exceeding 10% silt during rolling. Places inaccessible to the roller may be compacted by hand with log hammer or mechanical tampers or by hand rollers subject to the approval of the Engineer.

19.5 EXPANSION JOINT FILLER

Standard heavy density expanded polystyrene of minimum density 35 kg/cu.m and conforming to IS:4671 shall be supplied in sizes and used in accordance with drawings. The thickness of the material shall be as indicated on drawing. Adhesive if any required to fix expansion joint filler to all forms of structure shall be supplied by

the Contractor. A sample of material shall be approved by the Engineer before it is used on site. Installation shall be carried out as directed by the Engineer. The polythene sheet used for wrapping shall be minimum 250 micron thick and shall be got approved by the Engineer.

19.6 EXPANSION JOINT SEALING

Expansion joint shall be provided with PVC water stop / hot dip galvanised strips with class 2 zinc coating of width and thickness as stated in the schedule of quantities/ as shown on drawings or as approved by the Engineer. The strips shall be bent to shape indicated on the drawings and connected properly to the structure. Expansion joints shall be continuous and where two or more strips meet they shall be lapped 75 mm and brazed or welded as the case may be. Welding shall be carried out by qualified welders and shall be subject to non-destructive testing as directed by the Engineer. For the purpose of measurement, the laps provided shall be neglected.

19.6.1 G.I WATERSTOPS

The work to be done under this specification comprises the supply and delivery of Galvanized Iron water stops and accessories for the Main Plant Civil Works, all in accordance with the requirements of this specification. The Intent of this specification is to provide water stops completely in accordance with this specification ready for installation. Installation of material will be done by the contractor.

APPLICABLE CODES

IS: 277: 2003 Specification for Galvanized Steel Sheets (Plain and Corrugated)

DESCRIPTION

The GI Water stops shall be of 3.15 mm thick fabricated in accordance with IS: 277 (latest edition) and galvanized for dry film thickness of 60-100 micron

19.7 BITUMASTIC JOINT SEALING COMPOUND

Bitumastic joint sealing compound conforming to Grade A (normal) of IS: 1834 (latest Edition) shall be supplied and used in accordance with drawings. The size of groove to be sealed shall be in accordance with drawings/schedule of quantities. A sample of material shall be approved by the Engineer before its use on site. Work shall be carried out as per manufacturer’s instructions or/and as directed by the Engineer.

19.8 BITUMASTIC PAINT FOR ISOLATION JOINTS

Bitumastic Paint Conforming to IS: 9862 shall be supplied and applied by the Contractor. Two coats of paint shall be applied over surfaces to form isolation joints.

Painting shall be performed in accordance with the manufacturer's instructions or /and as directed by the Engineer. A sample of material shall be approved by the Engineer before it is used on site.

19.9 NEOPRENE & COPPER SHEET

Neoprene & copper sheet shall conform to the following specifications and a sample of material shall be approved by the Engineer.

19.9.1 NEOPRENE PAD

The pads shall be 100 percent Chloroprene compound known as "Neoprene" and shall be cast in moulds under pressure and heat. Compositions for pads shall meet the requirements listed below.

The pads shall meet the following physical test requirements:

PROPERTY	**REQUIREMENT**	**ASTM TEST METHOD**
Durometer (Type A), Hardness	60±5	D 2240
Ultimate Tensile PSI Min.	2500	D 412
Ultimate elongation at Break Min. %	350	D 412
HEAT RESISTANCE: 70 HRS. @ 212° F in AIR Change in Durometer Hardness , %Max Change in Tensile, %Max. Change in Elongation, % Max.	 +15 -15 -40	D 573
COMPRESSION SET 22 HRS. @ 212° F,% Max	35	D 395 Method B
Compression set induced in vulcanized Rubber During Exposure to high energy Nuclear Radiation, % Max.	25	ASTM D-2309
OZONE RESISTANCE 100 pphm ozone in air by volume, 20 % strain 100 ± 2 ° F, 100 hrs, mounting procedure ASTM D 518 Procedure A	No Cracks	D 1149
TEAR RESISTANCE, (kgf/cm), Min.	45	D 624
LOW TEMPERATURE TEST Brittleness at - 40° F	Pass	D 746 Procedure B

Neoprene sheet shall be placed and cut suitably to shapes and sizes as mentioned in the drawings. Brazing shall be carried out as per manufacturer's specifications and by qualified persons, subject to testing as directed by Engineer.

19.9.2 COPPER SHEET

Copper strips of material type-"O" (annealed) conforming to IS: 14811 shall be used.

19.10 POLYETHYLENE SHEET

Polyethylene sheets 250 micron thick conforming to the IS 2508 shall be supplied and used to form separation joints. A sample material shall be approved by Engineer before its use at site.

19.11 SLIDING COVER STRIP

At the expansion joints, members like columns and beams have been duplicated on either side of the separation and provided with embedded parts for installing the sliding type cover strip to accommodate any building block movement. The cover strip shall be provided both at vertical and horizontal points in accordance with details shown on drawings. The strip element shall be of mild steel, plain or chequered as indicated, and of size and thickness shown on drawings and schedule of quantities and rates. The fixed edge shall be suitably attached to the embedded bearing plate, as provided, by plug weld or tap screw as shown or as instructed by the Engineer. At the sliding edge, the sliding surfaces of the embedded plate provided and underside of the cover strip shall be machined smooth. Adequate care shall be taken not to cause any damage to the strip.

19.12 Aluminium Door, Windows and Partitions

The type and construction of Aluminium Doors shall be similar to steel doors.

These (doors, windows and partitions) shall be of sections extruded from aluminium alloy conforming to IS: 733 . Door skin plates and stiffeners shall have a minimum 3 mm thickness. All sections shall be manufactured by Indian Aluminium Co. Ltd., All doors shall be insulated with spun mineral wool insulation for sound deadening. Doors, frames, mullions, transoms and all other exposed aluminum sections shall be alumilited, 0.015mm thickness, satin finished in natural aluminium colour. A protective transparent coating shall be applied to the sections before shipment from the factory.

Aluminium frame work for glazed partitions with aluminium glazed access doors shall be as shown in drawings, excluding supply of glass and glazing. All sections shall have a minimum 3 mm thickness and alumilited as specified above.

Aluminium door shutters, windows and partitions shall have mechanical joints with necessary fasteners.

Portions of aluminium frames which come in contact with masonry construction shall, before shipment from the factory, be protected with a heavy coat of alkali resistant, bituminous paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer.

All work shall be fitted and shop assembled to a first class job and ready for erection. Shop joints shall be made to hairlines. Work on the above, other than described, shall be carefully fitted and assembled with name joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. All drilling of structural supports to install aluminium doors and frames shall be done and included in the work. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

All work shall be erected in plumb and true to line and ready for building into masonry or other types of wall construction. Doors and frames, not properly installed or being out of line or distorted shall be reset and corrected by the contractor at his expense.

Hardware and fixtures shall be as specified under "Door/Window Schedule". All hardware shall be heavy duty and the door closers of extra heavy duty type. All exposed metal shall be satin finished aluminium. All locks shall be cylinder type. All hardware shall be approved by the Engineer before installation.

19.12.1 **Fabrication Drawings**

Before starting fabrication of all metal doors windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. Only after approval of drawings, the fabrication shall be started.

19.12.2 **Workmanship**

Workmanship shall be of best quality, free from any flaws and defects. Samples of each type shall be submitted and approval of the Engineer taken by the Contractor, before starting bulk manufacture.

19.12.3 **Transporting**

All metal doors, windows, etc., shall be packed and crated properly before dispatch, to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in undamaged condition.

19.12.4 **Sliding Door (Supply and Installation)**

19.12.4.1 Scope

This specification covers the design, supply of materials, fabrication, delivery and

erection of MS sliding doors including all accessories as herein after specified.

19.12.4.2 General Description and Construction Details

The M.S. sliding doors shall be best quality adhering to the dimensions and details shown on drawings and schedule and as directed by the Engineer.

The sliding shutter shall be made of MS sheet steel panel of 16 gauge with siffeners made of 14 gauge MS, bent sheets of sizes & shapes as shown in the drawing.

The Heavy duty CI bracket shall be fixed to the lintel by means of coach screws of proper strength but of size not less 6mm diameter with length and spacing as given in the drawing.

The Standard Track/roller guide at top shall be supported on CI bracket at spacing not more than 1500 mm. The guide shall consist of Heavy duty 4 roller trolley fixed to the shutter by standard nut and bolt assembly of diameter not less than 5 mm.

The bottom guide shall made of MS section & it shall be fixed in the floors. This guide shall have 12 mm dia MS anchors of shape and spacing as shown in the drawing welded to it. 4 nos ball bearings16 dia ,with 16 dia stainless steel pin shall be fitted at bottom of each sliding leaf of the door.

The sliding shutter shall be provided with recessed handles and lock of approved make lockable on both sides. Each sliding leaf shall also have tower bolt.

The entire assembly of door shall be such as to have smooth & easy operations by a single person.

19.12.4.3 Erection

The doors shall be erected complete with all necessary hardware, operating mechanisms, equipment, wiring etc. complete, to suit sizes of openings. Upon completion, doors shall be in best operating condition. All installation and erection work, shall be done in accordance with the manufacturer's specifications. The Contractor shall arrange to have at no extra cost to NPCIL, the services of the manufacturer's Supervisor during erection. Any drilling to or cutting of concrete, masonry etc. shall be made good after erection of shutters.

19.12.4.4 Paint and Finish

Shutters shall be painted with one coat of red lead or zinc chromate primer in shop. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat. The doors shall be given final coats as given in the schedule and/or as directed by the Engineer.

19.13 STEEL DOORS AND WINDOWS

19.13.1 **DOUBLE PLATE FLUSH DOORS**

a) Double plate flush doors shall conform to IS: 4351 and shall be made from best quality 18 G galvanised mild steel sheets and shall be of hollow metal construction 45mm thick. Door frames shall be from the best quality 16 G pressed steel sheets. All doors shall be insulated with spun mineral wool / polyurethane foam insulation for sound deadening. All hollow metal doors shall be flush type as shown on drawings and spot welded to reinforcing members both vertically and horizontally. Reinforcing members shall be from steel sections spaced not over 150mm apart and shall extend for the full height of doors. The members shall be strictly as shown on drawing and/or as instructed by the Engineer. The doors to be provided shall be as per the drawings and shall be as per the approval of the Engineer. Generally, the doors frames shall be 45mm x 45mm x 6mm MS angle sections, shutters made of 43mm rolled steel channel section framework with stiffeners of 40mm x 40mm x 3mm M.S. angle section spaced approximately 45cms c/c, skin plate of one face of the shutter welded to the frame and stiffeners and the other face fixed with machine screws after inserting insulation material, all other details remaining as per the drawings and specifications. The mounting of the door shutters shall ensure leak tightness.

b) Built in louvers shall be stationary inverted ‘V’ blades and fabricated from 20 G cold rolled carbon steel sheets conforming to IS: 513. They shall be of sizes indicated in “Door Schedule” and completely installed in doors. Doors with vision panels shall have the openings formed into the face sheets so that no glass frame is required.

c) All bolts, counter-sunk screws, adjustable, fixing lugs, sleeves, chips etc. shall be provided for proper anchorage and support.

d) Doors and frames shall be fitted and reinforced for all hardware from templates.

e) Wherever required, provisions shall be made for fixing louvers (made of 16 G steel sheets) and/or 6 mm thick sheet glass, as shown on drawings. Glazing beads where required shall be from 20 G steel and shall be removable.

f)The steel doors shall be provided with 6 mm thick clear sheet glass vision panel of 240 mm x 340mm in each leaf.

g) The finished work shall be up to the satisfaction of the Engineer.

19.13.2 DOOR THRESHOLD

Wherever required, thresholds shall be provided as shown on drawings or schedule. Doors without threshold shall have bottom tie of approved type. Finished overall dimensions for doors shall conform exactly as shown on drawings.

19.13.3 STEEL WINDOWS, SASHES, VENTILATORS ETC.

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions and as shown in the on drawings. The details as called for in the above specifications shall

be applicable for coupling mullions, transom, weather bars, pivot arrangement for ventilators, fixtures and fastening etc.

All Finished overall dimensions shall conform to exactly as shown in the drawings. Individual members shall be of adequate strength and sections as per relevant IS codes and as shown in the drawings. All welds shall be dressed flush on all exposed and contract surfaces.

Where composite unit openings are shown in the drawings, the individual window units shall be joined together with requisite transoms and mullions and/or as shown in drawings. All projected out window shall be outside glazed, fixed with putty or metal glazing beads as shown on the drawings and/or specified under Schedule of Items. Where aluminium glazing beads are specified they shall be extruded aluminium channel 17/32" X 7/16" X 3/32" unless otherwise shown on drawings.

19.13.4 FITTINGS FIXTURES AND HARDWARE

Hardware and fixtures shall be as specified in "Door Schedule" and of best quality from the manufacturer as approved by NPCIL.

The Hardware and fixtures shall be of heavy-duty type and the door closers of extra heavy-duty type. Finish shall be dull bronze finish and/or anodised aluminium as specified in "Schedule of Items", except butts for interior and door closers. Interior butts shall be prime coat finish and door closers sprayed bronze.
The Contractor shall submit samples of each type of hardware and fixture to the Engineer for approval. The approved samples shall remain with the Engineer for comparing with the actual supply and only those conforming to the approved samples shall be accepted.

The Door closers shall be from approved manufacturer with ISI certification and manufactured and installed as per relevant IS Codes and good Engineering practices.

19.13.5 SHOP PAINT

The shop paint shall be best zinc phosphate primer of approved manufacturer. Before assembly, all surfaces shall be given a coat of rust resisting paint. After assembly, all exposed surfaces shall be cleaned and smoothened and two coats of approved make enamel paint shall be uniformly applied over the surface.

19.13.6 INSTALLATION

In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081 latest edition, and as shown in the drawings and 'DOOR SCHEDULE'. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvres etc. including transom and mullions for composite units in respective places as shown in then drawings. Keeping proper lines and levels, and in approved workman like manner. The installation shall be done according to the instructions of the manufacturer, and/or as approved by the Engineer. Care shall be taken to see that

framework is not loaded with the weight of masonry or used for securing scaffolding or other temporary staging. Temporary struts may be fixed across the widths preventing sides bulging inwards, which should not be removed till brickwork is set. Care shall be taken to protect the hinges from getting embedded in the mortar while filling the gap between the frame and the masonry opening. If necessary, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take every precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor without any extra charges and finished as per original, after installation.

After installation of steel doors, windows etc. all abrasions to shop coat of paint shall be retouched and made good with the same quality of paint used in shop coat. Rates quoted shall also include minor rectification at site if required such as welding of fixtures, making screw holes and providing screw and rectification of dents formed in the doors and shutters.

19.14 FIRE PROOF DOORS

19.14.1 SCOPE

The work under this section shall include supply and/or erecting and installing fireproof doors as shown in approved manufacturer's drawing with all material complete.

The scope of work shall also include assembly and erection of composite types of fireproof doors. Supplying and/or fixing of all door accessories and hardware and are also included in the scope.

The fire doors shall be single / double leaf fire rated hollow galvanized MS pressed steel flush doors conforming to BIS : 3614 (Part-1), along with frame at all elevations, with or without removable panels and with or without panic bar having fire rating as approved. The Fire doors shall be of galvanised MS sheets for frames and leaves, mineral wool / PUF/ any other fire retardant insulation material, mastic caulking and grouting the frame, reinforcing and insulating the shutters with fire retardant material including heavy duty SS hinges, thresholds, fittings complete with frame, fittings, fixtures, handles, aldrops, latches, necessary access control hardware, necessary gaskets, drop seal, smoke seal, etc for air tightness. The vision panel shall be of borosilicate float glass or approved equivalent of size 240 mm x 340 mm or as specified in drawing with same fire rating including necessary beading, mastic cement, cleaning and also all hardware as per door schedule including one coat of approved primer and two coats of approved fire resistant / intumescent paint as necessary as per drawings, door schedules and specifications.

All the doors shall have provisions for installation of access control devices such that these devices if installed at a later date shall not impair the basic functions of the door as a fire barrier. These provisions shall be in the form of providing a separate steel plate of approved dimensions of the same material as the parent door, fixed to the

main door at an approved location.

The fire rating of the door shall be clearly embossed on the doors.

The testing of Fire proof doors shall be carried out as per BIS:3614 Part-II standards for approved fire rating, for full size door with vision panel and all fittings and fixtures shall be conducted at approved laboratory for 3 nos. of doors. One door shall be tested from the first lot before shipment to site and remaining at random from balance supply.

19.14.2 DRAWING

Fire proof doors shall be as manufactured by manufacturer qualified by NPCIL. Before starting fabrication of all fire proof doors the contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

19.14.3 APPLICABLE CODES

Following are some of the important I.S.Codes as relevant to this section:

I.S: 3614 - Fire doors
I.S: 1038 Steel door, windows and ventilators
I.S: 4351 - Steel door frames
I.S: 1081 - Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.

19.15 ROLLING STEEL SHUTTERS

19.15.1 SCOPE

This specification covers the design, supply of materials, fabrication, delivery and erection of rolling shutters with motor drives and/or manual operation including all accessories as herein after specified.

19.15.2 GENERAL DESCRIPTION OF CONSTRUCTION DETAILS

The doors shall be of best quality rolling steel service doors adhering to the dimensions and details shown on drawings and schedule.

a) Slats for shutter shall be made from tested bright cold rolled, annealed M.S. Strips, not less than 18 gauge thickness, machined, rolled at 75 mm rolling centres, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.

b) Rolling grills shall be constructed out of 6 mm dia. rods at 35 mm centres running horizontally flexible connected with vertical links spaced not more than 200mm

centres. Alternatively, rolling grills shall be made from perforated slates of approved design reinforced with 6mm dia. rods.

c) End locks shall be heavy type and provided at each end of alternate slats unless specified otherwise in the schedule.

d) Bottom bars shall be finished with two angles not less than 6mm thick for external shutters. When shown on drawings a flexible weather strip shall be applied to make tight contact with the floor.

e) Steel guides shall be of angle frames secured to the metal frames or masonry at openings. Guides shall be of such depth as to retain the shutter under a wind pressure of 150 kg/sq.m. or as specified in IS: 875 for the double rolling steel shutters a central guide which is movable by sliding by mechanical arrangement shall be provided. Material for guide channels shall conform to IS: 513 latest editions.

f) Shafts shall be of steel pipe of sufficient size to carry the torsional load with a maximum deflection of $1/360^{th}$ of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.

g) Hoods shall be formed of not less than 20 gauge steel, suitably reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision to securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as described in Schedule or as desired by the Engineer.

i) Power unit shall be suitable for 3 phases, 50 cycles 400 Volt AC power supply and shall be higher floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metres per minute. The electric motor shall be 3-phase 415V AC, 50Hz. TEFC enclosure complying with NPCIL specifications PB-E-293. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built – in overload protection, a geared limit switch and one push button station located inside the building unless otherwise stated in schedule of drawing. It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge electrically connected to stop the travel of the door on meeting an obstruction.

j) Operating chains shall be of tested quality, heavily galvanised and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength grave cast iron; machine moulded from machine cut patterns.

l) Bracket plate thickness shall be minimum 3.15mm.

19.15.3 OPERATION

19.15.3.1 MANUALLY/ MECHANICALLY OPERATED SHUTTERS

Manually operated shutters shall be easily operable by one person. In general, manually operated shutters shall be push pull type for openings up to 9 sq. m. in area. Larger shutters shall be either chain or gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as described in Schedule or as desired by the Engineer.

19.15.3.2 POWER OPERATED SHUTTERS

These shall be operable from a push button station conveniently located beside the door or as shown in the drawings. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for in schedule, externally mounted shutters shall be operated by control mechanism located inside the building. Limit switch shall also be included. The power drive shall be so designed that electric motors may be removed without affecting operation by means of an auxiliary endless chain gear operator.

Motor driven shutters shall have the following compulsory operation system. Mechanism shall be galvanised and of tested quality and shall be guaranteed to prevent chain from leaving wheel and of sufficient length to terminate approximately 600 mm above floor. Reduction gear shall be extra strong, cast without teeth for machine-finished pattern. Necessary lubrication shall be provided.

19.15.4 ERECTION

The shutters shall be erected complete with all necessary hardware, operating mechanisms; equipment, wiring etc. complete, to suit sizes of openings. Upon completion, shutters shall be in best operating condition. All installation and erection work, shall be done in accordance with the manufacturer's specifications. The Contractor shall arrange to have at no extra cost to the owner, the services of the manufacturer's Supervisor during erection. Any drillingor cutting of concrete, masonry etc. shall be made good after erection of shutters.

19.15.5 PAINT AND FINISH

Shutters shall be painted with one coat of zinc phosphate primer and two coats of approved synthetic enamel paint unless specified otherwise.

19.15.6 ELECTRICAL WORK

All electrical work shall be in strict accordance with the latest Indian Electricity Rules or other approved codes as specified by the Engineer**.**

19.15.7 SHOP INSPECTION AND TEST AT MANUFACTURER'S WORK

After completion of the manufacture of different components of the rolling shutter,

drive and other components/ accessories of the rolling shutter, arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

If desired by the Engineer tests shall be carried out at the manufacturer's works in accordance with the approved standards in the presence of the Engineer. Four copies of all the test certificates shall be submitted for approval, if required by the Engineer.

19.15.8 ACCEPTANCE TEST AT SITE

After the equipment has been installed at site the contractor shall carry out performance tests to the satisfaction of the Engineer, after which the shutters shall be accepted. The doors shall be smoothly operable under all ambient conditions. All controls and locking devices shall have fault free performance.

19.15.9 DRAWINGS

The manufacturer / supplier of the rolling shutters shall be got approved by NPCIL before carrying out the work. Prior to fabrication of rolling shutters, the contractor has to measure exact size of the structural opening at site. Fabricated door shall suit to the actual structural opening at site. The Contractor then shall prepare necessary drawings/ detailing of the rolling shutters as per specification, which they intend to supply and seek prior approval of the Engineer. The contract drawings to be furnished by the Contractor shall include but not be limited to the following:

a) Foundation and anchorage drawings for the equipment and drive and their auxiliaries with similar detailed drawings for other equipment.

b) Dimensioned assembly and sub-assembly drawings showing plans and sections of the equipment, instruments and safety devices etc. clearly indicating limiting dimensions, if any.

c) Complete assembly drawings wiring and connection diagram for all instruments, gauges and controls.

19.15.10 GUARANTEE

The design of the rolling shutter shall be made for withstanding a wind pressure of 150 kg/m2. The Contractor shall give one year's guarantee against operational and material defects and for safety against the design wind pressure.

19.15.11 APPLICABLE CODE

IS: 6248 - Metal rolling shutters and rolling grills.

19.16 CHAIN LINK FENCING AND DOOR

19.16.1 SCOPE

This specification covers the fabrication and installation of wire-link fencing and doors with necessary hardware.

19.16.2 GENERAL

The Fencing shall be constructed of M.S. pipe/ angle frame with welded wire-mesh cladding.

The chain-link doors shall have either single or double shutters of sizes as indicated in the 'Door Schedule'.

The door shutters shall be constructed of M.S. angle frame with welded wire-mesh cladding. The door frame shall be made of M.S. angles built in the wire link partition or in the brick masonry.

19.16.3 SHUTTER FRAME

The frame for door shutter shall consist of two vertical and three horizontal members securely welded together. The shutter frame shall have pivoted arrangement for swing.

19.16.4 WIRE LINK

Welded wire mesh of 50mm x 50 mm with mesh made of 3mm diameter from standard manufacturer shall be used. The mesh shall be made from high tensile wires welded at every intersection. The welded wire mesh shall be positioned inside the angles of the framework. The wire mesh shall be properly stretched and welded to the angle frame.

19.16.5 DOOR FRAME

The door frame shall be made of 80 NB GI Pipe and M.S. angles with necessary provisions to revive hardware. The finished work shall be strong and rigid, neat in appearance and free from defects. Doors shall not have more than 6 mm clearance at jambs & head and not more than 3 mm clearance at the meeting stile edges for pair door.

19.16.6 INSTALLATION

Door frames and shutters shall be assembled and installed such that frames and doors are set plumb, square, level, and at their proper location. All necessary hardware including hasp and staple for locking, pull handle, etc. shall be furnished. The frame

shall be securely anchored with hold fasts at brick masonry openings.

19.16.7 CLEANING AND PAINTING

All welds shall be dressed flush on all exposed and contact surfaces. Steel frame members, wire-mesh and welds shall be cleaned of all rust, scale, grease and other foreign matter and then given a prime coat of zinc phosphate primer.

The finished work shall be to the satisfaction of the Engineer-in-charge.

19.17 FLOORING, SKIRTING AND DADO

19.17.1 SCOPE

This specification shall include furnishing of all labour, materials, and equipment, necessary to complete the different types of flooring work as shown in the drawings. Work under this section shall include:

i) Indian Patent Stone Floor (IPS)
ii) Concrete floor with metallic hardener
iii) Tiled floor (with underbed)
iv) Glazed tiled flooring and dado
v) Vacuum dewatering floors with ironite finish
vi) Cement Skirting and dado In-situ
vii) Precast tile skirting
viii) Ceramic tile flooring and dado
ix) PVC tile floor
x) Acid and/or alkali resistant floor
xi) Kota stone flooring and skirting
xii) Vitrified polished tile flooring and skirting
xiii) Granite flooring and dado/ cladding
xiv) PVC Electro static conductive flooring
xv) Precast cement concrete interlocking paver blocks

Any integral finish to the base concrete indicated in drawing or schedule like finishes F1, F2 & F3 for formed surfaces and finishes U1, U2 & U3 for unformed surfaces shall be deemed to have been provided in the structural slab.

19.17.2 PREPARATION OF BASE

For all type of flooring, skirting and dado work, the base cement concrete slab or the masonry surface shall be cleaned of all dirt with water and hard brush. If required the base surface shall be hacked or otherwise roughened to obtain a good bond. The surface shall be clean, free from grease, oil, dust, loose particles, etc. and thoroughly soaked with water to prevent absorption of mixing water from the base course. Before placing the under bed, and excess standing water shall be mopped out. Before laying the flooring, skirting or wall finish, approval of the Engineer shall be obtained

as to the acceptability of the base.

19.17.3 INDIAN PATENT STONE (IPS)

a) Preparation of base shall be as specified above. The patent stone floor unless otherwise stated shall have a minimum thickness of 40mm. The under-bed shall consist of cement concrete with 10mm down, clean, well-graded, hard approved stone chips and clean, sharp, coarse sand. Elongated or thin flake like fragments of stone shall be avoided. The proportion of the mix shall be 1 part cement, 1parts sand and 2 parts stone chips by volume.

b) Water content shall be minimum, sufficient to give a workable consistency, which will allow finishing without excessive trowelling. Generally water cement ratio of 0.4 should suffice. The floor shall be cast in panels not exceeding 5 sq.m. in area and no side more than 2.5m long. Panels shall be made using aluminium strips. The casting sequence shall be in a chequered board fashion, no two adjacent panels being cast before the contraction of the previous one has taken place. The edge of each panel into which the floor is divided shall be supported by flat bars of steel or wood duly oiled to prevent sticking. The bars shall be removed before filling in adjoining panels. At least 48 hours shall elapse before the concreting in the adjacent bay is commenced. After laying, the under bed shall be levelled, compacted and brought to proper grade with a screed or float.

c) Then a layer of minimum 6mm thickness shall be laid over the green under bed and trowelled smooth with a mixture of cement and sand (1:1 by volume). The under bed and topping shall be completed in one operation.

d) The topping shall be trowelled smooth to the satisfaction of the Engineer. Any marks of trowel shall be mopped with a soft cloth to give a clean, even and smooth surface.

e) Where specified on drawings the thickness of the under bed shall be adjusted to make the total thickness as shown in the drawings.

f) When polishing is to be done, if specified in the drawings and/or “Schedule of Quantities” it shall be done in a manner as approved by the ENGINEER.

19.17.4 CONCRETE FLOORING WITH METALLIC HARDENER

19.17.4.1 GENERAL

The specified hardening system shall be applied by a specialist applicator certified by the manufacturer of the system strictly as per the written method statement submitted by the manufacturer.

a) THICKNESS

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth over 28 mm thick concrete base. Total thickness shall be 40 mm thick.

b) MATERIAL

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand, soluble alkaline compounds or other injurious materials. Actual samples shall be tested prior to use at site.

c) MIX

Proportion of metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction, 1 part metallic hardener shall be mixed dry with 4 parts of cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to two parts of stone chips by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

d) LAYING

The concrete floor shall be laid as per the specification of Concrete work and levelled up to the required grade. The forms, if any, shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible.

12 mm thick finish shall be laid while the concrete under bed 28 mm thick is still very green within 3 hours of laying the latter. The finish shall be of uniform thickness and free from trowel marks, pin hole, etc. The topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. The surface shall be smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

19.17.4.2 **SUBSTRATE CONDITION**

The grade of concrete for substrate should be preferably M20. At the time of construction of floor, as soon as the plasticity of the mix is reached, the surface of the freshly poured concrete shall be smoothened out and shall be flattened out with the vibrating straight edge. This concrete should be dense and compact which could be obtained by adding plasticizers like Plastiment BV 40 or equivalent (0.3% by weight of cement or it may vary due to site condition). It is preferable to use a mechanical trowel for smoothening operation.

19.17.4.3 **LAYING**

The ready mix non-metallic hardener compound shall be spread over the newly laid smooth concrete surface at a stage when a nail mark of 3-4mm shall be obtained at standard pressure. The spreading shall be done by hand or with a suitable apparatus @ approximately 6.0 kg/m² for a thickness of 3 mm surfacing.

Time should be given till the mixture has been uniformly moistened by the surface water contained in the green concrete. The surface shall be smoothened out with a mechanical trowel which shall be maintained perfectly flat, operating at a low speed.

Immediately, after the flooring surface is finished, it shall be protected from rapid drying. As soon as the floor is hardened sufficiently, it shall be kept moist for at least 3 days by wet gunny bags.

19.17.5 VACUUM DEWATERING SYSTEM OF FLOORING WITH IRONITE FINISH

19.17.5.1 GENERAL

a) Thickness, material and mix shall be as per specification on “concrete flooring with metallic hardener” included earlier in this chapter.
b) Grading of constituents of concrete and slump shall be as per manufacturer’s recommendation.

19.17.5.2 JOINTS

The concreting shall be done in bays as recommended by the manufacturer. In absence of which bays of 20 M x 20 M shall be followed. Aluminum strips shall be provided for separation of panels.

19.17.5.3 LAYING AND WORKMANSHIP

All arrangements including installation of guide rail, positioning of pipes for water and drainage, shall be placed either by pump or manually. Poker vibration and tremix surface vibrators are used sequentially to obtain proper leveling and compaction. Suction mat shall be used with proper arrangement of suction holes to vacuum pump, draining line, etc. so as to achieve recommended pressure by the manufacturer on the concrete surface. Proper care shall be taken to drain out excess water from concrete. Normally concrete shall be subjected to suction for a period of 1 to 2 min per centimeter thickness depending on the particle shape of the mix. Immediately after vacuum dewatering the surface is power floated with skim floater. To obtain smooth surface skim floater fitted with troweling blades shall be used. The floating and troweling operation shall be completed within one hour for concreting.

19.17.6 TILED FLOOR WITH UNDERBED

19.17.6.1 GENERAL

The tiles shall be (a) plain cement tiles (b) plain coloured tiles, and (c) terrazzo floor tiles, conforming to IS: 1237 – latest edition and of dimensions as shown of under bed drawings. The wearing face of these tiles shall consist of plain or coloured cement for items (a) and (b) and white or coloured cement and marble chips for item (c), size, colour and proportions of which shall be as per instructions of the Engineer. All angles of tiles shall be right angles, and the colour and texture of the wearing face

shall be uniform throughout its thickness, which shall not be less than 6mm. Colour shall be non-fading and lime-proof and the face of tiles shall be plane, free from cracks, depressions and projections and reasonably parallel to the back face.

The portion of cement to aggregate in the backing of tiles shall not be leaner than 1:3. Colouring material wherever used shall not exceed 10% by weight of cement used in the mix.

19.17.6.2 **MATERIALS AGGREGATES**

a) Aggregates used for mortar for fixing the tiles shall conform to IS: 383 – latest edition.

b) The cement used for fixing the tiles and cement grouting shall conform to IS: 12269 latest edition – or white cement of approved quality.

c) Pigments incorporated in mortar or used for Pigments grouting shall be stable and non-fading.

d) Water shall be clean and free from oil, water acid, alkali and organic or vegetable matters.

e) Aggregates used for the terrazzo topping aggregates shall be marble chips of size varying from for 1mm to 20mm. The proportioning of chips of terrazzo various grades shall be as per directions topping of the Engineer. Marble powder used for the topping shall pass through IS Sieve No. 30.

f) The delivery of tiles shall be so arranged as to minimise handling. Adequate precautions shall be taken to prevent accidental damage to tiles while unloading. The tiles shall be stored under cover to prevent exposure to dampness, sun, rain, accidental injury or straining.

19.17.6.3 **LAYING AND WORKMANSHIP**

a) Preparation of the base shall be as laying specified under 1.28.2 above. The surface shall be thoroughly soaked with water after soaking with water, the under bed of thickness as shown on drawings shall be evenly as smoothly spread. The mortar for under bed shall be composed of 1 part cement and 3 parts sand. The under bed shall be well consolidated and brought to proper grade, to a level below the finished floor level equal to the thickness of the tiles. The tiles shall then be placed before the under bed has set.

b) The tiles shall be soaked in water for 10 to 12 minutes and allowed to dry for the same length of time. The under bed shall be thoroughly moist, and Portland cement shall be hand-dusted over this immediately before the tiles are laid. The tiles shall then be placed upon and firmly pressed on the under bed until exactly even with the finished floor level. The joints shall be carefully grouted and filled with cement grout

of the same colour as the matrix of the tiles. The joints shall not be more than 1.5mm wide.

c) The setting of tiles shall be so done that minimum rubbing is required later on. Initial grinding and polishing of tiles shall be done in the shop and the final rubbing and polishing shall be commenced only after the floor as well as the joints have set and done in a manner approved by the Engineer. Chequered or grooved tiles whether plain or terrazzo, shall always be polished by hand.

d) All work shall be cleaned thoroughly and left in an acceptable condition on completion. No harsh abrasive cleaning powders, acid or steel wire shall be used for cleaning the tiles. Curing shall start on the next day after laying and shall continue for 14 days. The entire work of laying, polishing, finishing and cleaning etc. shall conform for 14 days. The entire work of laying polishing, finishing and cleaning etc. shall conform to IS: 1443 latest edition. Tiles shall be selected and used, such that colour of each area of the floor remains uniform.

19.17.7 GLAZED TILE FLOORING AND DADO

19.17.7.1 MATERIALS

The glazed tiles shall be 6 mm thick premium quality tiles conforming to IS 15622 of approved shade and make. The top surface of the tiles shall be glazed with a mat finish of uniform colour and texture and free from flaws, cracks, chips craze, specks, crawling or other imperfections. These shall be sound, true to shape with true and straight edges, non-absorbing and non-fading having a texture, dense and homogenous. The edges and the underside of the tile shall be completely free from glaze so that these may adhere properly to the surface below. The tolerances shall be +1.5mm for length and breadth and +0.5mm for thickness. Before bulk supply, the contractor shall give samples of tiles to the Engineer for approval. Bulk supply shall only be adopted if it conforms in all respects to the approved samples kept with the Engineer.

White cement, sand, pigments and water shall be as specified.

19.17.7.2 HANDLING AND STORAGE OF TILES

The delivery of tiles shall be so arranged as to minimise handling. Adequate precaution shall be taken to prevent accidental damage to tiles while unloading and these shall be stored under cover in a manner approved by the Engineer.

19.17.7.3 LAYING AND WORKMANSHIP

a) Preparation of base shall be as specified. The under bed as shown in the drawings shall be laid with a mortar consisting of 1 part of cement and 3 parts of clean, sharp, coarse sand. The thickness of the under bed shall be at least 20mm thick for flooring and 10 mm thick for dado or as shown in the drawings. While still green, the under

bed shall be deeply scratched. The under bed shall be laid not earlier than 48 hours before commencing to set the tiles.

b) A mortar setting bed 6mm thickness shall be laid over the under bed to make an even and true surface; over which the tiles shall be laid. This layer consists of 1 part of Portland cement, 1 part of lime putty and 3 parts of clean, sharp, medium sand. The under bed shall be thoroughly saturated with water immediately before applying the mortar setting bed. The setting bed mortar shall be applied over such an area as can be covered by tiles before the initial set of mortar. After the mortar setting bed has been levelled, a skin of neat Portland cement shall be trowelled to the mortar setting bed immediately before the tiles are set.

As soon as the mortar setting bed has sufficiently hardened, all tiles shall be firmly secured in place and gently beaten in, with finished surface brought to desired level. When grouting the glazed tiles, special care shall be taken to prevent scratching of the glazed surface. All surplus grout or mortar shall be removed before it has set or hardened and the face of tiles left clean. The completed work shall be free from cracked, broken or otherwise damaged tiles, No joint shall be more than 1.5mm thick. The joints shall be flush pointed with white or coloured cement to match the tile surface and cured for seven (7) days.

19.17.8 CERAMIC TILE FLOORING AND DADO

19.17.8.1 FLOORING

Non-slippery ceramic tile flooring shall be laid using premium quality mat finished 6mm thick ceramic tiles conforming to IS: 15622 in approved size (minimum 300 mm X 300), make and shade. The tiles shall be laid as per approved pattern over 20mm thick cement mortar 1:4 bedding, close jointed & pointed with matching cement slurry using white cement mixed with pigment, finished to levels / slope or plumb as required including cutting of tiles, curing, acid washing etc. all complete as per manufacturer's specifications and direction of Engineer. The quoted rates shall include the provision for covering of floor tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.8.2 DADO

Ceramic tile dado shall be laid at all the elevations using premium quality ceramic tiles average 6mm thickness of approved size (Min 450mmx300mm), shade and make conforming to IS: 15622. The tiles shall be laid on walls with average 10 mm thick underbed with cement mortar 1:3 (1 cement : 3 coarse sand) and 6mm thick setting mortar, jointed with white cement slurry with matching pigment and curing, cleaning etc all complete. The final surface shall project at least 6mm beyond the plastering, but in no case shall the total thickness including under bed be less than 20mm. The surface shall be truly vertical and free from any scratched or cracked tiles. The quoted rates shall include the provision for covering the tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.9 CEMENT SKIRTING AND DADO IN-SITU

a) The height of cement skirting and dado shall be as shown in drawings and/or instructed by the Engineer. Preparation of the base shall be as specified earlier.

b) The mortar for underbed shall consist of 1 part of cement and 3 parts clean, sharp, coarse sand (by volume), mixed with adequate amount of water to make it workable (not too wet) and shall be thrown on the wall. After finishing with a wooden float, a neat cement paste of minimum 3mm thickness (6mm when polished) shall be applied and pressed to be finally finished with English trowel.

c) The total thickness shall be such that the finished surface projects 6mm beyond plastering, but in no case shall the thickness be less than 19mm or as specified on the drawing. The junction with floors and corners shall be rounded to 25mm radius and/or as instructed by the Engineer. Curing shall be done for a minimum period of seven days.

d) If polishing is specified on drawings and/or schedule of items, the surface shall be rubbed and polished as per standard practice approved by The Engineer.

19.17.10 PRECAST TILE SKIRTING

This shall be done exactly in the same way as specified above. The plaster at the upper edge of the dado shall be finished neatly as directed by the Engineer.

19.17.11 PVC TILE FLOOR

This shall include the quality of materials and the general requirements for the installation of different types of tiles manufactured from vinyl resins including cover base set with sticker on concrete or masonry base in the locations shown in the drawings.

19.17.11.1 MATERIALS

a) The type of tile shall be as indicated on the drawings, schedule and/or bill of quantities. Three types of Vinyl floor tile are covered.

i) Type - V

The tile shall be composed of 100% Vinyl from face to back with alkaline resisting colour pigments and other plastic compounds.

ii) Type VA

The tile shall be of Vinyl – Asbestos consisting of a through blend of Vinyl plastic resins, asbestos fibres, and alkali resisting pigments and fillers from face to back.

iii) Type VL

The tile shall be Vinyl-laminated consisting of a top-wearing surface of solid vinyl permanently fused to applicant, felt cushion backing.

b) Cove base shall be extruded PVC (100% putty) with moulded top-set cover, colour, and the height of the base shall be as indicated on the drawings, schedules, and/or as approved by Engineer.

c) The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or other physical defects which affect appearance or serviceability.

d) All edges shall be cut true and square. The colour shall be non-fading and uniform in appearance, insoluble in water and resistant to alkalies; cleaning against and unusual floor polishes.

e) Samples of tiles and cove base shall be submitted to the Engineer and must be approved before work is started. Samples shall bear the labels stating the colour gauge and manufacturer's name. Colour, designs and sizes shall be approved by the Engineer after submission of samples. The thickness of the tiles shall be as indicated in the Schedule of Quantities.

f) Adhesive and cements shall be furnished as recommended by the manufacturer of the tiles. The adhesive shall have a short during time and long life in addition to toughness.

g) The tiles shall be square n shape and of approved dimensions and shall conform to the requirements of IS: 3461 and IS: 3462. The tolerance in dimensions shall be +1.5mm and in thickness +0.5mm.

19.17.11.2 INSTALLATION

19.17.11.2.1 GENERAL

The tiles shall be kept in the room to be tiled for at least 24 hours prior to laying to bring them to the same temperature of the laying area. The work should not the carried out under high humidity conditions. For air-conditioned space, the flooring shall not be laid until the conditioning units have been in operation for at least seven (7) days. During this period the temperature shall neither fall below 20° C. These conditions shall be maintained during laying and for 48 hours thereafter.

19.17.11.2.2 PREPARATION OF SUB-FLOOR

a) The surface to receive this finish shall be firm, even textured but not too smooth, without undulations and other deficiencies. If an under bed is laid the same shall be cured for at least seven (7) days by keeping it moist and fully dried. Before commencing the laying operations, the sub-floor shall be examined for evenness and dryness. The sub-floor shall be broom clean and free of paint, wax, grease or oil. Cracks shall be filled with crack filler.

b) The layout of the PVC on the sub-floor to be covered should be marked with guidelines. The PVC flooring shall be first laid for trials and approval without using the approved adhesive.

c) The adhesive shall be applied uniformly by using a notched trowel to the sub-floor and to the backside and edges of the tiles and allowed to surface dry. Any adhesive squeezed out through the joints and contaminating the face of the tiles shall be removed immediately. An appropriate solvent shall be used to remove any adhesive that has hardened. The traces of solvents shall be removed and the tiles cleaned before reuse.

d) The tiles shall be laid true, level and even exactly to the approved pattern and close to each other with minimum gap between joints. It is preferable to start laying of the tiles from the centre of the area. The tiles should be lowered in position and pressed firmly on to the adhesive. After laying, the tiles shall be rolled over, in two directions, with a light wooden roller weighing about 5 Kg. to ensure full contact with the underlay. If the edges tend to curl up, weights should be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. Any undulations noticed on the tiling surface shall be rectified by removing and relaying the tiles after thorough cleaning of the underside of the affected tiles. Work should be constantly checked against guide lines in order to ensure that all four edges of adjacent tiles meet accurately. Tiles shall be fitted carefully to and around all permanent fixtures. Borders shall be fitted accurately.

e) A minimum period of 24 hours shall be given after laying the flooring for developing proper bond of the adhesive. During this period, the flooring shall not be put to service. It is preferable to take up PVC flooring work after completion of plastering, painting, false ceiling and other decorative works so as to avoid any damage to the flooring.

f) Cove base shall be firmly cemented to the walls and accurately scribed to trim and finish.

g) The exposed edges of PVC tiles are doorways and other locations shall be provided protection against damage by metallic edge strips securely fastened to the sub-floor.

h) When flooring has been laid and fixed, it shall be thoroughly cleaned of surplus adhesive. The flooring shall then be cleaned with a wet cloth soaked in ware soap solution. All scraps, packing materials and debris shall be removed.

19.17.11.3 ACCEPTANCE

Improper application of the adhesive or imperfect embedment of tile in the adhesive as evidenced by ridges in the surface, by lack of even and uniform bearing, by loose bond, or by curled loose edges will be cause for rejection. All such defects shall be remedied to the satisfaction of the Engineer prior to acceptance.

19.17.11.4 GUARANTEE

All work executed under this specification shall be guaranteed free of defects in material and workmanship for a period of one year after completion of the work. Upon written notice of any defect in material or workmanship, repairs or replacements shall be made at no expense to Corporation. Corporation shall, however, arrange for the removal and replacement of all fixtures and equipment attached to the surface on which the work will be done.

19.17.12 ACID AND/OR ALKALI RESISTANT FLOOR

19.17.12.1 MATERIALS

The Acid and/or alkali resistant tile or rolls shall be to true and straight edges, shall be non-absorbing, without stains, non-fading, and obtained from approved manufacturers.

The rolls shall be 3 mm thick Thermo Plastic Polypropylene glass lined and shall be guaranteed to resist acid and alkalies of about 30% concentration. The laying of Acid proof rolls shall be carried out as per manufacturer's recommendation strictly and by a specialised agency.

The tenderer shall specify the characteristics of the tiles or rolls and shall enclose the manufacturer's literature for the same confirming their service ability for both acids and alkalis. The Contractor shall submit samples of tiles or rolls for approval to the Engineer and the bulk supply will only be accepted if it conforms in all respects to the approved samples kept with the Engineer.

19.17.12.2 LAYING AND WORKMANSHIP OF TILES

a) The surface should be levelled, dried, cleaned of dust, and should not be too smooth (sand finish) prior to pasting of PPG roll. The PPG roll should be cut into desired size for pasting. The required quantity of pasting compound should be mixed from the two components. The hardener should be added further in this mixture. The mixture is to be applied to the surface and the back side of the PPG roll after laying the fibre mat as per manufacturer recommendation and pasted by applying dead weight by putting sand bags etc. The pressure may be applied by jacks on the vertical surfaces.

b) Thermoplastic sheets should be welded by using fusion welding technique as per manufacturer's specification.

c) The Contractor shall furnish full details regarding the materials for the different treatments described above pertaining to this flooring work as per manufacturer's specifications, and shall lay and set the rolls properly in full conformation with the manufacturer's instructions. The entire work shall be done in workman like manner to the complete satisfaction of the Engineer.

d) The Contractor shall give a guarantee for the satisfactory life of the floor for a minimum period of one year under operating conditions. All defects appearing within

this period shall be rectified to the satisfaction of the Engineer by the Contractor at no extra cost to Corporation.

19.17.13 KOTA STONE FLOORING AND SKIRTING

Kota Stone shall be of best quality and obtained from approved sources. Kota stones shall not be less than 20mm thick for flooring and 20mm thick for skirting or as specified in schedule and shall be cut to the required sizes, as approved by the Engineer. The stones shall have to be machine cut and double machine polished. The edges to be pointed shall be true to line and dressed wherever found necessary to the full depth all round. The stones shall be hard, sound, and free from cracks, veins and other defects and of uniform colour. In case of Kota stones available in different shades, the samples shall be submitted for approval of the Engineer.

19.17.13.1 LAYING AND WORKMANSHIP

Before laying the flooring the surface to laying be paved, shall be thoroughly hacked, cleaned of all mortar scales, concrete lumps, loose materials etc. Unless and until, the surface is approved by the Engineer, the paving shall not be taken in hand. A bedding of cement mortar (1:4) of 20 mm thickness for flooring shall be laid evenly and to the required slopes as directed. The stones shall then be truly and evenly set in a thin paste of neat cement applied to sides, bottom and to the prepared base. The stones shall then be tamped down with wooden mallet until they are exactly in true plane and line with the adjacent stones. All stones shall be extended up to the masonry wall and underside of plaster. The stones shall be close jointed and joints shall be as thin as possible.

The cement that oozes out thorough the joints shall be wiped clean. The joints shall then be pointed with matching cement and finished neatly. The flooring shall be cured for seven (7) days. The entire surface and flooring shall be re-polished with machine to the satisfaction of Engineer.

19.17.13.2 KOTA STONE SKIRTING

Kota stone skirting shall be laid against a bedding of cement mortar (1:3) 12mm thick to the full height of skirting to a true plane, level and plumb. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. The continuous horizontal groove at the top of skirting shall be provided as per drawing or as directed by the Engineer. No extra will be paid for grooves. The skirting shall be cured for seven (7) days. The skirting surfaces shall be re-polished with had to the satisfaction of the Engineer.

19.17.14 VITRIFIED POLISHED TILE FLOORING AND SKIRTING/DADO

19.17.14.1 FLOORING

Vitrified polished tiles shall be of premium quality of size 600mm x 600mm of approved make and shade, conforming to IS: 15622 having minimum thickness of 9

mm. The tiles shall be laid in approved pattern over 20mm thick cement mortar 1:4 bedding. The tile slabs shall be close jointed & pointed with matching pigmented white cement slurry and shall be finished to levels / slope as required. Scope of work also includes cutting of tiles to the required size , curing, washing etc. complete with all materials, tools labour etc. all complete as per manufacturer's specifications and direction of the Engineer. The quoted rates shall include the provision for covering of floor tiles with PVC sheet over it to protect the tiles laid from painting stains and scratches during various finishing activities.

19.17.14.2 DADO

Vitrified polished tile skirting/ dado shall be of approved make and shade, conforming to IS: 15622 having minimum thickness of 9 mm. This shall be laid at all elevations in approved pattern laid in skirting over and including on 12 mm thick cement mortar 1:3 (1 cement: 3 coarse sand) and jointed with neat white cement slurry with pigment of matching shade to match the shade of the tile including curing, cleaning etc. all complete as per manufacturer's specifications and direction of the Engineer..

19.17.15 GRANITE FLOORING AND DADO/ CLADDING

19.17.15.1 FLOORING

Granite slab shall be of 1st quality in approved colour and size (Minimum 600mmX600mm). Granites slabs shall be provided and laid in 20 mm nominal thickness, with inlay for the border as flooring design, laid in approved pattern over base 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand) and jointed with white cement slurry mixed with pigment to match the shade of the slab.The scope of the work shall also include surface preparation, rubbing, curing, moulding and mirror polishing complete as per manufacturer's specifications and as directed by the Engineer.

19.17.15.2 DADO

Providing and fixing 20 mm nominal thick granite slab of 1st quality as wall cladding with approved colour and size (to cover the entire height of the dado in single piece without any joint and minimum 600mm width) laid in approved pattern over a base of 20 mm thick cement mortar 1:4 (1 cement : 4 coarse sand) jointed with white cement slurry mixed with pigment complete as directed including filling the gaps between the base mortar and granite slab with 1 : 2 cement slurry and making 'V' grooves wherever required, inclusive of stainless steel fisher clamp with expansion bolts at least 2 nos. for each slab wherever necessary, including rubbing, curing and mirror polishing complete as per specifications and as directed by Engineer. Quoted rate shall include supplying and providing stainless steel clamps as necessary with expansion bolts or any other accessories required to complete the dado work.

19.17.16 PVC ELECTROSTATIC CONDUCTIVE FLOORING AND SKIRTING

19.17.16.1 FLOORING

PVC Electrostatic conductive flooring and skirting 2 mm thick shall be installed over integral concrete floors finish/IPS/ hardonite flooring. The material specification and laying procedure shall be as per NPCIL Specification No. PPE-2273 (latest Rev.)

19.17.16.2 SKIRTING

PVC electrostatic conductive skirting shall be minimum 2 mm thick and shall be supplied and installed at various elevations inside main plant buildings over concrete / plaster surfaces satisfying all the requirements laid down in NPCIL technical specification PP-E-2273. The scope shall include all accessories / material required for installation of the same such as copper grounding strips, welding rods, surface preparation / levelling of floor, adhesive etc. as per requirements and testing at site all complete as per drawing, manufacturer's specifications and direction of the Engineer.

19.17.17 PRECAST CEMENT CONCRETE INTERLOCKING PAVER BLOCKS

Precast cement concrete interlocking pavers blocks shall conform to IS 15658. Paver blocks shall be of M-40 grade and 80mm thick factory made coloured blocks made by block making machine with strong vibratory compaction. The blocks shall be of approved colour and shape. Cement Concrete paver blocks shall be laid in approved pattern over 50mm thick compacted bed of fine sand, filling the joints with fine sand etc. all complete as per manufacturer's specifications and the direction of the Engineer.

19.18 GENERAL PAINTING ON INTERIORS & EXTERIOR SURFACES

19.18.1 SCOPE

a) This specification covers general painting on concrete, plastered and steel surfaces both interior and exterior as shown in drawings, schedules or as directed by the Engineer.

b) The Contractor shall inspect the surfaces of works completed by other agencies prior to the application of paint. If surface to be finished cannot be put in suitable condition for painting by customary preparatory methods, the painting contractor shall notify the Engineer in writing or assume responsibility for and rectify and unsatisfactory finishing that results.

c) Before commencing painting, the contractor shall obtain the approval of the Engineer in writing regarding the scheduling of work to minimize damage, disfiguration or staining by other trades. He shall also undertake normal precautions to prevent damage, disfiguration or staining to work of other trades or other installations.

19.18.2 MATERIALS

a) Materials shall be of the highest grade products of well known approved manufacturer and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name, and colour shade, with labels intact and seals unbroken.

b) All materials shall be subject to inspection, analysis and approval by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade be obtained from the same manufacturing batch.

c) All paint shall be subject to analysis from random samples taken at site from painter's bucket, if so desired by the Engineer.

d) All primer coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

e) All unspecified materials such as shellac, turpentine or linseed oil shall be of highest quality available and shall conform to the latest I.S. specifications. All such materials shall be made by reputable recognized manufacturers and shall be approved by the Engineer.

f) All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

19.18.3 **STORAGE**

The contractor shall arrange for safe and proper storage of all materials and tools. The storage space if allotted within the building shall be adequately protected from damage, disfigurement and stains. Paints shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken by the Contractor to prevent fire.

19.18.4 **PREPARATION OF SURFACE**

Before starting the work the Contractor shall obtain the approval of the Engineer regarding the soundness and readiness of the surface to be painted.

19.18.4.1 MASONRY, CONCRETE AND PLASTERED SURFACE

Before taking up painting works F3 finish shall be carried out on concrete surfaces. Plastered Surface shall be wire brushed and sand papered, clean and free of all oil, grease, efflorescence, mildew, loose paint or other foreign and loose materials. Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and uniformly textured. Where this type of resurfacing may lead to the finishing paint being different in shade from the original surfaces, the resurfaced area shall be treated with minimum one coat of cement primer, which should continue to the surrounding area for a distance of minimum 100 mm.

Surface with mildew or efflorescence shall be treated as below:

a) MILDEW

All mildew surface shall be treated with an approved fungicide such as ammonia wash consisting of 7g of copper carbonate dissolved in 80 ml liquor ammonia and diluted to 1 litre with water, or 2.5 percent magnesium silica fluoride solution allowed to dry thoroughly below the paint is applied.

b) EFFLORESCENCE

All efflorescence shall be removed by scrubbing the affected surfaces with a solution of muriatic acid in water (1:6 to 1:8) and washed fully with clear water and allowed to dry thoroughly.

19.18.4.2 **METALSURFACE**

All metal surfaces shall be absolutely clean, dry and free from wax, grease or dried soap films. All steel and iron surfaces, in addition, shall be free from rust. All steel or galvanized iron surfaces shall be pre-treated with a compatible primer according to the manufacturer's direction. Prime coat for steel work shall, however, be applied by the fabricator. Any abrasion in shop coat shall be touched up with the same quality of paint as the original coat.

19.18.5 PAINTING

Various types of finishing shall be done as indicated in the 'Interior Finish Schedule' and/or as on drawings. The colour shall be in accordance with 'Painting Schedule' or as selected by the Engineer.

19.18.5.1 ACRYLIC PLASTIC EMULSION PAINT

Acrylic plastic emulsion paint shall conform to IS: 15489. It shall be water-based acrylic co-polymer emulsion with rutile titanium dioxide and other selected pigments and fungicide. It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to escape without peeling or blister. The paint, after it is dried, shall be able to withstand washing with mild soap and water without any deterioration in colour, or without showing flaking blisters or peeling.

Plastic emulsion paint shall be of premier quality conforming to IS 15489. It shall be applied in minimum two coats over a coat of approved primer to interior concrete, plaster & other surfaces after cleaning / scrubbing of the surfaces with wire brushes, soft brushes, sand papers, steel sheet scrappers and mechanical grinder etc. for removing all kind of burrs, imperfections, undulations and other such defects existing in the surface including filling surface imperfections such as holes, dents, cracks by using mixture of white cement & fine sand (in the ratio of 1:3) to achieve plain & even surface. The scope of work includes spreading of suitable and clean protection covering on all exposed surfaces to protect them from staining. All surfaces

surrounding to painted area including window frames & glasses shall be cleaned to sparkling clean condition using suitable thinners, detergents, chemical cleaners etc. under the scope of the item as directed, at all elevations as indicated in the drawings including labour, materials, scaffolding, preparation of the surface, protecting & cleaning etc. all complete as per specification and direction of the Engineer.

All concrete surfaces shall be F3 finished before taking up the painting works. Quoted rates of painting shall include cost of F3 finish. Lime gauged cement plastered surfaces shall not be painted for at least one month after plastering. A sample patch shall be painted to check alkali reaction if so desired by the Engineer. Painting shall be strictly as per manufacturer's specification.

19.18.5.2 SYNTHETIC ENAMEL PAINT

Synthetic enamel paint shall be made from synthetic resins and drying oil with rutile titanium dioxide and other selected pigments to give a smooth, hard, durable and glossy finish to all exterior and interior surfaces. White and pastel shades shall resist yellowing and darkening with aging. The paint shall conform to IS: 2932 & IS: 2933. Glossy synthetic enamel paint shall be used on metal surfaces. Ready mix matt synthetic enamel paint shall be used on wall surfaces.

Synthetic enamel paint shall be of approved make and shade premium quality mat / glossy (as directed). It shall be painted in minimum 2 coats to give an even shade on steel surfaces at all elevations after erection including surface preparation and touch up with zinc phosphate primer wherever required. The scope also includes providing and removing scaffolding, all as per manufacturer's specifications, drawings and direction of the Engineer. The rate shall be inclusive of surface preparation with wire brushing and touch up with zinc phosphate primer.

Synthetic enamel paint shall be applied on properly premiered surface. Subsequently, coat shall not be applied till the previous coat is dry. The previous coat shall be lightly sand papered for better adhesion of subsequent coats.

19.18.5.3 ACID, ALKALI RESISTING PAINT

Acid and alkali resistant paint shall be of approved make and colour conforming to IS: 9862. The paintshall be applied in minimum 500 micron DFT over a coat of approved primer on prepared surfaces of flooring, ceiling and walls and other surfaces at all elevations. The scope of work includes all labour, materials, scaffolding, preparation of the surface, protecting & cleaning etc. all complete as per manufacturer's specification and das per direction of the Engineer. Primer coat shall be as per manufacturer's instructions.

19.18.5.4 POLYURETHENE PAINTING

19.18.5.4.1 GENERAL

Polyurethane painting on concrete and steel surfaces shall be done at locations

wherever specified in the drawings. Generally the external surfaces of the specified buildings shall be painted with polyurethane paint after completion of the work.

19.18.5.4.2 **SCOPE**

The scope of work covered under this specification is supply and application of one coat of primer and two coats of polyurethane finish paint of approved make for total dry film thickness of 125 microns (excluding 75 micron thick primer) on exterior surfaces.

19.18.5.4.3 **MATERIALS**

a) Primer compatible for PU paint shall have outstanding resistance properties and shall contain a high level of penetrating pigment, which renders superior performance when applied over concrete and it should be compatible when over coated with polyurethane paint.

a) The finish paint shall be two-component air-drying acrylic aliphatic polyurethane coating.

c) Suitable thinner for the above will be as per the manufacturer's recommendations.

d) Finish paint shall be glossy/ matt finish of approved shade and as specified by the engineer.

19.18.5.4.4 **DESCRIPTION**

The surface shall be cleaned of dust, loose particles, finished and cured properly. Biological growth if any, accumulated on the surface over the period shall be removed completely. Painting shall commence with application of one coat of 75 micron thick primer and finished with 125 micron DFT of polyurethane paint in two coats. The shade of the finish paint is generally light grey in colour and Contractor shall obtain prior approval of Engineer before commencement of work. Method of painting shall be either brush application or using air less spray equipmentusing a pump with nozzle tip of size 0.33 mm to 0.45 mm and more than 2000 psi pressure.The rate quoted shall cater for both methods.

A) Primer shall be two pack epoxy primer with outstanding resistance properties and shall contain a high level of penetrating pigment which renders superior performance when applied over steel/ concrete having the following properties.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTANCE VALUE**
Density	ASTM D 4052	g/cc	1.09 + 0.05 at 25°C
Mixing Ratio, by weigh	ASTM D 4052	ratio	100(Base): 35(Hardener)
Flexural Strength	ASTM C 580-02	Mpa	35 at 7 days

Tensile Strength	BS 6319, Pt 7	MPa	22 at 7 days
Compressive Strength	ASTM C 579	MPa	70 at 1 Day 75 at 3 Days 80 at 7 Days
Adhesive Bond Strength	ASTM D 4541	MPa	>1.5
DFT of Primer	ASTM D 1005	Micron	75

B) The two component polyurethane paint shall have the following parameters.

PROPERTY	**TEST METHOD**	**UNIT**	**ACCEPTACE VALUE**
Volume of Solids	ASTM D 2697	%	57±3
Pot Life	ASTM C603-90	Min	120 (at 25 deg C) 50 (at 40 deg C)
Mixed Density	ASTM D 4052	Kg/Ltr	1.2 (at 25 deg C)
Mixing Ratio, by Volume	ASTM D 4052		4(Base) : 1 (Hardner)
Touch Dry	ASTM D 1640	Min	90 (at 25 deg C)
Recoatable	ASTM D 1640	Hour	6 – 8 (at 25 deg C)
Final Curing Time		Day	7 (at 25 deg C)
Bond Strength	ASTM D 4541	MPa	>2 (Concrete Failure)
Abrasion Resistance , CS17 wheel	ASTM D 4060	Mg/1000 cycles	<125
UV Resistance	ASTM G 53	Hour	>1000
DFT in two Coats of PU Paint	ASTM D 1005	Micron	125

The acceptance criteria shall be based on Manufacturer test certificate except for Bond & Abrasion Resistance test, which shall be performed (one sample per lot) at independent approved Laboratory at the cost of contractor. The test certificate shall clearly specify the PU material as “Aliphatic”.

19.18.5.5 EPOXY PAINTING ON STEEL AND CONCRETE SURFACES

19.18.5.5.1 GENERAL

Epoxy painting on concrete and steel surfaces shall be done at locations wherever specified in the drawings.

19.18.5.5.2 SCOPE

The scope of work to be performed under this specification comprises of supply and application of heavy duty high build epoxy paint of approved make for painting of concrete and steel surfaces in various buildings and areas specified in the drawing, for walls, ceiling, floors and fabricated structural steel members as per relevant drawing and specifications to the thickness as specified in the drawings including surface preparation.

19.18.5.5.3 MATERIAL SPECIFICATIONS

For the areas, important from radiological considerations, where decontamination and

radiation resistance properties are required, the material shall conform to PP-M-1219 as applicable and as specified in the drawings or decided by the Engineer. This material shall be Polyamide cured two pack epoxy coating in mix and use form.

The areas which are not important from radiological consideration as specified or decided by the Engineer, material shall meet the requirements under relevant clause of this section.

19.18.5.5.3.1 **INTENDED USE**

19.18.5.5.3.1.1 **For areas important from radiological considerations**:

The epoxy coating would be used for painting the concrete floors, ceilings and walls. Mild steel surfaces on inorganic zinc silicate primed fabricated structural steel surfaces, construction joints caulked with polysulphide or epoxy mortar caulking compound, metallic expansion joints made from steel and copper etc. The materials used in the coating should not form radioactive isotope on absorbing neutrons. The paint should form a thick, radiation resistant, abrasion resistant, impact resistant, non-adsorbent, de-contaminable, humidity resistant, hot water and steam resistant liner.

19.18.5.5.3.1.2 For areas not important from radiological considerations:

The epoxy coating can be used for painting the concrete floors, ceilings and walls over Epoxy based compatible primer and on Mild steel surfaces over inorganic zinc silicate primed fabricated structural steel surfaces, construction joints caulked with polysulphide or epoxy mortar caulking compound, metallic expansion joints made from steel and copper etc. The paint should form a thick, abrasion resistant, impact resistant, non-adsorbent, humidity resistant liner.

19.18.5.5.3.2 **QUALIFICATION**

19.18.5.5.3.2.1 **For the areas important from radiological considerations:**

The qualification and procurement of epoxy paint shall be in accordance with PP-M-1219 as applicable. At the time of bulk supply samples shall be drawn from the batch in presence of representative from NPCIL, sealed and got tested by the contractor for batch tests in accordance with PP-M-1219 as applicable. The rate for application of paint shall include all the costs related with procurement.

19.18.5.5.3.2.2 **For the areas not important from radiological considerations:**

The Epoxy paint shall have following properties:

a) **For Epoxy on concrete floors**: The Epoxy shall be high build solvent free, self-smoothing, 4 component (Base, Hardener, Filler & Pigment) material. The DFT of coating (Excluding Primer) shall be minimum 1200 micron for its use on floors unless specified otherwise.

Property	Acceptance criteria	Reference Standard
Mixed Density	1.6+/- 0.05 kg/ liter	ASTM D14752
Pot Life	Min 40 min at 25 ^{0} C Min 15 min at 40 ^{0} C	ASTM C603
Setting time for foot traffic	15 Hour at 15 ^{0} C	ASTM D5895
Maximum Service Temperature	60 ^{0} C	ASTM 24712
Compressive Strength	24 MPa at 1 day 50 MPa at 7 days	ASTM C579
Flexural Strength	18 MPa at 7 days	BS 6319 PART 3
Tensile Strength	10 MPa at 7 days	BS 6319 PART 7
Abrassion Resistance H22 Wheel 1000 cycles – CS17 wheel	Less than 230 mg Less than 85 mg	ASTM D2240
Hardness, Shore D	Min 80	ASTM D2240
Adhesive Bond strength to concrete at 7 days	>1.5 MPa (Concrete failure)	ASTM D4541

b) **For Epoxy on concrete walls & structural steel**: The Epoxy shall be high build solvent free, 3 component (Base, Hardener & Pigment) material. The DFT of coating (Excluding Primer) shall be 250 micron for concrete walls & 200 micron on structural steel, unless specified otherwise.

Property	Acceptance criteria	Reference Standard
Mixed Density	1.48+/- 0.05 kg/ liter at 25 ^{0} C	ASTM D 14752
Volume Solids	100 %	ASTM D 2697
Pot Life	Min 60 min at 25 ^{0} C	ASTM C603-90
Setting time for foot traffic	2 days at 25 ^{0} C	ASTM D 5895
Compressive Strength	60 MPa at 7 days	ASTM C579
Flexural Strength	38 MPa at 7 days	ASTM C 580-02
Tensile Strength	8 MPa at 7 days	ASTM C307
Abrassion Resistance H22 Wheel 1000 cycles – CS17 wheel	Less than 230 mg Less than 130 mg	ASTM D2240
Hardness, Shore D	Min 80	ASTM D2240
Adhesive Bond strength to concrete at 7 days	More than 1.5 MPa Concrete failure	ASTM D4541

19.18.5.5.4 **SURFACE PREPARATION**:

Generally all surfaces to be painted shall be cleaned of oil, grease and other foreign matter. If the surface is very oily a detergent wash may be applied. The surface shall then be rubbed with No. 60 to 80 emery paper and the dust removed thoroughly with a clean cotton cloth.

19.18.5.5.4.1 CONCRETE SURFACES

Air water jet at a pressure of 7 Kg/cm2 shall be applied through a nozzle having a tip orifice of 1.5mm. The surface shall be allowed to dry. Pin holes if any exposed due to air water jetting shall be filled with cement paste and excess cement mortar shall be removed after drying by rubbing with emery paper followed by wiping with clean cloth.

In the case of floors, all laitance, stains and other deleterious substances shall be removed by using a floor polishing machine followed by a thorough air water jetting and cleaning. Oil and grease shall be removed by wiping with cloth soaked in thinner or acetone.

19.18.5.5.4.2 STEEL SURFACES

All steel work shall be cleaned of rust, scale, dirt, oil, weld splatter and other deleterious substances by shot blasting.

19.18.5.5.5 EQUIPMENT FOR PAINTING

Generally, only airless spray equipment of ratio not less than 66:1 shall be used for all painting works. Only trained personnel shall be allowed to operate the airless spraying equipment. The capacity of the equipment shall be such that it will provide maximum dry film thickness without sagging of the paint film. However, at places, where airless spray equipment cannot be used, painting with brushes shall be permitted at the discretion of the Engineer-in-charge only.

19.18.5.5.6 APPLICATION OF PAINT

General

Painting shall commence from top of walls and shall be worked down. Floors shall be painted from one corner working towards exit to avoid walking over painted areas. The paints shall be mixed and applied in accordance with manufacturer's instructions. Only approved primer coat shall be applied on the concrete or steel surfaces. The final finish paint should give a dry film thickness as specified in drawings/ specifications. The thickness shall be made up in minimum number of coats as possible.

The curing time between successive coats shall be around 16 hours unless recommended otherwise by the paint manufacturer.

On concrete surfaces, inert filler shall be applied after the first coat to cover the uneven surface. It shall be noted that inert filler material shall not be applied over the entire surface as such layer will lead to loss of adhesion of the subsequent layers of paint. After application of the inert filler the surface shall be rubbed down with Nos. 80, 120 and 140 (as the case may be) sand paper and the rubbed surfaces cleaned by air jetting followed by cleaning with soft cloth before the successive coat of paint is applied. Each coat of paint except the final coat shall be slightly roughened using sand paper to obtain good adhesion of the successive coat of paint.

The paint shall be spread uniformly without runs, sags or brush marks (in case of brushing). Care shall be taken during spraying operations to hold the nozzle sufficiently close to the surface (not closer than 300mm) being painted to avoid evaporation of the volatile constituents of the paints and loss of materials into the air. The air pressure shall be kept at the required level through the entire painting operation. Each coat of paint shall be inspected after curing for the finish and dry film thickness. Necessary compositor plates shall be fixed on to the surface during painting, for checking the dry film thickness at various intervals as may be necessary. Wet film thickness gauges shall also be used during the painting and the thickness of wet film shall be recorded.

19.18.5.5.7 APPLICATION OF SELF LEVELING EPOXY FLOORING

The floor receiving the self-leveling epoxy flooring must be sound, dry, fine-grained and load bearing, free of laitance, loose and brittle particles and shall also be free from substrate and substances which impair adhesion such as oil, grease, rubber skid marks, paint or other contaminations.

The bond strength of the substrate must be at least 1.5 MPa. Ensure the compressive strength of the floor concrete is at least 25MPa and that floor slabs directly in contact with the ground have a proper vapour barrier installed and the moisture content of substrate shall not be higher than 4% throughout.

The temperature requirements shall be in the range given below:

A] Substrate temperature: 15°C - 35°C
B] Material temperature: 15°C - 30°C

The priming is essential to seal the concrete surface prior to the application of the self-level epoxy flooring. For primer shall be applied using medium nap roller ensuring a complete coverage without holidays, if after drying the surface appears patchy due to high absorption, recoating of primer shall be done in such areas. Primer shall be allowed to dry before commencing topcoat application of the self-level epoxy floor coating.

All mixing should be done mechanically, using a slow speed drilling machine fitted

with a paddle, taking care to ensure that the mixing head is well within the material during mixing.
Applicator must wear spiked shoes during application. Mixed material shall be poured onto the primed and sealed surface and spread to full specified thickness using a pin screed or a notched trowel to achieve the specified thickness. The spread material should be immediately rolled with a spiked roller to release entrapped air and remove trowel marks. Control rolling shall be continued until all air is released well before the material starts stiffened.

19.18.5.5.8 PRECAUTIONS TO BE TAKEN

Required oil free compressed air at correct pressure shall be available with suitable compressors.

The equipment with all its accessories shall be cleaned immediately after the painting is completed with suitable thinner after painting.

All material such as paints, thinner, inert filler and Primer shall be stored safely, handled carefully and account of consumption recorded regularly. The paints used are volatile and hence proper ventilation shall be maintained in the areas of painting.

Explosion meters shall be used to constantly check the fume concentrations to avoid any explosion. The area to be painted shall be well ventilated by using fans/air blowers.

Sufficient lighting arrangements shall be ensured before start up of painting.

Proper staging and scaffolds shall be ensured while painting at heights.

Embedment, equipments pipes etc. shall be suitably masked before the painting commences.

After the painting, areas shall be cleaned of stains if any.
Care shall be taken to see that no welding/ Gas cutting is carried out where painting work is in hand or near to storage area.

19.18.5.5.9 Maintenance of records

A daily progress record shall be maintained.

19.18.5.5.10 Handling precautions

All the precautions must be taken to avoid direct contact of resin and hardener with skin. The persons handling epoxy resin and hardener must use rubber or polythene gloves. Parts of the skin, which come in contact with resin or hardener, should be washed with lukewarm water and mild soap. Manufacturer’s recommendation on these aspects should be followed.

19.18.5.6 ANTI CARBONATION, ANTI CORROSIVE AND WATERPROOF COATING

19.18.5.6.1 SCOPE

The specification described here covers material description, physical and mechanical properties, testing, applicable codes and standards, acceptance criteria, surface preparation and QA requirement etc. for protective coating using Aliphatic acrylate system on external surface of buildings unless specified otherwise.

19.18.5.6.2 MATERIAL

The protective coating on the external concrete surfaces shall be pure aliphatic acrylate system. It shall be single component; solvated aliphatic acrylic resin based coating for protection of concrete from carbonation, chloride ions, weathering and industrial pollution.

19.18.5.6.3 SURFACE PREPARATION

The surface shall be clean and free from loose particles, oil, grease, or any other contamination. The concrete surface shall be cleaned with wire brush and shall be washed with clean water. The surface having oil and grease shall be cleaned with detergents.

The surface irregularities such as blow holes, honeycombs, crevices and surface blemishes shall be filled with polymer modified cement putty mortar to achieve smooth and level surface this shall be allowed to cure by spraying water for two days and to dry for one day.

The substrate shall be in dry condition before the application of protective coating for better performance. The compatibility of this system shall be checked with the existing coating system, if any.

19.18.5.6.4 APPLICATION

Prepared Concrete substrate shall be applied with a compatible coat of primer at least 2 hours before application of Coating. The Primer shall have following properties.

PROPERTY	UNIT	TEST METHOD	ACCEPTANCE VALUE
Mixed Density	Kg/ltr	ASTM D 6237	0.95
Volume Solid	%	ASTM 5201	Min 32%
Over Coating Time	Hrs	ASTM D 1005	2 (at 25 ^{o}C)

Over the primer the protective coating shall be applied using brush or roller or airless spray. The complete protective coating shall be applied in minimum one primer and two main coats. The first and the second main coat shall be applied approximately

with a gap of 24 hours at right angles to each other. At low temperature, the subsequent coat shall be applied after ensuring that the earlier coat is fully dry.

19.18.5.6.5 CURING

The aliphatic acrylate based protective system is naturally air cured. Hence, no separate curing is required.

19.18.5.6.6 COVERAGE

The coverage depends on the type of surface (concrete, plaster, masonry) and surface finish. The Engineer In Charge shall check the coverage as per the manufacturer's specification. Engineer-in-charge shall verify the quantity of material used at site along with bills from the manufacture and the coverage specified in the manufacturer's specification.

The protective coating shall be applied in two coats over a primer coat. Each coat shall have a minimum thickness of 75 microns. The total dry film thickness inclusive of Primer shall be minimum 225 microns.

19.18.5.6.7 STORAGE AND SHELF LIFE

The material shall be stored under cover, out of direct sun light and shall be protected from extremes of temperature. The shelf life shall be as per the manufacturer's specification.

19.18.5.6.8 Properties

The properties of aliphatic acrylate based protective system are as follows. The base and system shall be pure aliphatic acrylate base and single component system.

PROPERTY	UNIT	TEST METHOD	ACCEPTANCE VALUE
Density	Kg/ litre		1.10 (min)
Volume solids	%	ASTM D 5201	37% (min)
Dry film thickness (DFT) for 1 Primer in white shade + 2 Top Coats	Microns	ASTM D 1186	225 microns in 1 Primer + 2 Top Coats
Adhesion with Concrete/ plaster surface	MPa	ASTM D4541	3.0 or concrete failure
Water vapour permeability test	gm/sq.m/day	ASTM D 1653	7 gm/sq.m/day at 75% RH at 25C (max)
Water penetration test	% weight gain	IS 3085	NIL at 5 kg/cm^2 hydrostatic test

Flexibility -Standard bend test		ASTM D 522	No cracks on the surface in 1/8 inch Mandrel
QUV- condensation test	Hours	ASTM G 53 for 500 hours	Passes - No discolourisation and chalking
A.C. Impedance Test in 3% sodium chloride	Coating resistance	Using Electrochemical impedence measurement for a frequency range of 100 KHz to 0.01Hz with AC amplitude of 20 Mv.	Initial value: $9x10^9$ Ohms (min) Final value after 30 days: $1x10^7$ 0hms (min)
CO2 diffusion resistance	Equivalent air layer thickness, R	AS/NZS 4548.5 – 1999: Taywood Method	>70m
	Equivalent Concrete Layer Thickness		>170 mm

Note: A.C. impedance test for the protective coating is required for application on RCC surface. This test may not be required for application on masonry/ PCC surfaces.

19.18.5.6.8.1 **Material**

Base: Aliphatic Acrylate Solvented System
Components: Single component

19.18.5.6.8.2 **Volume Solids**

Test Method: ASTM D 5201 –97 Standard practices for calculating formulation physical constants of paints and coatings.

19.18.5.6.8.3 **Dry Film Thickness**

Test Method: ASTM-D-1186: Test method for non-destructive measurement of dry film thickness of non magnetic coatings applied to ferrous base.

Methodology for adopting on concrete/masonry/plaster surface: Cleaned steel plates shall be fixed to the concrete surface firmly at regular intervals during application of protective coating. The dry film thickness (DFT) measurement shall be carried at every 100 sq.m area or part there off.

19.18.5.6.8.4 **Adhesion with concrete/ plastered surface**

Test Method: ASTM-D-4541-02: Standard test method for Pull-off strength of coating using portable adhesion testers.

19.18.5.6.8.5 **Water Vapour Permeability test**

Test Method: ASTM-D-1653: Standard test method for water vapour transmission

of organic coating films.

19.18.5.6.8.6 **Water penetration Test**

Test Method: Water penetration resistance tested by immersing coated concrete cubes (5 cm x 5 cm x 5 cm size) for 12 days. Even at the end of 12 days, the weight gain shall be NIL to negligible.

19.18.5.6.8.7 **Flexibility- Standard bend test**

Test Method: ASTM-D-522: Standard test method for mandrel bend test for attached organic coatings.

19.18.5.6.8.8 **QUV- Condensation Test**

Test Method: ASTM-G-53: Standard practice for operating light and water exposure apparatus (fluorescent UV- condensation type) for exposure of non-metallic materials.

19.18.5.6.8.9 **Impedence Test (in 3.0% NaCl solution)**

Test method: Electrochemical impendence measurements for a frequency range of 100 kHz to 0.01 Hz with an AC amplitude of 20mV.

19.18.5.6.9 TESTING

The material shall be tested as per this specification by the contractor at no extra cost to NPCIL. Each batch of material used for the NPCIL job shall be tested in any of the approved independent laboratories. The independent test certificates along with the manufacturer's test certificate shall be submitted to NPCIL. The independent testing shall be witnessed by NPCIL representative, If felt necessary by the Engineer.

19.18.5.6.10 PACKAGING AND SHIPMENT

Materials delivered at site shall be clearly marked with legible and intact labels with manufacturer's name, brand name, product identification, manufacturing & expiry dates and batch number. The products shall be in original, unopened / sealed containers. Material shall be stored in areas where temperatures conform to manufacturer's recommendations and instructions.

19.18.5.6.11 SAFETY PRECAUTIONS

The work shall be carried out by an authorized contractors/applicator

The application shall comply with the procedure given above, all current relevant codes of practice and the Building Regulations.

All materials shall be stored clear of ground and moisture with weather protective covering. All the materials shall be kept away from sources of ignition.

The protective coating shall not be applied during inclement weather or when ambient condition is not allowing proper application.

Safety scaffolding, access ladders etc shall be provided in accordance with the current industrial safety and all the health and safety regulations shall be adhered to.

Care shall be taken during storage and use to avoid contact with eyes, mouth, skin and food stuff. The container shall be sealed after use.

19.18.6 PROTECTION

Furniture and other movable objects, equipment, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationery equipment shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as per instruction of the Engineer.

19.18.7 CLEANING UP

In addition to the provision in 'Conditions of Contract' the Contractor shall, upon completion of painting etc., remove all marks and make good surfaces, where paint has been spilled, splashed or splattered, including all equipment, fixtures, glass furniture, fittings, etc. to the satisfaction of the Engineer.

19.18.8 ACCEPTANCE CRITERIA

a) All painted surfaces shall be uniform and pleasing appearance (gloss/ matt finish).
b) All varnished surfaces shall be of uniform texture and high glossy finish.
c) The colour, texture etc. shall match exactly with approved samples.
d) All stains, splashes and splatters of paints and varnishes shall be removed from surrounding surfaces

19.19 WATER SUPPLY, DRAINAGE AND SANITATION

19.19.1 SCOPE

The specification covers the general requirements for providing and laying water supply, piping, and providing and laying drainage lines.

19.19.2 CODES AND STANDARDS

Some of the important Codes and Standards relevant to this specification shall be followed: Latest editions shall always be consulted.

The following IS Codes shall be applicable:

IS: 1172 - Code of basic requirements for water supply drainage and sanitation.

IS: 1200 - Methods of measurement of building and civil engineering works.

IS: 1239 - Steel Tubes, Tubulars and other wrought steel fittings. (Pt. I & II)

IS 16098-2-Structured-Wall Plastics Piping Systems for Non-Pressure Drainage and Sewerage –specification

IS 7634-2- Plastics Pipes Selection, Handling, Storage and Installation for Potable Water Supplies - Code of Practice, Part 2: Laying and jointing of polyethylene (PE) pipes.

IS 14333 -High density polyethylene pipe for sewerage

IS: 1742 - Code of Practice for building drainage.

IS: 5329 - Code of Practice for sanitary pipe work above ground for buildings.

IS: 3076 - Specification for Low density polyethylene pipes for potable water supplies.

IS: 4984 - High density polyethylene pipes for potable water supplies.

IS: 458 - Pre cast concrete pipes (with and without reinforcement) - specification

IS: 783 - Code of Practice for laying of concrete pipes.

IS: 784 - Pre-stressed concrete pipes.

IS: 1726 - Specifications for Cast Iron Manhole Covers and Frames.
IS: 5961 - Specification for Cast Iron gratings for drainage purposes.

IS: 5219 - Specification for cast copper alloys traps. Part-1 - ‘P' & 'S' traps.

IS: 771 - Specifications for Glazed fire-clay sanitary appliances.

IS: 772 - Specifications for general requirements for enameled cast iron sanitary appliances.

IS: 774 - Flushing cistern for water closets & urinals (Other than plastic cisterns) - specifications.

IS: 775 - Cast Iron brackets & supports for wash basins and sinks.
IS: 2548 - Plastic seats and cover for water closets – specifications.

IS: 2527 - Code of Practice for fixing rain water gutters and down-pipes for roof drainage.

19.19.3 DRAWINGS

a) Checked and approved drawings showing locations of sanitary and water supply fixtures will be furnished to the Contractor and all drawings so furnished shall form a part of this specification. The Contractor shall refer these drawings for all information contained thereon which pertains to and required for his work. He is, however, not to commence detail plumbing, water supply and drainage on the basis of drawings unless such drawings or parts of such drawings are officially released as 'Released for Construction'. Revision to drawing and any new drawings made to include additional work by the Contractor shall be considered a part of this specification and contract.

b) Unless otherwise specified, the plans and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and accordingly the job shall be carried out for completeness as required whether each item is mentioned here or not.

c) Based on line diagrams/drawings furnished by the Engineer, the Contractor will have to prepare detailed working drawings indicating the positions of fittings, valves, joints, nature, type and location of supports, connections to main lines etc. Four prints of each of these detailed drawings shall be submitted to the Engineer for approval. The drawings shall be got approved before proceeding with the execution of the work. The Contractor shall obtain permission from all local statutory authorities for all proposed works prior to commencement of execution and necessary fees, etc. shall be borne by him. The Contractor should, after completion of all works, give "as built" drawings incorporating all field changes made, for reference and use of the client. The final payment due to the Contractor will be effected only after such drawings are finalized.

d) Construction shall not be started until the Contractor has received copies of such drawings upon which the Engineer has endorsed approval. The approval of the Engineer of any of the drawings shall not relieve the Contractor from his responsibility for correctness of Engineering workmanship, fit of parts, details, materials, errors or commissions of any all work shown thereon. The Engineer's approval shall constitute approval of the design, sizes of pipes and layout only. The approval shall not invalidate any claim the Owner may make for damages on account of faulty construction.

e) The Engineer will return one copy of the Contractor's drawings marked with his approval/comments. The Contractor shall furnish the Engineer 2 prints and one reproducible of all final drawings for record purposes.

19.19.4 **PIPING FOR PLANT DRAIN WORKS**

a) Double walled corrugated pipes, conforming to IS:16098, Part 2

For equipment (plant) drain works underground double walled corrugated pipe conforming to IS: 16098, Part 2, stiffness class SN 8 shall be used. These pipes will be used for external buried (underground) pipe lines. Work involved includes providing, jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS : 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

b) HDPE pipes conforming to IS:4984

For equipment (plant) drains works underground HDPE pipes of higher diameter conforming to IS:4984, grade PE 100, pressure rating PN 6 shall be used. These pipes will be used for external exposed pipe lines. Work involved includes providing, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

19.19.5 PIPING FOR PLANT SEWER WORKS

a) Internal sewer works

For internal sewer works of main plant buildings under floors or against walls, HDPE pipes conforming to IS: 14333, grade PE 100, pressure rating PN 12.5 shall be used. Scope of work shall include providing HDPE pipes and fittings, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Laying and jointing shall conform to IS: 7634 (Part-2).Scope shall also include cutting and trimming of pipes, preparation of bends as per requirement at site, taking suitable supports from Ceiling and walls/ preparation of bed etc. all complete as per drawings, manufacturer's specifications and direction of the Engineer.

b) External sewer works

i) For external sewers under gravity flow underground double walled corrugated pipe conforming to IS: 16098, Part 2:2013stiffness class SN 8 shall be used.Scope of work shall include providing pipes and fittings, laying or fixing in position, including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Scope shall also include laying and jointing of pipes conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

ii) For external sewers under pressure, underground HDPE pipes conforming to IS: 14333, grade PE 80, pressure rating PN 6 shall be used. Scope of work shall include providing pipes and fittings, laying or fixing in position including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints. Scope shall also include laying and jointing conforming to IS : 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. all complete as per manufacturer's specification.

19.19.6 WATER SUPPLY PIPING AND FITTINGS

a) All water supply pipes shall be 'C' class (heavy duty) galvanized M.S. pipes of the specified internal diameters, conforming to IS: 1239**.** The pipes shall be fixed in longest possible lengths with all necessary bends, tees and couplings, reducing tees, etc. in perfect straight lines vertically and horizontally. For joining pipes threads of tube sand fittings shall be smeared with white lead and screwed down together with jute threads smeared with lead. Exposed surfaces of pipes shall be coated with 2 coats of oil paint if required by the Engineer. G.I. pipes shall be embedded in a chase out in internal wall chase shall be filled with cement mortar when directed at no extra cost. All G.I. pipes inside shaft shall remain clear off walls by at least half an inch. They shall be fixed with galvanized malleable iron bat clamps.

b) All brass or chromium plated fittings shall be of approved make and of the best quality, heavy cast or drawn brass, thoroughly annealed and shall be seamless.

19.19.6.1 **VALVES**

Valves shall be of best quality gun metal sluice valves unless specified otherwise, of screw down type with cast iron hand-wheel. Valves up to and including 15 mm diameter shall have threaded sockets.

19.19.6.2 **SUPPORTS**

a) Supply pipes, ladders, soil drain rain water and waste pipes etc. installed in a vertical position shall be hold firmly in place by GI/ W.I. clamps unless projecting ears with fixing holes are provided at socket and of pipes or by approved inserts wall fastened to the walls or structural framing.

b) Sleeves shall be provided for all pipes passing through walls floor and partitions, except at locations specifically forbidden by the Engineer. All sleeves shall be painted steel pipes. Pipe hangers where provided shall not be wider apart than 1.5 m on centres for cast iron pipes. General scheme for support arrangement shall be got approved by the Engineer before it is erected in position. The Engineer shall have the right to increase the number or strengthen or modify the supports at site.

c) All piping, where not concealed and where location is not specifically fixed by drawings shall run parallel and as close as possible, to wall.

19.19.6.3 **PLUMBING WORK**

The pipes before being laid shall be thoroughly cleaned specially the inside of pipes if required. Socket ends of pipes shall always face upstream of effluent flow. The drains shall run in perfect straight lines between manholes. The trenches shall not be filled in until the joints have been tested and alignment of drains and connections into and from the manhole and their positions have been examined and certified and certified by the Engineer, if required. The whole of sanitary work comprising provisions of drainage and water supply arrangements including sanitary and water fittings and fixtures complete in all respects shall be carried out in accordance with the rules and regulations of the local authority through the agency of a licensed plumber. If required, the Contractor shall have to get all materials brought on site for incorporation in the work approved by the local authority at his own expense.

19.19.6.4 **PROTECTIVE PAINTING**

All exposed wrought iron clamps, steel suspenders or brackets for fixing the pipes to the wall face in case of vertical pipes and suspending the horizontal run of pipes shall be painted with one coat of zinc phosphate primer and two coats of paint of approved make and shade.

19.19.7 **TEST AND GUARANTEE FOR WATER SUPPLY, SOIL AND VENT SYSTEM**

a) Water supply lines shall be tested to a hydrostatic pressure of 12 times the design water pressure at any point over a period of 24 hours. All soils, waster, rain water pipes and vents shall be tested under a pressure of 3 meters of water. Rain water pipes shall be tested to a height of water equivalent to the height of the building plus 3 meters to ensure no leakage in case of choking sections by first installing test plugs in all openings, erecting 3 metres stand pipe, filling the system with water or by hydrostatic plus air test. Pipes shall be deemed to have passed the test, if water level in the stand pipe remains reasonably constant for a period of one hour.

b) The Contractor shall deliver to NPC upon completion of this work under this Contract a written guarantee: -

i) That for a period of one (1) year after acceptance by the Engineer, plumbing and drainage work shall be free from defective material and workmanship;

ii) That for a period of one (1) year after acceptance by the Engineer the Contractor shall be responsible for the tightness of all joints make by him;

iii) That he at his own expense, repair and replace all such defective work, and all other work damaged thereby, which becomes defective during the term of guarantee;

iv) After the completion of the work, the Contractor shall obtain and hand over to NPC necessary certificates from the local authority/authorities concerned at no extra cost to NPC.

19.20 SANITARY FITTINGS/ FIXTURES AND TOILET REQUISITES

19.20.1 MATERIAL

All sanitary fixtures shall be of the best quality from approved manufacturers. Contractor has to obtain the approval from the Engineer, the names of the manufacturer whose product he proposes to use. All fixtures shall bear the seal of the approved manufacturer. All fittings, screws, gratings, etc. shall be chromium plated. The connecting lead pipes and bends shall weigh at least 3 kg per 25 mm diameter per metre length. After the fixtures are brought to the site, the Contractor shall arrange for their inspection by the Engineer and only after the approval, the fixtures shall be installed. All broken, damaged or rejected fixtures shall be removed from the site within two days after inspection.

19.20.2 INSTALLATION

All sanitary fixtures shall be installed to required level and plumb in the best workman like manner skilled labours and it shall be securely anchored to walls and floors.

All fixtures likely to be damaged shall be covered and protected during the progress of the building work, and uncovered after completion. Fixtures and accessories shall include all anchors and screw plates, screws, bolts, toggle bolts, expansion shields, set screws, wood blockings and plugs, lead connecting lead-pipes, etc. as required by the type of fixtures and accessories selected and by the type of construction to which they are connected. All fixtures and fittings shall be connected by water-tight joints. No dripping shall be accepted. All holes in walls and floors as required shall be made to the minimum desired size and depth only and they shall be properly made good and finished to match the existing finish. All brackets, supports, etc. shall be painted with a prime coat of anti-corrosive paint.

19.20.3 SANITARY FITTINGS &FIXTURES

The contractor has to mention the names of the manufacturers of the fixtures he intends to use. The sanitary fittings &fixtures shall be as described here under.

19.20.3.1 WATER CLOSETS

a) WESTERN STYLE

European water closet shall be of premium quality of size 710*390*765 mm of approved make and shade comprising of

(i) Double siphonic pattern coupled water closet with integral 'P' trap 180 mm roughing in and 'S' trap 250 mm roughing in,in glazed vitreous chinaware of matching colour.

(ii) 10 litres capacity PVC slim type single flushing low level flushing cistern (Dual Flush Tank white) with all fittings complete.

(iii) 15 mm NB heavy quality CP inlet connection pipe with brass unions and wiped solder joints at ends.

(iv) 15 mm NB screw down easy clean variety heavy quality CP brass angle valves with C.P. flange of superior quality.

(v) Germfree EWC solid seat cover (white) with C.P. brass hinges and rubber buffers of approved brand.

(vi) Jet spray provision with 1 Meter PVC tube (stainless steel) with 01 nos 15mm dia CP brass angle valve with CP flange as approved.

(vii) 15 mm NB heavy quality GI pipes and specials for overflow from cistern upto 150 mm above floor level, concealed in wall and terminated with 15 mm NB brass mosquito proof jali etc. all complete as per direction of the Engineer.

The European water closet shall be installed properly in all line and level as per direction of the Engineer.

b) INDIAN STYLE

Orissa type water closet shall be of premium quality of approved make and shade with 'P' or 'S' trap in vitreous chinaware best quality first grade with or without vent, having size 580mm x 440 mm or equivalent. It shall have following accessories.

(i) 10 liters capacity PVC slim type single flushing low level flushing cistern Dual Flush Tank with all fittings fitted over a pair of CI or MS bracket etc.

(ii) Lead valve loss syphon 15 mm nominal size, 32 mm NB GI flush pipe heavy quality of appropriate length with brass unions at end, wiped solder joints etc. complete.

(iii) 15 mm NB GI overflow pipe concealed in wall and brought down to 15 cm above floor level with mosquito proof jali at end as per specification.

(iv) 15 mm NB heavy type CP brass inlet connection with brass unions and wiped solder joints at ends.

(v) 15 mm NB heavy type CP brass screw down angle valve with C.P. brass flange of superior quality on inlet connection, recess concreting using 1:5:10 nominal mix as per site requirements.

The scope shall include all accessories, necessary brackets, supports, fittings, screws, gratings etc., installation including cutting and making good necessary opening chases etc. all complete as per specifications, drawing and as directed by the Engineer.

The WC pan shall be installed as per manufacturer's specifications. The W.C. pan shall be sunk in floor. The floor should slope towards the pan, care being taken not to damage the pan in the process of fixing. It shall be fixed on the proper cement concrete base taking care that the cushion is uniform and without having any hollows between the concrete base and the pan. The joint between the pan and the trap shall be made with cement mortar (1 cement: 1 sand) and shall be leak proof.

19.20.3.2 URINALS

(a) LIPPED URINAL

The lipped urinal shall be of premium quality white vitreous chinaware flat back lipped front urinal of approximate basin size 465 x 355 x 265 mm of approved make with PVC flushing cistern with all fittings, fitted on CI brackets, standard size galvanised iron flush pipe, waste pipe and CP brass spreaders with brass union, push cocks, specials, connecters & stopcock, CP brass fittings etc. and GI clamps, painting of fittings and brackets, cutting chase and making good the walls etc. all complete. The urinal shall be bowl type, flat back of angular, lipped front basin and shall be of glazed stoneware. It shall be fixed in position by using wooden plugs embedded in wall and screws of proper size.

The flushing of the urinals shall done for one urinal basin with 5 litres capacity automatic or equivalent with PVC flushing cistern. The flushing of the urinals shall done for range of two urinal basins with 10 litres capacity automatic or equivalent with PVC flushing cistern. It shall be supported on a pair of C.I. cantilever brackets which shall be embedded /fixed to wall by means of wooden plug and screws. The cistern shall be connected to urinal basin by means of C.F. brass flush pipe with fittings. The pipe shall be fixed by using proper holder – bat clamps.

The joint between the urinal basin and flush and waste pipe shall be made by means of putty or white lead mixed with chopped hemp.

(b) URINAL PARTITIONS

The Urinal partitions shall comprise of be premium quality black granite of 18mm thick with rounded exposed corners etc. as approved by Engineer. It shall be in size 600 x 1000 mm or as approved by the Engineer. The scope

shall include installation of partitions by cutting the wall & making good the same after fixing the partitions in approved pattern including all materials, labour, fittings and fixtures complete as per specification and direction of the Engineer.

19.20.3.3 WASH BASINS

(a) STANDARD WASH BASIN

The standard wash basin shall be premium quality glazed vitreous chinaware wash basin of approved make and colour having size 550 mm x 400 mm or equivalent. This shall include one pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make., 32 mm NB CP brass waste coupling heavy quality with rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved., 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, One no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm dia B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti-corrosive bituminous paint etc. and accessory required for installation and fixing of the wash basin all complete as per the direction of Engineer. The wall plaster on the rear shall be cut to overhang with top edge of the basin.

(b) OVAL SHAPED WASH BASINS

The oval shaped was basin shall be of premium quality glazed vitreous chinaware wash basin of approved make and colour having size 560 mm x 450 mm or equivalent. This shall include one pair of wall bracket of 35mm x 35mm x 5mm M.S. angle painted with two coats of white enamel paint of approved quality and make., 32 mm NB CP brass waste coupling heavy quality with C.P. grating, rubber plug and chain, angle valve and PVC connector, 32 mm NB CP casted brass bottle trap with extension piece and wall flange and connected C.P. pipe as approved., 15 mm NB, CP brass pillar tap heavy deluxe type with triangular / roundish knob for hot & cold water and 15 mm NB CP inlet connection with all brass unions and wiped solders joints, One no. central hole C.P. brass basin mixer without popup waste system with 450mm long braided hoses of superior quality as approved., 32mm diameter B class G.I. waste pipe (concealed) of required length (from bottle trap to nahani trap) including painting with anti-corrosive bituminous paint etc. and any other accessory required for installation and fixing all complete as per the direction of Engineer.

19.20.3.4 SINK

(a) VITREOUS CHINAWARE LABORATORY SINK

The vitreous chinaware laboratory sink shall be of premium quality glazed conforming to BIS 771 Part-2 of bowl size 600mm x 400mm x 200mm with

integrated drain board of approved make including all fittings, CI brackets, CP brass chain with rubber plug, angle valve and connector etc. complete with 40 mm CP brass waste fitting and 40 mm CP brass trap with necessary CP brass union, CP brass connecting pipes and any other accessory as required etc. complete as per specification and direction of the Engineer. The scope includes installation of the sink as per manufacturer's specification.

(b) STAINLESS STEEL SINK

The stainless steel sink shall be of premium quality of SS grade 304 glossy finish having size 600 x 400 x 200 mm (24"x18"x8") with edges rounded off. All fittings, fixtures, waste connection etc. shall be of standard size and appropriate for use with SS sink material. Accessories shall include: GI brackets: 32 mm NB CP brass waste coupling heavy quality with rubber plug and chain: 32 mm NB CP brass bottle trap with extension piece and wall flange: 15 mm NB CP brass inlet connection with all brass unions and wiped solders joints and all accessories such as choke stop stainer, outlet pipe upto floor trap and any other accessory as required. The sink shall be installed as required complete as per specifications and direction of engineer in charge.

19.20.3.5 **WATER CONNECTION**

Water connection to flushing cistern, wash basins and sinks shall be by means of PVC/ GI pipe connection pieces, with stop C. P. Brass cocks. The size of the PVC pipe connection and stop cock shall depend upon the size of water connection.

19.20.4 **TOILET REQUISITES**

a) MIRROR

Mirror shall be of premium quality cut edge mirror 6mm thick of overall size 600X450mm especially fabricated with superior glass (of approved quality) with designer acrylic PVC frame of approved colour and make mounted all-round with 6mm thick non-water absorbent Acrylic/PVC material backing fixed with cleats using C.P. brass screws and washers all complete as per the specifications and directions of Engineer. Scope shall include supply and fixing of mirror.

b) SHOWER SETS

Shower rose shall be of premium quality easy clean CP brass shower rose. It shall include shower arm 190mm long and wall flange of superior quality with 15 mm inlet of 100 mm diameter revolving type etc. all complete. Shower sets shall be swivel type

CP brass shower rose, complete with water valve, supply pipes, and any other accessory etc. Scope shall include supply and fixing of shower rose.

c) GLASS SHELVES

Glass shelves shall be of premium quality of size 600 x 125 mm of sheet glass 6 mm thick or equivalent with CP brass brackets and guard rails, fixed to wooden cleat with CP brass screws. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

d) TOWEL RAILS

Towel rods shall be of premium quality CP brass heavy quality of size 600 x 20mm with a pair of CP brass brackets, wall flanges etc. fixed to wall with CP brass screws, screwed on to rawl plugs. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

e) LIQUID SOAP DISPENSERS

Liquid soap dispenser shall be of premium quality of CP brass with CP brass lid and brackets fixed to wooden cleat with CP brass screws. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

f) TOILET ROLL HOLDER

Towel roll holder shall be of premium quality of size 150 mm x 150 mm or equivalent recess type in white glazed vitreous chinaware including cutting into wall and making good the same all complete. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

g) COAT HOOKS

Coat hooks shall be of premium quality CP brass two pronged hooks fixed to wall / door with CP brass screws and rawl plugs including cutting and making good the wall etc. complete. The scope shall include all fixtures and fittings required for installation of the glass shelves complete as per specifications and direction of the Engineer. Scope shall include supply and fixing of glass shelves.

20 BUILDING JOINTS

20.1 EXPANSION JOINTS

20.1.1 SCOPE OF WORK

The work shall include providing and installing sealed expansion joints for various buildings in accordance with the requirements and details given in the specifications, drawings, schedule of quantities, together with the manufacturer's instructions, all to the complete satisfaction of the Engineer. The typical details of Expansion joint system are given in the enclosed drawing. The drawing given here is indicative. The contractor has to get the drawing prepared & approved before its actual use. The joints shall be designed utilizing extruded aluminum base members, self aligning / centering arrangement and support plates as applicable. The work involves sealing the Expansion Joints using properly designed extruded seals which may be mechanically fastened between extruded metal shapes, depending on the application. The design shall allow for joint movement in all direction and shall guard against water ingress. The latter shall be provided for all external joints, joints in areas in contact with water and at all other locations as directed by the Engineer. The complete details of the material proposed to be used shall be furnished to the Engineer for his approval. The material shall be used only after obtaining the written approval of the Engineer. The contractor shall furnish the necessary documents, prepared by the manufacturer of the expansion joints, to enable the Engineer to satisfy himself regarding the suitability of the materials and adequacy of the design of the expansion joints.

20.1.2 The Work shall be carried out by the manufacturer or through an experienced manufacturer approved applicator, with the prior approval of the Engineer. In case, the work is carried out by the manufacturer-approved applicator, the manufacturer will have to provide the guarantee for the successful performance of total system including material & workmanship.

20.2 MATERIALS

20.2.1 The Expansion joint materials shall be procured from manufacturers such as Sanfield (India) Ltd. / Z. Tech (India) Pvt. Ltd/ BASF or any other equivalent as approved by the Engineer and shall be installed by the manufacturer themselves and not by any distributor / agent / any other externally appointed agency so as to guarantee the quality of workmanship.

20.2.2 The Material shall conform to the following Codes / Publications.

a) Aluminum Extrusions shall conform to ASTM B221. The alloy shall be 6063-T5 or Indian equivalent IS 63400.

b) Aluminum sheet and plates shall conform to properties of ASTM-B209. The alloy shall be 6063-T5 or Indian equivalent IS 63400.

c) Steel Shapes shall conform to ASTM-A36 or Indian equivalent IS: 2062.

d) Stainless Steel shall conform to ASTM-A-479 Gr. 304 or Indian equivalent IS: 6529 Gr. 0.4Cr18Ni10.

e) **Bronze Extrusions:** Materials shall be Architectural Bronze 385 Alloy.

f) **Electrometric Compression Seal**: these shall be preformed extruded multi-web cellular section of Chloroprene (Neoprene). Chloroprene shall conform to Clause 915.1 of IRC: 83 (Part II) and satisfy the Physical properties as Durometer Type "A" Shore hardness of 55±5and a tensile strength of 2000 PSI (min).

g) **Moisture barrier**: shall be vinyl EPDM / bituminous modified moisture barrier as recommended by the joint manufacturer or an approved equivalent, all as subject to the approval of the Engineer.

h) **Fire rated joint system**: shall have independent laboratory test reports reflecting the endurance result of the materials run to time temperature curve.

i) **Elastomeric Joint Systems**: Material shall be a flexible extruded poly vinyl chloride or manufacturer's alternate material exhibiting a Shore "A" hardness of 64±5 with U.V. Stabilizer. Provide multi-cellular profile able to transfer loads to adjacent aluminum extrusions. The profile shall be flexible and exhibit a non-slip exposed surface that remains flat during all phases of movement. Block-out required for installation shall be provided at site by the contractor as per the dimensions given by the manufacturer.

j) Lubricant adhesive used shall be a one-part moisture curing polyurethane and aromatic hydrocarbon solvent mixture and shall conform to ASTM D4070.

k) **Visual seal**: shall be a flexible extruded poly vinyl chloride / santoprene or manufacturer's alternate material exhibiting Shore "A" hardness of 64±5 with U.V. Stabilizer. Other properties shall be in accordance with manufacturer's standard physical properties.

l) **Functional seal**: shall be flame retardant vinyl material.

m) **Sealant**: shall be a one-part polysulphide base synthetic rubber / Silicon sealant as per Manufacturer Specifications.

n) **Self-Centering Arrangement**: shall exhibit circular sphere ends that lock and slide inside the corresponding aluminum extrusion cavity to allow freedom of movement and flexure in all directions including vertical displacement so as to accommodate multidirectional seismic movement without causing stress to Joint components.

o) The materials used for Expansion Joints (other than air seal & metazeal type joint) shall have following properties.

Item Description	Given Specification	Indian Equivalent	Parameters to be Checked	Acceptable Values

Aluminium Extrusions. / Sheets & Plates	Alloy 6063-T5	IS 63400	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 15.00 21.00 8.00
Steel Shapes	ASTM – A36	IS: 2062	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 36.00 58.00 20.00
Stainless Steel	ASTM – A 479 Gr. 304	IS 6529 Gr. 0.4C Ni10	Mechanical Properties Yield Stress (Ksi) Tensile Strength (Ksi) Elongation (%)	 30.00 75.00 30.00
Neoprene Compression Seals	ASTM – D 2628	IRC – 83 (Part II) & MORT&H Specifications	Hardness (Shore "A") Elongation (%) [Min.] Tensile Strength (MPa) [Min.] Compression Set (%) [Max.]	55 +/- 5 250.00 13.80 28.00

20.3 JOINTS FOR NORMAL LOCATIONS

The Contractor shall provide all necessary accessories, related parts, devices, anchors etc. required for completing the installation of expansion joints in following locations.

a) Floor to Floor Joints at all internal locations
b) Roof to Roof Joints
c) Floor to Wall Joints at internal locations
d) Roof to Wall Joints
e) Wall to Wall Joints in exterior locations
f) Wall to Wall Joints & Slab to Slab Joints in case of underground trenches
g) Wall-to-Wall Joints & Slab to Slab Joints in case of underground tunnel subjected to ground water pressure from outside & water pressure from inside
h) Tunnel & Wall junction in case of underground structures.

20.4 JOINTS FOR CRITICAL LOCATIONS / HYDROSTATIC CONDITION APPLICATION

In case of underground structures which are susceptible for leakage due to ground water & hydraulic structures the expansion joint shall be provided with Airseal / Aladin type of expansion joint and/or Metazil type of expansion joint of M/S Sanfield / M/s BASF/ M/s Kanta Flex or any other equivalent with approval of Engineer. These joints are to be provided on the water face or both the faces depending on the wall thickness, severity of leakage & functional requirements as specified in the drawing or as directed by Engineer. These materials shall be qualified based on water hold test to the specified pressure and shall meet the following specifications.

20.4.1 AIR SEAL/ALADIN TYPE JOINT

The work shall consist supply and installation of Expansion Joint System model Airseal/Aladin of M/s Sanfield /M/s BASF or equivalent in accordance with the approved drawings and shall meet the following specifications.

The joints shall be designed utilizing neoprene profile, air pressurization and bonding in place with a specially formulated epoxy adhesive as per specifications.

The material shall be preformed, watertight, ozone and UV resistant, resilient and flexible neoprene profile with ribs on side faces for proper adhesion and bonding with the surface. The Joint shall be installed by air – pressurization technique only. Complete adhesion of the Epoxy to the neoprene seal profile and Joint Gap walls shall be achieved by air inflation during the installation. The relaxed (uncompressed) width of the seal shall be equal to the Joint Gap value and the Seal shall be always installed in uncompressed position so as to allow maximum expansion & contraction movements. The Joint system should be able to sustain water pressures upto 2 Bars minimum.

The structural sealing joint profile shall be preformed and manufactured from an extruded neoprene compound exhibiting the physical properties listed in the table below.

TABLE 20.1
PHYSICAL PROPERTIES NEOPRENE COMPOUNDS

SL. NO.	*PHYSICAL PROPERTIES*	TEST METHOD	REQUIREMENT
1	Tensile Strength, Min.	ASTM D 412	2000 PSI
2	Elongation @ break, Min.	ASTM D 412	250 % Min.
3	Hardness, Type A Durometer	ASTM D 2240	65 + / - 5 Points
4	Oven Aging 70 hrs. @ 212 ºF	ASTM D 573	
4.a	Tensile Strength	ASTM D 412	20 % loss Max.
4.b	Elongation	ASTM D 412	20 % loss Max.
4.c	Hardness	ASTM D 2240	0 to + 10 Points
5	Ozone Resistance @ 20 % Strain	ASTM D 1149	No Cracks

The adhesive used to fix the Airseal/ Aladin type joint with concrete/ steel surface shall be resistant to most common organic and inorganic acids in diluted form, also resistant to alkalis, water, oils, grease, etc. It shall have following properties.

SL. NO.	*PHYSICAL PROPERTIES*	TEST METHOD	REQUIREMENT
1	Tensile Strength, Min.	BS 6319	10 MPa @ 7days
2	Compressive Srength, Min. @ 25deg cen.	ASTM C 580	40 MPa at 1 day 60 MPa at 7 days
3	Flexural Strength	ASTM C 580	20 MPa at 7 days
4	Pot Life	ASTM C603-90	50 min at 25 deg cen. min at 40deg cen
5	Bond Strength, Min	ASTM D 4541	2 MPa.
6	Slant Bond Strength		13 MPa

7	Setting Time	ASTM D 5895	1 day Initial Cure 5 Days Final Cure

20.4.2 META ZEALTYPEJOINT

The work shall consist supply and installation of Expansion Joint System model Metazil of M/s Sanfield / M/s Z-tech or equivalent as approved by Engineer in accordance with the approved drawings and shall meet the following specifications.

The joints shall be designed utilizing a low density, closed cell, expanded polyethylene joint material and specially formulated epoxy adhesive for Bonding purpose as per specifications.

The material shall be a preformed, waterproof, ozone and UV resistant, resilient and flexible expansion Joint material. No Halocarbon gases or volatile hydrocarbons shall be used in the manufacturing of the product. The product should have a working movement range of 60% compression and 30% tension. The Joint system should be able to sustain water pressures up to 2 Bars minimum. The same shall be demonstrated conducting water hold tests simulating site conditions. The product should be suitable for Potable water applications and should have ADA Compliance. The material shall exhibit the properties listed below.

PROPERTY	TEST	REQUIREMENTS
Density, Min.	ASTM D 3575	2.5 to 3.5 lb./cf
Tensile Strength, Min.	ASTM D 3575	70 psi
Water Absorption, Max.	ASTM D 3575	1.0 %
Compression Set, 22 hrs. @ 50 %	ASTM D 1056	
24 hrs. Recovery	(Residual Set, Max.)	8 %
Elongation @ break, Min.	ASTM D 3575	175 %
Tear Strength, Min.	ASTM D 624	13 psi

NOTE: For critical Joint locations, where the thickness of structural member (wall / slab) is exceeding 230 mm. Double layer Treatment comprising of Airseal on the critical / outer exposed face i. e. the face in contact with water / earth soil and Metazeal on the inner face is to be applied.

20.5 FABRICATION

20.5.1 Aluminum sections shall have factory-drilled holes spaced as per manufacturer's recommendation. Extrusions shall be miter cut at the site to suit directional changes.

20.5.2 Extrusions shall be supplied to site in their original packing in lengths as fabricated to suit the building dimensions.

20.5.3 Steel shapes shall be supplied in lengths as fabricated to suit the building dimensions.

20.5.4 Aluminum sections shall have mill finish unless otherwise specified.

20.5.5 Steel sections shall be blast cleaned and suitably treated against corrosion prior to their dispatch to the site. The cleaned metal surfaces which come in contact with the seal shall be protected against water logging / rusting till the seal and the adhesive are placed against the metal surface.

20.5.6 The Details of the finished colours offered by the manufacturer for Stainless Steel and Elastomeric components shall be furnished to the Engineer to enable him to exercise his choice.

20.6 EXECUTION

The expansion joint system shall be installed strictly as per the manufacturer's instructions and as directed by the Engineer. The work shall be carried out by the manufacturer or through an experienced manufacturer approved applicator, with the prior approval of the Engineer. In case, the work is carried out by the manufacturer-approved applicator, the manufacturer will have to provide the guarantee for the successful performance of total system including material & workmanship.

20.7 QUALIFICATION OF MATERIALS

For qualification of material at site contractor shall supply the Test Certificates for the material confirming the properties given in above-mentioned tables. In addition to above one sample (3 specimens) from each batch supplied at site, shall also be tested at independent approved laboratory for all the desired properties listed above, in case of Neoprene compression seals & Airseal.

20.8 EXPANDED POLYSTYRENE BOARDS FOR EXPANSION AND ISOLATION JOINTS

20.8.1 GENERAL

Expansion and isolation joints in concrete structures shall be provided with expanded polystyrene boards of specified thickness and form expansion joints shall be provided with 500 micron thick polyethylene sheets as per the relevant drawings.

20.8.2 SCOPE

The scope of work covered under this specification is as follows:

- Supply and use of approved quality polystyrene boards wrapped in 250 micron thick polyethylene sheet at various expansion and isolation joints in all main plant buildings.
- Supply and use of 500 micron thick polyethylene sheets as form separation joint, wherever required.

20.8.3 MATERIAL

- High density polystyrene boards conforming to IS: 4671 of density 35 kg/m^3.

- Polyethylene sheets conforming ton IS: 5210 of 250 micron & 500 micron thickness.

20.8.4 DESCRIPTION

Heavy duty expanded polystyrene boards of specified thickness and sizes shall be wrapped all round with 250 micron thick polyethylene sheet. These boards shall be placed in the locations (both in vertical and horizontal) as specified in the relevant drawings. Polyethylene sheet shall be properly secured and tied in position with expanded polystyrene boards.

Wherever specified, 500 micron thick polyethylene sheet as form separation layer.

20.9 WATERSTOPS

20.9.1 GENERAL

Water stops made of polyvinyl chloride (PVC) or galvanised MS sheet shall be provided in construction joints as indicted in the relevant drawing and specifications for all main plant buildings including underground structures and tunnels.

20.9.2 SCOPE

The work under this specification comprises of

- Supply, delivery, install in position water stops in accordance with the requirements of specifications
- Polyvinyl chloride water stops
- PVC fix cap.
- Galvanised MS sheet water stop of 3.15 mm thick. Installation including necessary site connection by furing/welding.
- Testing of joints and DPT for 100% of the weld length.

20.9.3 MATERIALS

PVC water stops : Material shall conform to the following Standards of the American Society for Testing Materials (ASTM)

D412-66 Tentative method of Tension Testing of Vulcanized Rubber

D624-54 Standard method of Test for Tear Resistance of Vulcanized Rubber

D2240-64-TTentative method of Test for Indentation Hardness of Rubber by means of a Durometer

PVC fixocap type 38 or equivalent conforming to IS 4461

Metal water stops of 3.15 mm thick conforming to IS 2062 galvanised for dry film thickness of 60-100 microns.

20.9.4 **DESCRIPTION**

Generally water stops shall be provided in construction joints as indicated in the drawing, water stops may be PVC of different width (with or without centre bulb), fixco cap of standardtype GI water stopper of 3.15 mm thick plate made to different width. Generally, Fixo-cap shall be provided in expansion joints of underground tunnels and PVC water stops shall be provided in water retaining structures unless specified otherwise by the Enginner .. The shear key shall be provided wherever specified and the water stops are generally located in the centre of wall at the construction joints or near to the edges in case of earth retaining walls and half of width shall be embedded into concrete. Necessary holding arrangement shall be made to ensure that water stops does not displace during concreting. It should be noted that, there shall not be any through supporting arrangement in order to prevent leakages. Continuity of the water stops shall be established by fusing or welding as the case may be. PVC water stops shall be joined together by fusing and metal water stops shall be 75 mm overlapped and welded on both sides. 100% dye penetrant test shall be carried on all joints. As far as possible care shall be taken to minimise the number of joints and also in-situ fusing/ welding.

21 Aluminium Lineal False Ceiling

Aluminium lineal suspended ceiling work shall be executed in flat, tapered, curved or circular form, both in plan and in section together with coves, etc. as required as per design.

21.1 General

Aluminium lineal ceiling shall be of Hunter Douglas as manufactured by Luxalon Building Products or approved equivalent together with all accessories and fittings such as carrier and clip, carrier splice, edge cover profile and corner splices, cross "T" connection near to the wall, etc.

21.2 Materials

21.2.1 Panels

The panels shall be 84C or 84R as per Luxalon's catalogue or approved equivalent and either plain or micro perforated. The length of the panel shall be 6m approximately. The panels shall be of any colours as approved by the Engineer, according to manufacturer's colour chart.

21.2.2 Panel carriers

Panel carriers shall be 4mm dia enamelled aluminium of satin black colour as per Luxalon's catalogue. The edges shall be provided with edge cover profile with a gap of specified width from the wall.

21.2.3 Suspension

The panel shall be suspended from the suspension system as mentioned in the relevant clause by means of adjustable turn buckle / level adjuster etc. In addition to the suspension system, the panel carriers shall be suspended by means of adjustable suspension steel rods of 4mm diameter with threaded rods and nuts for micro levelling, fixed to the slab/ beam by expansion fasteners. The expansion fasteners shall be fixed with epoxy/polyester resin. Seismic anchoring and isolation shall be provided as directed by the Engineer. Bracing shall be provided as specified for Gypboard ceilings.

21.2.4 Acoustic Pads

Acoustic pads shall be laid on top of perforated panels. Acoustic pads shall be of the approved manufacturer and shall consist of an insulation of 25mm thick glass wool pad having a density of 32 kg/cum wrapped in glass cloth. The provision of these acoustic pads for perforated ceiling is deemed to be part of the quoted rate and noting extra shall be payable for the same.

21.3 **SHOP DRAWINGS**

Shop drawings shall be prepared for all suspended ceiling work by the Contractor. The shop drawings shall show the entire installation system, including framing around light fixtures, ducts, grilles, access panels, etc. Shop drawings shall be submitted to the Engineer for approval. It will be the responsibility of the Contractor to co-ordinate with all the service Contractor’s doing work in ceilings, to incorporate appropriate suspension systems free of ducts, pipes, cable trays etc.

21.4 **APPROVALS**

The Contractor shall submit catalogues, samples of all items to be used in the ceiling and samples of workmanship, for approval of the Engineer.

22 GLASS AND GLAZING

22.1 **Scope**

The work in general shall consist of supplying and fixing all glass and glazing including all clips putty, mastic cement, etc., wherever required as shown on drawings and specifications.

In general, wherever applicable and unless otherwise noted, the work shall conform to IS 1081. Fixing and Glazing of metal (Steel and Aluminium) Doors, Windows, and Ventilators.

22.2 Installation

22.2.1 General

The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions, unless otherwise stated in the drawing or schedule. All glass shall be of superior quality from approved manufacturer like Modiguard or equivalent, having uniform refractive index and free from flaws, streaks, laminations and bubbles. The glass should be free from “wavy and rainbow formation”. Float glass for glazing and framing purposes shall conform to IS : 1761 . The glass shall be brought to site in the original packing from the manufacturer and cut to size at site. The cut edges shall be straight and free from chips, spalls or any other damages. Wherever clear glass is specified, it shall be flat drawn float glass and shall be at least 6mm thick. Where wire glass is mentioned, it shall be thick rolled glass with centrally embedded wire mesh of Georgian type. Where obscure glass is mentioned, it shall have a cast surface on one side. Heat absorbent and glare reducing glass shall be 'Calorex' of Modiguard , having a thickness of 6 mm unless specified otherwise in the schedule of Quantity. The Contractor shall submit samples of glasses for prior approval of the Engineer.

22.3 Putty

In general, the putty shall conform to IS:419. The putty shall be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing. Quick setting putty shall be used for windows and sashes except when glare reducing glass is used.

Neoprene gaskets with snap-fit glazing beads shall be fixed as per manufacturer’s instruction and shall sit snugly against glass to give a leak proof installation.

22.4 Glazing, Setting and finishing

All glazing clips, bolts, nuts, putty, mastic cement, etc. as required shall be supplied by the Contractor.

All glass shall be thoroughly cleaned before putting in position. Each glass pane shall be held in place by special glazing clips of approved type. As specified in relevant IS Codes, four glazing clips shall be provided per glass pane, except for large panes where six or more clips shall be used as per the Engineer's instructions. All holes that may be necessary for holding the clips and for all other attachments, shall be drilled by the Contractor at his own cost.

Glass panels shall be set without springing, and shall be bedded in putty and back puttied, except where moldings are specified. Putty, mastic cement, etc. shall be

smoothly finished to a true even line. Obscure and figured glass shall be set with smooth side out.

Necessary glazing clips, putty mastic cement etc., shall be supplied by the Contractor. The Contractor shall be responsible for damage of glass supplied by NPCIL during handling, transportation, fixing etc. and shall replace the same at his own cost.

After completion of glazing work, the Contractor shall remove all dirt, stains, excess putty, etc. clean the glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at Contractor's own cost.

22.5 **Float glass for Doors**

Float glass for vision panels in door shall have a minimum thickness of 4.0 mm unless otherwise specified or shown on drawings.

22.6 **Acceptance Criteria**

a) All installation shall be free from cracked, broken or damaged glass. Edge of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipping cracked or ungrounded edges.

b) Glazing shall be carefully done to avoid direct contact with metal frames.

c) All glass shall be embedded in mastic or fixed by neoprene gaskets to give a leak proof installation.

d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer.

22.7 **Drawings**

The contractor has to submit the drawings based on the above specification while quoting for these items.

23 ROOFING INSULATION, WATER PROOFING ETC.

23.1 SCOPE

The work under this specification shall cover all insulation and waterproofing necessary for the roofing work as shown in the drawings.

23.2 INSPECTION OF SURFACES

Prior to start of the work, the surfaces on which waterproofing /insulation is to be applied shall be inspected by the contractor and any visible/ noticeable defects found in the surfaces shall be rectified. The water ponding test shall be conducted by

ponding water on the roof slab and maintaining minimum 50 mm head of water on it for a period of 3 days. Any noticeable leakage/ seepage shall be corrected by the contractor at no extra cost to NPCIL. The surface then shall be made clean and dry before laying screed concrete/ starting roof insulation / waterproofing work.

23.3 SCREED CONCRETE

The grading shall be provided by an under bed using M-15 grade concrete (with max 10 mm aggregate) prepared properly to the satisfaction of the Engineer Unless otherwise specified, the grading shall be done in such a way so as to ensure a run-off gradient of not less than 1 in 120. The minimum thickness at low points and/or valleys shall not fall below 25 mm. After curing the under bed for 7 days, insulation work shall be taken up with prior approval of the Engineer. The screed concrete shall be laid on the invert of gutters for maintaining slope in the gutter.

Fillets at junction of roofs and vertical walls/ pedestals etc. shall be provided along with the roof screed concrete. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

23.4 INSULATION

23.4.1 MATERIAL

In case of structure where thermal insulation requirements are specified in the drawings or as decided by the Engineer, the concrete surface shall be applied with polyurethane foam (PUF) insulation. The PUF should be a 75 mm thick layer of two components high density spray applied polyurethane resin foam. The spray PU foam is carried out by a smooth spraying or pouring (for small areas) action to obtain the fill. The spray application to be done using specially designed spraying machine. The product must comply to class B2 as per DIN 4102, part 1 and shall exhibit the following properties:

PROPERTY	**ACCEPTANCE VALUE**	**TEST METHOD**
Core Density	40 Kg/m^3	DIN EN ISO 845,
Thermal conductivity (λ),	< 0.024W/(m.K)	DIN 52612
R-Value of 50mm thick,	> 2.1	ECBC Code
Compressive Strength,	DIN 53423,	>175KPa
Flexural Strength,	DIN 53423,	> 250KPa
Closed Cells	ISO 4590	90%
Water Vapour Diffusion	DIN 52615	60
Water absorption,	DIN 52848	<2.25%

23.5 WATER PROOFING

23.5.1 FOR BUILDING ROOFS

After completion of the curing period of the roof slab/ screed concrete and insulation (wherever applicable), the top surface shall be waterproofed using a solvent free spray applied polyurethane membrane.

In case of concrete prior to application of PU membrane, the surface should be ensured to be sound, clean and free from grease, oil or loose particles, laitance free shall have at least 1.5N/mm2 surface strength and moisture content shall be less than 4%. The concrete can be considered sufficiently dry when the relative humidity at the surface falls to 75% or less when measured with a hygrometer conforming to BS 8201 Appendix A. The preferred surface pretreatment for concrete is grinding or scarifying as necessary for concrete or when the primer has become soiled or when the re-coating interval has been exceeded.

The scope of work shall cover supply and application of one coat of primer (DFT 75 micron) and polyurethane membrane of approved make for total dry film thickness of 2200 microns comprising 2000 Microns thick (DFT) base coat of aromatic/ aliphatic PU and 200 Microns thick (DFT) UV resistant Aliphatic PU top coat excluding primer on flat or curved roofs.

a) Priming shall be done when the temperature of the substrate is at least 3 degrees above the dew point with a two pack epoxy primer with outstanding resistance properties and shall contain a high level of penetrating pigment which renders superior performance when sprayed over concrete having the following properties:

PROPERTY	**TEST METHOD**	**UNITS**	**ACCEPTANCE VALUE**
Density	ASTM 4052	g/cc	1.09 + 0.05 at 25°C
Mixing Ratio, by weight	IS 104		As per manufacturer recommendations
Flexural Strength	ASTM C 580-02	MPa	>30 at 7 days
Tensile Strength	BS6319 Pt 7	MPa	>20 at 7 days
Compressive Strength	ASTM C 579	MPa	>65 at 1 Day >70 at 3 Days >75 at 7 Days
Adhesive Bond Strength	ASTM D 4541	MPa	>1.5 at 25°C

For acceptance of material listed in above table, Manufacturer Test Certificate (MTC) from manufacturer confirming to above specified properties except for Tensile, Compressive &Bond strength shall be acceptable. The Tensile, Compressive & Bond strength tests shall be conducted by the contractor as per QAP in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL at no extra cost to NPCIL.

On the tacky primer surface, sand shall be broadcasted using dried, graded silica sand (size 0.3 to 0.9 mm) on to applied Primer Coat prior to its hardening. The sand shall

be evenly spread over the entire primed surface at the rate of 0.8 to 1.0 Kg/m2. When the surface is sufficiently cured, the surface is vacuumed to remove any loose sand.

The waterproofing system base coat shall be solvent free, two-component, fast setting, seamless spray applied Aromatic / Aliphatic Polyurethane (PU) membrane installed over the roof on primed substrate (concrete screed) using a pneumatic machine as per the manufacturer's specifications. The machine for application shall have optional pressure monitor kit to assure on mixing ratio. The pressure gauge shall monitor the spray pressures on both sides and shall automatically shut down the sprayer in case of non-acceptable conditions, like running out of material, pump cavitation, packing failures, leaks in valves or fittings, or plugged filters. The two component spray applied PU membrane for base coat shall have a total average dry film thickness of 2000 microns (excluding primer and top coat, with no single value less than 1800 microns). It shall possess the following properties:

Sr No	**Property**	**Test Method**	**Values**
1	Solids Content	ASTM D2697	> 95%
2	Density	ASTM D1475	>1.0 g/cm3
3	Ready for Light Traffic	DIN 53213	Max. 60 seconds
4	Adhesion Strength	ASTM D4541	Minimum 3.5 N/mm^2
5	Tensile Strength	ASTM D 412	> 8 MPa
6	Impact Strength	ASTM G14	>190 N/sq mm
7	Elongation at break	ASTM D 412	>400%
8	Average Tear Propagation	DIN 53363	>35 N/mm
9	Tear strength	ASTM D624	>25 N/mm
10	Puncture Resistance	ASTM E 154	>300 N
11	Crack bridging	ASTM C 836	No crack till 5 mm crack width
12	Shore Hardness (Shore A)	ASTM D2240	>65
13	Taber Abrasion Resistance	ASTM D4060	< 70 mg
14	Water Vapor Transmission	ASTM E 96	0.11 g/m2/day
15	Root Resistance	DIN 4062	No penetration

For acceptance of material listed in above table, solid content, density, tensile strength, % elongation at break, crack bridging & shore A hardness shall be performed in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL for every individual batch. For all other tests, MTC from manufacturer conforming to above specified properties shall be acceptable. Pull off adhesion test shall be done at site as per relevant standards using a portable pull off adhesion tester. All the laboratory tests shall be conducted by the contractor as per QAP at no extra cost to NPCIL.

b) The solvent free, two-component, spray applied base Polyurethane membrane system shall be protected using a two-component polyurethane UV stable aliphatic top coat having average 200 microns thick DFT (with no single value lesser than 150 microns). The top coat material shall have following properties:

Sl No.	Property	Test Method	Values
1.	Elongation at break (14 days)	ASTM D 412	>150%
2.	Tensile Strength (14 days)	ASTM D 412	>10 Mpa
3.	Tear strength	DIN 53515	>60 N/mm
4.	Density (Mixed)	At 20ºC	1.2 g/cm^3
5.	Viscosity (Mixed)	ASTM D2393	2000-4000 CPS at 23 degree C
6	Accelerated UV resistance	ASTM G 154	>1000 hours i.e No cracking, blistering or flaking
7	Shore A Hardness	ASTM D 2240	89

For acceptance of material listed in above table density, tensile strength, % elongation at break & shore "A" hardness as applicable shall be performed in laboratories like IITs, ICT etc. or other Government approved/ NABL accredited laboratories as acceptable to NPCIL for every individual batch. For all other tests, MTC from manufacturer confirming to above specified properties shall be acceptable. All the laboratory test shall be conducted by the contractor as per QAP at no extra cost to NPCIL.

23.6 PROTECTION SCREED CONCRETE

The water proofing done on roof other than OC dome shall be protected against damage due to working of other agencies on the roof top, wherever specified or decided by the Engineer. The membrane shall be overlaid with a layer of M-15 grade concrete (with max 10 mm aggregate) for a thickness of 50mm. The concrete shall be laid in panels of 2m x 2m, with an expansion groove 10 mm wide and 15 mm deep between the panels. The expansion groove shall be sealed with polyurethane sealant.

23.7 TESTING OF THE ROOF WATER PROOFING

The water proofing system on roof other than OC dome shall be tested by ponding water for a depth of 50 mm over the membrane layer, before laying the protective screed concrete. The water shall be retained for a period of 24 hrs and inspected for leakages if any. In case leakage/ seepage of water is observed, the contractor shall identify the leakage/ seepage spots and take corrective action as per manufacturer's recommendations at no extra cost to NPCIL. Repair procedure shall have the approval of the Engineer. The cost of testing the water proofing system is deemed to be included in the item rate for water proofing.

23.8 PROJECTING PIPES AND PEDESTALS ON ROOF TOP

The pedestals on the roof top and pipes passing through a roof on which water proofing treatment is to be laid, a cement concrete angle fillet shall be built around it. The spray PU water proofing treatment shall be taken over the fillet in the manner shown in drawings. Where pipe is passing through pipe sleeve embedded in concrete, a 20 mm Square groove shall be cut at top of concrete around pipe sleeve and the

same shall be filled with a hydro-swelling polymeric paste of 1.5kg/litre mix density. The paste shall be formulated to exhibit low premature swelling (less than 50% within 12 hours) and shall not release super absorbents during its service life. The re-swelling paste shall have low swelling pressure; not exceeding 0.25 MPa at full swelling capacity; confined between mortar & cement concrete angle fillet.

23.9 QUALITY ASSURANCE & SUPERVISION

A detailed work procedure in line with this specification and manufacturer's specification with resources deployment shall be prepared by the contractor and submitted to NPCIL for approval before proceeding with the work. Contractor shall carry out testing of materials as per direction of Engineer and shall submit testing reports and manufacturer's test certificates to the Engineer. A strict check on coating thickness and consumption of coating material shall be exercised by Contractor's QA Engineer and necessary records in this regard shall be submitted to NPCIL. Contractor shall provide necessary assistance to NPCIL in supervision of roof insulation and water proofing work and checking of PU coating thickness.

During the entire process of work under this specification, the Contractor shall arrange at his own cost the supervision of the work on insulation, water proofing and flashing by the manufacturer's representative to ensure that the work is being executed as per manufacturer's specifications and instructions.

23.10 GUARANTEE

The Contractor shall be responsible for maintaining the roof top insulation for a period of 10 years from the date of acceptance of the water proofing work by the Engineer. The Contractor shall make periodical inspection especially before start of the rainy season and repair the waterproofing for any apparent defects to ensure effectiveness of water proofing during the guarantee period.

The Contractor shall submit a bank guarantee from a scheduled commercial bank (other than co-operative bank) for 10% of the cost of roof insulation and water proofing works carried out. The bank Guarantee shall be valid for a period of five years from the date of acceptance of the water proofing work by NPCIL.

24 SURFACE DRAINS, UNDERGROUND TUNNELS, TRENCHES, SEWAGE CONVEYING SYSTEM ETC.

24.1 SCOPE

This specification covers furnishing all materials, plant, labour, equipment tools and services for the complete and proper construction of storm water, surface drainage, pitching using fly ash bricks and culverts as specified herein and shown in the drawings including all surveying and setting out necessary for the same and clean up of working areas.

24.2 GENERAL

All drains and culverts shall be constructed at the locations shown in the drawings or as directed by the Engineer. Care shall be taken to avoid clogging of the drains during progress of the work and should any drain become clogged or obstructed from any cause until final acceptance of the work, it shall be cleaned in a manner as approved by the Engineer or replaced by the contractor at no extra cost to NPCIL.

24.3 EXCAVATION

Excavation for storm water/ surface/ cut off drain and for culverts/ for laying RCC hume pipes shall be carried out as per the requirements covered in the technical specification for 'Excavation, Dewatering and Backfilling'

The excavated material shall be removed from the excavated/ adjoining area and disposed of at location(s) as directed by the Engineer.

24.4 STORM WATER/ SURFACE DRAINAGE

Where shown in the drawings, storm water/ surface drainage shall be constructed consisting of RCC trenches. Storm water/ surface drains shall be placed to prevent ground water from flowing directly into the structures and shall be constructed to a line and grade to allow proper drainage over the area of the site to the nearest natural drainage and in turn to the nearest natural water body. The contractor shall construct the storm water/ surface drainage system as per the details shown in the drawings.

24.5 PITCHING

Fly ash bricks of nominal size of 230x110x70 mm having compressive strength of minimum 75 Kg/sq cm shall be used in the work. Bricks shall be laid over sloped/ flat surfaces of the drain over well prepared and compacted bed of insitu soil. The joints between the bricks shall be filled with 1:6 cement mortar. Provision of weep holes with filter media etc. shall be provided in the pitching.

24.6 CUT OFF DRAINAGE

Where shown in the drawings, deep cut off drains shall be constructed at the various elevations to a line and grade to allow lowering of ground water levels and to arrest seepage water and surface runoff and direct the same to the nearest natural drainage for further flow to the nearby water body. The cut off drains shall consist of deep trenches, with concrete lining finished smooth of the bottom and the side facing as given in the drawing.

24.7 CULVERTS

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per drawings and as directed by the Engineer after clearing the site etc. as per specifications of Earthwork. The construction of culverts shall be done true to

line and levels as shown in drawings. The specification for masonry and/or plain and reinforced concrete shall be followed as applicable**.**

24.8 REINFORCED CONCRETE SPUN PIPES

24.8.1 GENERAL

The drainage pipes unless otherwise shown in the drawings or instructed by the Engineer shall be made of R.C.C. and shall be of class NP3.

Pipe culverts shall also be made of reinforced concrete pipe and shall be of class NP3. All pipes materials shall meet the requirements of IS: 458-Latest edition and shall be procured from approved manufacturers with collars as per manufacturers standard specifications.

24.8.2 APPLICABLE CODES

The manufacture, testing, supplying, jointing and testing of pipes at worksite shall comply with the code of practices, latest revisions, as given below:

IS: 456 Code of practice for plain and reinforced concrete

IS: 458 Specification for concrete pipes (with and without reinforcement)

IS: 783 Code of practice for laying of concrete pipes

IS: 3597 Method of tests for concrete pipes

24.8.3 CARTING AND HANDLING OF PIPES

Pipes and fittings shall be transported from factory to work sites by the Contractor and he shall be responsible for the safety of the pipes in transit and loading/unloading. Any pipe, which shows sufficient damage to preclude it from being used, shall be discarded. Dragging of pipes along concrete or similar pavements shall not be allowed.

24.8.4 STORAGE OF PIPES

Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom to keep the stack stable. The stack shall be in pyramid shape with height of pyramid not exceeding 1500 mm.

24.8.5 LAYING OF PIPES

a) Laying of concrete pipes shall correspond to IS: 783 – Latest edition – and specification given below. Safety requirements to be provided while laying of pipes shall conform to IS: 3764.

b) The foundation bed for pipe shall be excavated true to lines and grades shown in the drawings or as directed by the Engineer. When trenching is involved its width on either side of the pipe shall not be less than 150 mm not more than one-third the diameter of pipe unless otherwise instructed / permitted by the Engineer. The sides of the trench shall be as nearly vertical as possible. Side slope, shoring, bailing out water, etc. as required shall be done by the contractor without any extra cost. Side slope, if there be any, shall be removed by the contractor without any extra cost. Pipes shall be carefully lowered with the help of tripods with chain pulley blocks or any other mechanical means in the approved trenches. In no case pipe shall be dropped. Pipes damaged during lowering shall be rejected by the Engineer. After laying of the pipes are completed, back-filling of the trenches shall be done in 250 mm layers measured loose, clods and lumps broken, watered and compacted with iron rammers to the satisfaction of the Engineer. The surplus spoils shall be transported and filled in low-lying areas within the plant area, as instructed by the Engineer.

c) When bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock / boulders in the area shall be removed and space filled with approved earth free from stone of fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

d) Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

e) When two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

f) Laying of pipes shall start from the outlet and proceed towards inlet. Pipes are to be laid perfectly true both in alignment and to gradient specified. Pipes must be secured in place with approved backfill material tamped under it except at the collar. Precaution shall be taken to ensure that dirt do not enter jointing space. Pipes shall be laid such that the marking on pipes appears at the top of the pipes.

g) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS: 783 – Latest edition – having a projection ratio of not greater than 0.70, in which the pipe shall be carefully bedded on fine granular materials in an earth foundation, carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height, and in which the earth filling material shall be thoroughly rammed and tamped in layers not exceeding 15 cm in depth around the pipe for the remainder of the lower 30 percent of its height.

h) If the pipe is laid in trench, pipe bedding shall be first class bedding as per IS: 783.

i) When indicated on the drawings or directed by the Engineer, the pipe shall be bedded on a cradle constructed of concrete having a mix not leaner than N/20. The shape and dimension of the cradle shall be as indicated on the drawing or directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete has set.

j) The drop walls shall be made with first class brickwork or stone masonry in 1:4 cement mortar.

k) The pipe culverts shall be made with proper care regarding the invert of the pipe, gradient, if any, etc. as specified on drawings and / or instructed by the Engineer.

24.8.6 Where R.C.C. pipes are encased in concrete at road crossings or at other places the pipes shall be suitably supported avoiding reinforcements of concrete blocks, and joints properly done before concreting is taken up. Concreting of total height of the block may be done in one single operation or may be done up to some height for pipes to be properly laid in position and the remaining height of the block concreted subsequently.

24.8.7 The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part cement and 2 parts of clean sand with only enough water for workability. Procedure of jointing shall be as per IS: 783 – Latest edition.

24.9 ROOF DRAIN PIPING

24.9.1 Double walled corrugated pipe (For underground works)

Underground double walled corrugated pipe conforming to IS: 16098, Part 2, stiffness class SN 8 shall be provided for roof drains works. The scope of work includes supplying pipes including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes and any other fitting, fixtures, accessories required to complete the job etc. all complete as per manufacturer's specification and direction of the Engineer.

24.9.2 HDPE pipes for Roof drains works (Above ground)

HDPE pipes conforming to IS: 4984, grade PE 100, pressure rating PN 6 shall be used for elevated roof drain works. Scope of work includes supply of pipes including jointing of pipe to pipe or pipe to long neck pipe ends by electric heating mirror at site, joints to be flanged joints, laying and jointing conforming to IS: 7634 (Part-2), cutting and trimming of pipes, preparation of bends as per requirement at site, preparation of bed for laying the pipes etc. and any other fitting, fixtures, accessories required to complete the job etc. all complete as per manufacturer's specification.

24.9.3 RAIN WATER DOWN COMERS

24.9.3.1 GENERAL

Rain water down comers shall be ultra violet stabilized UPVC rain water pipes conforming to IS: 13592 Type-A and shall run along the exterior wall / column surface of all main plant buildings, unless specified otherwise.

24.9.3.2 SCOPE

The scope of work comprised in this specification are as follows:

- Supply, erection, fixing UPVC pipes at various elevations of main plant buildings including UPVC/ heavy cast iron roof drain and floor drain, all fittings and fixtures and including leak testing of the erected system.

- Supply, fixing necessary fittings inclusive of shoes, gratings, bends, sockets etc.

24.9.3.3 MATERIALS

- Ultra violet stabilized UPVC rain water pipes conforming to IS: 13592 Type-A and fittings conforming to IS 5382/ IS14735.

24.9.3.4 DESCRIPTION

Rain water down comers shall run along the exterior surface of walls/ columns and longitudinally over the roof and to be secured well to walls/ columns with strong clamps/ brackets as specified in the relevant drawings. Where desired by the Engineer these may have to be installed in chases cut in the structure. The brackets may be of galvanized iron/ anti-corrosive material clevis type, split ring or perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer shall be provided against the vertical surface. All bends and junctions shall be supplied with water-tight clean outs.

Roof drains at top shall be provided at locations as specified in the drawing and shall be provided with suitable MS gratings where ever specified.

25 QUALITY CONTROL, SURVEILLANCE AND ASSURANCE REQUIREMENTS

25.0 SCOPE

This chapter specifies requirements to be incorporated in the Contractor's quality assurance program for construction. The Contractor is responsible for planning and developing a program that assures that all his management, design and technical responsibilities for quality are incorporated and executed effectively. The program is aimed primarily at ensuring an efficient quality management in construction and taking corrective actions, when necessary.

Planning and detailed written procedures are essential for specifying how such activities as the following, which affect quality, are to be performed and controlled.

a) Design management whenever applicable

b) Procurement

c) Construction

d) Special processes

e) Measuring and testing equipment

f) Inspection and test

g) Handling, storing, preservation, packaging and shipping.

h) Item identification and traceability

i) Documentation and quality records.

j) Disposition of non conformances and corrective action.

25.1 APPLICABILITY

The requirements of this chapter apply to the construction activities when specified in a contract.

25.2 CONTRACTORS RESPONSIBILITIES

The Contractor's responsibilities

a) To develop and implement the controls and quality assurance procedures, specified herein, that will promptly detect and dispose of, or prevent, non-conformances to contractual requirements.

b) To comply with the NPCIL's requirements as specified in the contract.

c) To prepare a quality assurance manual which shall be submitted for the Purchaser's concurrence before the contract is awarded or at the latest before the work starts. This manual should cover activities of building design consultant, proof check consultant and building contractor and their subcontractors.

d) To prepare a quality plan which shall be submitted to the Purchaser before the work starts, as required in 25.3.3 (b).

e) To update and resubmit the quality assurance manual and quality plan to reflect current practices when significant changes occur in the Contractor's program or organization in order to improve its effectiveness or to prevent recurrence of non-conformances.

f) To initiate corrective measures promptly when the quality assurance representative notifies the Contractor of deviations from established requirements.

25.3 DEFINITIONS AND REQUIREMENTS

25.3.1 QUALITY ASSURANCE PROGRAM

The Contractor shall plan, establish, implement and maintain a quality assurance program that complies with the requirements of this chapter.

25.3.2 ORGANISATION

The Contractor shall :

a) Clearly define management policies, objectives and responsibilities for quality assurance, including the responsibility of each division within a multi-divisional organization. The responsibility and authority for quality of those managing and performing the work and of these auditing and verifying conformance to quality requirements shall be defined and their relationships shown on organization charts.

b) Provide for the review by management of the status and adequacy of the quality assurance program.

c) Appoint a representative who shall report regularly to management at a level that ensures that quality assurance requirements are not subordinated to design, manufacturing, construction or delivery and define his authority to resolve quality matters. Purchaser shall be notified of the appointment in writing.

d) Define the responsibility and authority of personnel who are primarily responsible for quality assurance and their organizational independence during audits and define the responsibility and authority of personnel who are primarily responsible for quality control and their organisational independence to :

- identify and record quality problems
- initiate or recommend or provide solutions through designated channels.
- verify the implementation of dispositions.
- control further processing, delivery or installation of a non-conforming item or service until the deficiency or unsatisfactory condition has been resolved.

Note that, generally, audit personnel shall not be within the pattern of daily activities.

e) Use competent persons for inspection, other than those performing or directly supervising the work being inspected, unless specifically designated otherwise in the quality plan. Such persons shall report to an adequate level of management,

excluding direct reports to supervisors responsible for producing the work being inspected.

Generally, inspectors shall verify the conformance to the specifications and drawings. In cases of problems or difficulties they shall request clarification from the design or other competent organisations and initiate appropriate measures.

If examinations, being a part of the whole inspections, are performed and documented by works personnel, the extent of the inspections by the independent personnel may be reduced, if such has been provided for by the quality plant.

25.3.3 **QUALITY ASSURANCE DOCUMENTS**

a) **QUALITY ASSURANCE MANUAL**

i) The Contractor shall :

- Prepare a quality assurance annual, approved and signed by a senior management official, and submit it for the Purchaser's concurrence before the contract is awarded or at the latest before the work starts. A quality assurance manual submitted under a previous contract or tender maybe referred to.

- Review and update the manual to reflect current quality assurance polices and procedures and resubmit the resulting manual.

- Implement the program according to the provisions specified in the manual.

ii) The quality assurance manual shall deal as appropriate with the following :

Organization - The manual shall define the organizational measures as specified 25.3.2.

Quality plan - The manual shall identify the group responsible for the quality plant specified in 25.3.3 (b) and define its main principles and features in adequate procedures.

Quality assurance procedures - Documented quality assurance procedures as specified in 25.3.3(c) shall be included or shall be outlined and cross- referenced. Referenced QA procedures shall be made available to the quality assurance representative.

Manual review - A statement shall be incorporated for reviewing and updating the manual as specified in 25.3.3. (a)(i).

b) QUALITY PLAN

i) The Contractor shall :

- Plan the inspection and test activities

- Identify in the quality plan the inspections and tests to be performed on the items listed in the contract, in compliance with contractual and/or technical requirements.

- Submit the plan for the Purchaser's concurrence following the award of the contract and before the work starts. Referenced inspection and test specifications and/or procedures shall be made available to the quality assurance representative during the implementation of the quality plan.

- Update the plan during the life of the contract to reflect current conditions of manufacturing, construction, inspecting and testing and resubmit the plan to the Purchaser.

b) ii) The quality plan may be of any format to suit the Contractor's system. The quality plan shall deal as appropriate with :

- Identification of the characteristics or items to be inspected and tested.

- Identification of required inspection, test and special process operations and their relative location in the construction cycle. The Contractor may include additional in-process inspection points for his own evaluation of quality which will not be subject to acceptance and witness by the quality assurance representative.

- Reference to inspection, test and special process procedures, standards, acceptance criteria and sampling plan, if any.

- Indication of hold points beyond which the activity shall not proceed until the required inspections or tests have shown satisfactory results and have been documented.

- Provisions for the Purchaser to insert witness points at which activities are to be observed. The activity may nevertheless proceed beyond a witness point should the Purchaser fail to attend in spite of due notification.

b) iii) The quality plans for subcontracted items, when concurred with by the Contractor, shall be submitted to the Purchaser as applicable, for concurrence & insertion of witness points.

c) <u>QUALITY ASSURANCE PROCEDURES</u>

The Contractor shall have procedures for the following specific requirements should they apply to the contract :

Document control	Cl.25.3.3
Design Control	Cl.25.3.5
Procurement	Cl.25.3.6
Measuring and testing equipment	Cl.25.3.7

Inspection and test	Cl.25.3.8
In-process inspection	Cl.25.3.9
Final inspection	Cl.25.3.10
Inspection status	Cl.25.3.11
Identification and traceability	Cl.25.3.12
Preservation, handling and storage	Cl.25.3.13
Construction	Cl.25.3.14
Special processes	Cl.25.3.15
Quality records	Cl.25.3.16
Non-conformances	Cl.25.3.17
Corrective actions	Cl.25.3.18

Each QA procedure shall define, as applicable, such things as: its purpose and scope; who is responsible for what; how all steps are to be performed; what materials, equipment and documentation are to be used; how it is all controlled.

Forms used shall be exhibited.

QA procedures shall be updated when necessary.

25.3.4 SPECIAL REQUIREMENTS

The Contractor shall

a) Establish measures to ensure that all essential quality related documents including but not limited to those listed below are reviewed for adequacy and approved for release by authorized personnel.:

i) Quality assurance manual required by 25.3.3 (a)

ii) Quality plan required by 25.3.3 (b)

iii) Quality assurance procedures required by 25.3.3(c)

iv) Design documents required as a consequence of 25.3.5

v) Procurement documents required by 25.3.6

vi) Calibration procedures required by 25.3.7

vii) Inspection and test procedures required by 25.3.8

viii) Manufacturing documents required by 25.3.13

ix) Special process procedures required by 25.3.15

b) Establish distribution lists for the above mentioned documents, update and maintain them in the current form to assure that the proper personnel are issued

with all the documents necessary to perform the work.

c) Make the applicable issues of these documents available at areas where these activities are performed.

d) Establish and update lists of applicable documents for construction and distribute them systematically. Controlled distribution is required for these lists only.

e) Ensure that changes to documents receive the authorizations by the same organizations as the initial documents unless other organizations are specifically designated. Maintain a record of changes as they are made. Written notes or documents are acceptable provided that they are made by authorized persons according to established procedures. Documents shall be revised and re-issued after a practical number of changes have been issued.

25.3.5 DESIGN CONTROL

a) General

The supplier shall establish and maintain documented procedures to control and verify the design of the product in order to ensure that the specified requirements are met.

b) Design and development planning

The supplier shall prepare plans for each design and development activity. The plans shall describe or reference these activities, and define responsibility for their implementation. The design and development activities shall be assigned to qualified personnel equipped with adequate resources. The plans shall be updated as the design evolves.

c) Organizational and technical interfaces

Organizational and technical interfaces between different groups which input into the design process shall be defined and the necessary information documented transmitted and regularly reviewed.

d) Design input.

Design input requirements relating to the product, including applicable statutory and regulatory requirements, shall be identified, documented and their selection reviewed by the supplier for adequacy. In complete, ambiguous or conflicting requirements shall be resolved with those responsible for imposing these requirements.

Design input shall take into consideration the results of any contract review activities.

e) Design output

Design output shall be documented and expressed in terms that can be validated against design input requirements.

Design output shall :

i) Meet the design input requirements.

ii) Contain or make reference to acceptance criteria;

iii) Identify those characteristics of the design that are crucial to the safe and proper functioning of the product (e.g. operating, storage, handling, maintenance and disposal requirements).

Design output documents shall be reviewed before release.

f) Design review

At appropriate stages of design, formal documented reviews of the design results shall be planned and conducted. Participants at each design review shall include representatives of all functions concerned with the design stage being reviewed, as well as other specialist personnel, as required. Records of such reviews shall be maintained .

g) Design verification

At appropriate stages of design, design verification shall be performed to ensure that the design stage output meets the design stage input requirements. The design verification measures shall be recorded.

NOTE : In addition to conducting design reviews, design verification may include activities such as

- performing alternative calculations.
- Comparing the new design with a similar proven design,, if available.
- Undertaking tests and demonstrations, and
- Reviewing the design stage documents before release.

h) Design validation

Design validation shall be performed to ensure that product conforms to defined used needs and / or requirements.

NOTES:

11. Design validation follows successful design verification .

12. Validation is normally performed under defined operating conditions.

13. Validation is normally performed on the final product, but may be necessary in earlier stages prior to product completion.

14. Multiple validations may be performed if there are different intended uses.

i) Design changes

All design changes and modifications shall be identified, documented, reviewed and approved by authorized personal before their implementation.

25.3.6 PROCUREMENT

a) Selection of Subcontractors

The Contractor shall identify items to be procured. He shall undertake the following :

i) Determine for these subcontracted items the applicable Quality Management Requirements. Classification of these Quality Management Requirements shall be in such a y that the overall quality is not impaired. The classification list shall be submitted to the Purchaser for acceptance.

ii) Evaluate and select subcontractors in accordance with of the applicable Quality Management Requirements with regard to their ability to meet subcontract and quality requirements.

iii) When `off the shelf' items are to be procured, evaluation of subcontractor may not necessarily be required. The Contractor shall nominate to the quality assurance representative those materials, parts and components that belong to this category.

b) SUBCONTRACT REQUIREMENTS

The Contractor shall include in subcontracts the following, as applicable:

i) A clear description of the items or services to be procured including technical data and inspection and test requirements by reference to standards, technical specifications, drawings, etc.

ii) A designation of the applicable Quality Management Requirements to be applied to the items and exceptions, if any.

iii) A designation of the Contractor's QA procedures to be implemented by the subcontractor, if applicable.

iv) Instructions for the submission, retention and disposition of quality records.

v) Requirements for packaging and shipping, where applicable.

vi) A statement related to the right of access to the subcontractor's premises and records for audit and/or surveillance by the Contractor or the Purchaser.

vii) Instructions for notification of witness points.

viii) Requirements for the subcontractor to report non-conformances.

ix) Applicable requirements to be extended to lower tier subcontractors, if any.

Subcontract documents shall be reviewed and approved in accordance with 25.4.4 (a).

All unpriced subcontracts and associated reference data shall made available on request for review by the quality assurance representative.

c) **Amendments to Subcontracts**

The Contractor shall process amendments to sub- contracts in the same way as the initial subcontract and reference the initial subcontract number in the amendments.

d) Verification of the Quality Management System Implemented by the Sub-contractor Refer applicable Quality Management Requirements.

e) **Receiving Inspection**

To the extent that is practical, receiving inspection shall be specified in the quality plan.

The Contractor shall:

i) Identify and inspect items on receipt to ascertain that they comply with contractual requirements. In determining the amount or nature of receiving inspection, consideration shall be given to the surveillance exercised at source and documented evidence of quality conformance. Receiving inspection shall cover as a minimum: verification of deterioration or damage during transport, identification control, review of required documentation.

ii) Initiate corrective action with sub-contractors when non-conforming items are received, as required by the nature and frequency of non-conformances.

iii) Hold incoming items until the required inspection and/or test have been completed or the necessary inspection and/or test reports have been received and verified except when items are released under positive recall.

25.3.7 MEASURING AND TESTING EQUIPMENT

All measuring and testing equipment and devices used to verify characteristics that can affect item quality shall be controlled and maintained. At prescribed intervals, or prior to use, they shall be calibrated and adjusted against certified equipment having a known valid relationship to nationally recognized standards. Where no national standards exist, the basis employed for calibration shall be documented.

No special calibration and control measures are necessary on rulers, tape measures, levels and other such devices, if normal commercial practices provide for adequate accuracy and/or if large tolerances are allowed for the corresponding measurements.

The Contractor shall:

a) Include in calibration procedures; equipment type, frequency of checks, description of check method, acceptance criteria and action to be taken when results are unsatisfactory. Exception will be allowed for measuring and testing equipment for which calibration is simple and does not require a specific detailed procedure. The Contractor shall identify those types of measuring equipment for which he has not provided calibration procedures.

b) Identify measuring and testing equipment with a tag, sticker, or other suitable indicator to show the calibration status.

c) Maintain calibration records for measuring and testing equipment.

d) Assess and document the validity of previous inspection and test results when measuring and testing equipment are found to be out of calibration.

For concreting and earthwork activities :

e) The above mentioned requirements are mandatorily applicable only to the following equipment and instruments :
- laboratory scale
- concrete batching plant
- compression test machine
- tensile test machine
- prestressing pressure gauge
- soil-cement batching plant
- gauge for mechanical splicing
- grout batching machine

For all other equipment and instruments, the requirements are non-mandatory but they may be used as a guide.

25.3.8 INSPECTION AND TEST

a) The Contractor shall provide for the performance of inspections and tests as specified in the quality plan. These inspections and tests shall be carried out in accordance with written procedures that define the method, the materials, instruments or equipment to be used and acceptance/rejection criteria.

The Contractor shall amend the selected inspection methods in cases where their unsuitability is demonstrated.

b) Inspections and tests shall be documented on inspection and test reports that identify as a minimum the item inspected or tested, applicable drawings, specifications or procedures, the date of inspection or test, the inspector, tester or data recorder, the type of observation, the results, the acceptability and the action taken in connection with any deficiencies identified.

25.3.9 **IN-PROCESS INSPECTION**

The Contractor shall:

a) Identify, inspect and/or test items as required by the quality plan.

b) Monitor process methods, where inspection is not feasible.

c) Hold items until the required inspections and/or tests have been completed or necessary reports have been received and verified except when items are released under positive recall. Release under positive recall shall not preclude (a) above.

For concreting activities :

i) The Contractor shall establish adequate measures for preconcreting, in-process and post-concreting inspections to be performed as applicable.

ii) A part of these inspections and the documentation thereof may be delegated to the works personnel. In such cases, the independent inspections can be reduced to an extent to be defined in the quality plan or in the inspection procedures.

This applies particularly to the case where a specialist is incorporated into the work staff for difficult or sophisticated tasks such as reinforcement placing, prestressing, etc.

iii) Such measures do not preclude complete independent inspections to be performed on a programd basis or as a consequence of results obtained.

25.3.10 **FINAL INSPECTION**

The Contractor shall :

a) Identify, inspect and/or test the completed item as required by the quality plan.

b) Verify that the item has been inspected at all points shown in the quality plan and that the records are adequate and complete.

25.3.11 **INSPECTION STATUS**

The Contractor shall :

a) Provide means for assuring that required inspections and tests are performed and that the acceptability of items with regard to inspections and tests performed is known throughout manufacturing and construction.

b) Establish and maintain a system for identifying the inspection/acceptance status by means of tags, stamped impressions, or other physical means to be affixed to the item or its container or by means of inspection records.

c) Show the identity of the Contractor and his inspector on any inspection marking used.

d) Provide for measures for controlling status indicators including the authority for application and removal of tags, stamps or other marking.

e) Identify non-conforming items.

25.3.12 **IDENTIFICATION AND TRACEABILITY**

The Contractor shall establish and maintain as adequate system to :

a) Identify each item (lot, component or part) to the applicable drawing, specification or other technical document, throughout the whole construction process.

b) Assign to each item a unique identification where specific traceability is required by the contract.

c) Record this identification on all process, inspection and test records, where traceability is specified.

d) List the items that do or do not require traceability concerning concrete activities.

25.3.13 **PRESERVATION, HANDLING AND STORAGE**

The Contractor shall :

a) Establish, maintain and document a system for the preservation, storage and handling of all items from the time of receipt through the entire construction process and subsequent storage to prevent abuse, misuse, damage, deterioration or loss.

b) Periodically inspect stored items for condition and shelf-life expiry.

c) Inspect and test-special handling tools and equipment at specific times to verify that the tools and equipment are adequately maintained and will not damage the items and will ensure safe and adequate handling.

d) Use specific written procedures for lifting of critical or high value items.

25.3.14 **CONSTRUCTION**

a) The Contractor shall clearly define the responsibilities for the documented preparation of works.

This written preparation shall consist of instructions or work assignments. It shall be established in accordance with the construction schedules and be available to the works and inspection personnel prior to commencement of work. This work instruction will document the following :

- Work methods
- sequence of operations
- workmanship criteria
- type of equipment needed
- special working environment, if any.

For concreting and other common civil work activities, these instructions may be included in drawings, specifications or other design documents.

b) The Contractor shall ensure that prior to release for construction all jigs, fixtures, tooling masters, templates, and patterns used for verifying quality are controlled. The extent and frequency of tool control shall be defined.

25.3.15 **SPECIAL PROCESSES**

The Contractor shall :

a) Identify those special processes subject to the requirements of this clause. Special processes shall include welding, heat treating and non- destructive examination, as applicable.

b) Establish documented procedures to assure that these processes are accomplished under controlled conditions by qualified personnel using qualified documented procedures and suitable equipment in accordance with applicable codes, standards, specifications, criteria and contractual requirements.

c) Maintain documentation for currently qualified personnel and processes according to the requirement of pertinent codes and standards.

d) Define the necessary qualifications of personnel and procedures for special processes not covered by existing codes or standards, or where item or service quality requirements exceed the requirements of established codes or standards.

e) Not consider concreting as a special process. However, the Contractor shall ensure that foremen and vibrator operators are properly selected from experienced or trained personnel prior to assignment of works and are given regular training by concrete placement experts as needed.

25.3.16 **QUALITY RECORDS**

The Contractor shall :

a) Maintain quality records as evidence that :

i) The quality assurance program meets the requirements of these Quality Management Requirements (manual, procedures, quality plan).

ii) The items or services meet contractual or other applicable technical requirements (specifications, drawings, calculations, manufacturing, inspection and test procedures).

iii) Personnel and procedures for special processes are qualified as required by 25.3.15.

iv) Measuring and testing equipment is calibrated as required by 25.3.7

v) The procurements meet the requirements of 25.3.6

vi) Corrective actions are being taken and are effective as required by 25.3.18

vii) Audits are performed as required by 25.3.19.

b) Maintain final performance quality records which include as appropriate :

i) as build records
ii) material test reports or certificates
iii) non-destructive examination records or certificates.
iv) inspection and test records.
v) non-conformance reports.
vi) concrete batch plant printout.

Items (iii) and (iv) apply to those operations performed after receipt of materials from the supplier.

c) Identify, index and file quality records for easy retrival.

d) Retain quality records for the time specified in the contract. If not specified, final performance quality records shall be retained for 10 years.

e) Provide a suitable environment for storing of records to minimize deterioration or damage and to prevent loss (the use of a double filing system is an acceptable

method).

25.3.17 **NON-CONFORMANCES**

The Contractor is responsible for the identification and disposition of all non-conforming items, including those of sub-contractors. Final acceptance of the Contractor's disposition of those items that violate contractual requirements is the prerogative of the Purchaser. The Contractor shall :

The Contractor shall :

a) Verify NPC certification.

b) Examine NPC supplied items on receipt for completeness and proper type and to detect transit damage. Further receiving inspection is not required unless the Contractor needs actual characteristics for subsequent work or unless specified in the contract. Examination may be deferred until further processing is scheduled if items are in sealed containers or have special preservation or packaging.

c) Control NPC supplied items from receipt onwards according to the requirements of this standard.

d) Report promptly in writing to the quality assurance representative, any NPC supplied items found damaged, lost, non-conforming, or otherwise unsuitable or unnecessary for use either on receipt or while in the Contractor’s custody.

25.3.18 **CORRECTIVE ACTION**

The Contractor shall :

a) Investigate the causes of significant or recurring non-conformances and take appropriate action to prevent repetition.

b) Document and have reported to appropriate levels of the Contractor's management causes of significant conditions that adversely affect quality and the corrective action taken.

25.3.19 **VERIFICATION OF QUALITY**

25.3.19.1 **INITIAL EVALUATION**

Quality Assurance Program, Facilities and Physical Resources :

Prior to the award of a contract, and to the performance of the activity, the Purchaser shall evaluate the Contractor's quality assurance program, manufacturing facilities and resources to determine whether the requirements of this section can be met.

In the event of the Contractor not fulfilling all applicable requirements, NPC may award the contract provided that he takes the responsibility for those QA requirements that will not be met by the Contractor. In such a case, the exceptions shall be clearly defined in the contract.

25.3.19.2 **QUALITY PLAN**

NPC shall evaluate the quality plan and all revisions thereto in order to determine its acceptability.

NPC shall indicate witness points on the accepted quality plan.

In addition, NPC shall perform surveillance according to the accepted quality plan.

25.3.19.3 **ACCESS**

The Contractor shall provide for reasonable access of the competent authorities and of NPC to his premises and records for audit and surveillance purposes.

LIST OF ANNEXURES

1. Annexure – 1: Typical details of Bore log data & Geotechnical Parameters of Natural Soil
2. Annexure – 1A: Geotechnical Parameters of Improved Soil
3. Annexure – 2: Procedure for preparation and approval of design documents
4. Annexure – 3: Digital value of Response spectra of SSE
5. Annexure – 4: Information to be Submitted Alongwith the Bid for the proposed agency for Civil Works
6. Annexure – 5: Details of Company
7. Annexure – 6: Proposed Deployment of Plant & Machinery
8. Annexure – 7: Technical Details to be Supplied along with Bid

LIST OF TENDER DRAWINGS

1. Drawing no. GHAVP- 1&2/10120/2001/DD- Borehole Location Layout
2. Drawing no. GHAVP- 1&2/10000/5001/GA- Main Plant Layout
3. Drawing no. GHAVP- 1&2/24200/ 2011 TO 2018/ GA - Control Building GA drawings
4. Drawing no. GHAVP-1&2-29700-2001-SK- Terminal Point of Turbine Island Package
5. Drawing no. GHAVP-1&2/29700/5002/GA - Outdoor Tunnel & Trenches Layout
6. Drawing no. GHAVP1&2/16000/2003 and 2004/DD – Excavation Drawings
7. Drawing no. GHAVP1&2/15300/5001/GA – Surface Drain Layout
8. Drawing no. GHAVP1&2/15200/5101/GA – Plant Water Drainage Layout
9. Drawing no. GHAVP1&2/15200/5001 and 5002/GA – Roof Drain Layout
10. Drawing no. GHAVP1&2/15200/5201/SK – Sanitary Sewer Layout
11. Drawing No.-.GHAVP1&2/15600/5001/SK- Typical Cross section of Road
12. Copy of drawings showing various Architectural Joints

LIST OF ATTACHMENTS

1. Report on Field Mock-Up for Ground Improvement by Replacement of Liquefiable Strata by Compacted Soil / Soil-Cement Mix (with addendum)
2. PC-E-00034-Scope of work for fabrication and erection of Critical and Important Embedded Parts (EPs) for 700 MWe Main Plant Civil Works
3. PC-E-160-Technical Specification for Manufacture of Embedded Parts
4. PP-E-2273-Technical Specification for Electrostatic Conductive Floors for KAIGA – 3&4 and RAPP- 5&6
5. PP-M-400-R1 – Technical Specification for two part Polysulphide Sealing Compounds for Containment Building
6. PP-M-1219 – Specification for Epoxy Coating for Reactor Building Internal Structure and Equipment

ANNEXURE - 1

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-103	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 25/06/2013 TO 30/06/2013
CO-ORDINATES	: N : 3257147.330, E : 561712.655	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.895m	CASING	: SX Ø Upto 52.00m Below EGL..
GROUND W. T.	: 2.73m Below EGL..	BOREHOLE DEPTH	: 52.00m.Below EGL..

FIELD DATA										DESCRIPTION	LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG			CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
												GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.00	SX	0.00	DS1																		
0.50		0.50																			
1.00																					
1.50		1.50/ 2.10	SPT1	(05) 02/02/03/03																	
2.00										Loose, brownish, silty SAND											
2.50																					
3.00		3.00/ 3.50	UDS1								SM	00	68	← 32 →		15.73	← NP →			2.33 X 10 $^{-6}$	1.89
3.50																					
4.00																					
4.50		4.50/ 5.10	SPT2	(09) 03/04/05/07																	
5.00																					
5.50																					
6.00		6.00/ 6.30	UDS2								ML	00	13	69	18	20.28	33	26	07	--	1.84
6.50										Stiff, greyish brown, clayey Silt of low compressibility											
7.00																					
7.50		7.50/ 8.10	SPT3	(12) 04/05/07/09																	
8.00																					
8.50																					
9.00		9.00/ 9.33	UDS3								ML	00	32	57	11	21.34	27	24	03	--	1.83
9.50										Stiff, brown, clayey SILT of low compressibility											
10.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

DBM GEOTECHNICS AND CONSTRUCTIONS PVT. LTD. MUMBAI.
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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/11.10	SPT4	(31) 07/14/17/20					Stiff, brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/12.34	UDS4							SM	00	76	← 24 →		23.39	← NP →			--	1.80
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(37) 09/17/20/29																
14.00																				
14.50																				
15.00		15.00/15.34	UDS5						Dense, greyish brown, silty SAND	SM	00	78	← 22 →		16.24	← NP →			1.58×10^{-6}	1.90
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(44) 12/20/24/37																
17.00																				
17.50																				
18.00		18.00/18.33	UDS6							SM	00	82	← 18 →		22.03	← NP →			--	1.84
18.50																				
19.00																				
19.50		19.50/20.10	SPT7	(60) 15/25/35/48					Very dense, greyish brown, silty SAND											
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
20.50																				
21.00		21.00/ 21.30	UDS7							SM	00	86	14		12.39	NP			--	1.91
21.50																				
22.00	SX																			
22.50		22.50/ 22.83	SPT8	(>50) 20/25/52/--																
23.00																				
23.50																				
24.00		24.00/ 24.23	UDS8							SM	00	76	24		14.27	NP			--	1.84
24.50									Very dense, greyish brown, silty SAND											
25.00																				
25.50		25.50/ 25.80	SPT9	(>50) 34/52/--/--																
26.00																				
26.50																				
27.00		27.00/ 27.24	UDS9							SM	00	80	20		15.27	NP			--	1.86
27.50																				
28.00																				
28.50		28.50/ 28.74	SPT10	(>50) 35/52/--/--																
29.00																				
29.50																				
30.00		30.00/ 30.20	UDS10							SM	00	81	19		21.79	NP			--	1.85

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
30.50																				
31.00																				
31.50		31.50/ 31.79	SPT11	(>50) 39/52/--/--					Very dense, brownish grey, silty SAND											
32.00	SX																			
32.50																				
33.00		33.00/ 33.30	UDS11/1							SM	00	88	← 12 →		20.27	← NP →			--	1.86
		33.34/ 33.64	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/ 34.80	SPT12	(>50) 40/52/--/--																
35.00																				
35.50																				
36.00		36.00/ 36.30	UDS12/1						Very dense, greyish brown, silty SAND	SM	00	81	← 19 →		19.31	← NP →			--	1.87
		36.34/ 36.64	UDS12/2																	
36.50																				
37.00																				
37.50		37.50/ 37.80	SPT13	(>50) 33/52/--/--																
38.00																				
38.50																				
39.00		39.00/ 39.30	UDS13/1							ML	05	18	64	13	26.31	33	25	08	--	1.83
		39.35/ 39.65	UDS13/2						Hard, greyish brown, clayey SILT with gravels of low compressibility											
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 5 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
40.50		40.50/ 40.80	SPT14	(>50) 35/52/--/--					Hard, greyish brown, clayey SILT with gravels of low compressibility										
41.00																			
41.50																			
42.00	SX	42.00/ 42.30	UDS14/1							SM	00	76	← 24 →		23.23	← NP →			--	1.85
		42.34/ 42.64	UDS14/2																	
42.50																			
43.00																			
43.50		43.50/ 43.79	SPT15	(>50) 37/52/--/--															
44.00																			
44.50																			
45.00		45.00/ 45.30	UDS15/1							SM	00	71	← 29 →		24.79	← NP →			--	1.84
		45.34/ 45.64	UDS15/2																	
45.50																			
46.00									Very dense, yellowish brown, silty SAND										
46.50		46.50/ 46.78	SPT16	(>50) 37/52/--/--															
47.00																			
47.50																			
48.00		48.00/ 48.30	UDS16/1							SM	00	79	← 21 →		23.13	← NP →			--	1.86
		48.34/ 48.64	UDS16/2																	
48.50																			
49.00																			
49.50		49.50/ 49.76	SPT17	(>50) 37/52/--/--															
50.00																			
49.50																			
50.00																			

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-103 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50	SX	51.00/ 51.32	UDS17/1						Very dense, yellowish brown, silty SAND											
51.00		51.36/ 51.66	UDS17/2							SM	00	83	← 17 →		19.06	← NP →			--	1.88
51.50									Very dense, greyish brown, silty SAND											
52.00		52.00/ 52.22	SPT18	(>50) 41/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104		SHEET NO. : 1 OF 6	
LOCATION : TB-1		DATE : 27/04/2014 TO 29/04/2014	
CO-ORDINATES : N 3257191.105, E 561697.122		METHOD : ROTARY DRILLING	
GROUND R. L. : 213.884m		CASING : SX mm Ø Upto 52.50m BGL.	
GROUND W. T. : 2.65m Below EGL.		BOREHOLE DEPTH : 52.50m.Below EGL.	

FIELD DATA

DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG
0.50	SX	0.00	DS1					
		0.50						
1.00								
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/06				
2.00								
2.50								
3.00		3.00/	UDS1/1					
		3.30/ 3.60	UDS1/2					
3.50								
4.00								
4.50		4.50/ 5.10	SPT2	(14) 04/06/08/10				
5.00								
5.50								
6.00		6.00/	UDS2/1					
		6.30/ 6.60	UDS2/2					
6.50								
7.00								
7.50		7.50/ 8.10	SPT3	(22) 08/10/12/15				
8.00								
8.50								
9.00		9.00/	UDS3/1					
		9.30/ 9.60	UDS3/2					
9.50								
10.00								

DESCRIPTION	CLASSIFICATION	GRAVELS %	SAND %	SILT %	CLAY %	NMC	LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
Loose brown, silty SAND	SM	11	40	43	06	11.45	26	24	02	--	1.86
Stiff, greyish brown, clayey SILT of low compressibility with gravels	ML	07	39	48	06	12.08	27	23	04	--	1.85
Very stiff, brownish grey, clayey SILT											
Hard, brown, clayey SILT of low compressibility	ML	00	32	58	10	21.80	31	25	06	--	1.81

LABORATORY DATA

GRAIN SIZE ANALYSIS

CONSISTENCY LIMIT

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale

Drawn By: Jitin More

SCALE : 1: 50
JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104 | SHEET NO. : 2 OF 6

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
10.50		10.50/ 11.10	SPT4	(32) 10/15/17/21					Hard, brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/	UDS4/1																	
		12.30/ 12.60	UDS4/2							ML	00	40	52	08	15.53	28	24	04	--	1.82
12.50																				
13.00																				
13.50		13.50/ 14.10	SPT5	(39) 15/18/21/24					Hard, greyish brown, clayey SILT of low compressibility											
14.00																				
14.50																				
15.00		15.00/	UDS5/1																	
		15.30/ 15.60	UDS5/2							ML	02	38	51	09	13.66	27	23	04	--	1.84
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(40) 14/18/22/26					Hard, brownish, clayey SILT of low compressibility											
17.00																				
17.50																				
18.00		18.00/	UDS6/1																	
		18.30/ 18.60	UDS6/2							ML	02	35	55	08	13.45	29	25	04	--	1.85
18.50																				
19.00																				
19.50		19.50/ 20.10	SPT7	(38) 17/18/20/28					Hard, brownish grey, clayey SILT of low compressibility											
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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BORE HOLE NO. : RBH-104 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
20.50																					
21.00	SX	21.00/	UDS7/1																		
		21.30/ 21.60	UDS7/2							ML	00	11	70	19	17.18	33	26	07	--	1.82
21.50									Hard, brownish grey, clayey SILT of low compressibility												
22.00																					
22.50		22.50/ 23.10	SPT8	(44) 15/20/24/32																	
23.00																					
23.50																					
24.00		24.00/	UDS8/1																		
		24.30/ 24.60	UDS8/2							ML	02	08	65	25	18.24	34	27	07	--	1.82
24.50																					
25.00																					
25.50		25.50/ 26.10	SPT9	(52) 18/22/30/38																	
26.00																					
26.50																					
27.00		27.00/	UDS9/1						Hard, brown, clayey SILT of low compressibility												
		27.30/ 27.60	UDS9/2							ML	02	11	71	16	17.52	32	25	07	--	1.83
27.50																					
28.00																					
28.50		28.50/ 29.10	SPT10	(55) 15/25/30/42																	
29.00																					
29.50																					
30.00		30.00/ 30.30	UDS10/1							SM	00	70	← 30 →		17.51	← NP →			--	1.84

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
30.50		30.30/30.60	UDS10/2																	
31.00	SX																			
31.50		31.50/32.10	SPT11	(56) 16/24/32/46																
32.00																				
32.50																				
33.00		33.00/	UDS11/1						Very dense, brownish grey, silty SAND	SM	00	71	← 29 →		17.62	← NP →		--	1.88
		33.30/33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/35.10	SPT12	(60) 17/26/34/45																
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SM	00	72	← 29 →		16.09	← NP →		--	1.86
		36.30/36.60	UDS12/2																	
36.50																				
37.00																				
37.50		37.50/38.10	SPT13	(58) 15/20/38/50																
38.00									Very dense, greyish brown, silty SAND											
38.50																				
39.00		39.00/	UDS13/1							SM	00	76	← 24 →		15.70	← NP →		--	1.89
		39.30/39.60	UDS13/2																	
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50	SX	40.50/41.10	SPT14	(70) 20/32/38/48																
41.00																				
41.50																				
42.00		42.00/	UDS14/1																	
		42.30/42.60	UDS14/2							SM	00	73	← 27 →		12.52	← NP →			--	1.91
42.50									Very dense, brownish grey, silty SAND											
43.00																				
43.50		43.50/44.10	SPT15	(78) 18/38/40/49																
44.00																				
44.50																				
45.00		45.00/	UDS15/1																	
		45.30/45.60	UDS15/2							SM	00	86	← 14 →		12.53	← NP →			--	1.91
45.50																				
46.00																				
46.50		46.50/47.10	SPT16	(79) 20/37/42/51																
47.00									Very dense, greyish, silty SAND											
47.50																				
48.00		48.00/	UDS16/1																	
		48.30/48.60	UDS16/2							SM	00	72	← 28 →		14.86	← NP →			--	1.88
48.50																				
49.00																				
49.50		49.50/51.10	SPT17	(86) 22/39/47/49																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-104 | SHEET NO. : 6 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL %	PL %	PLASTICITY INDEX		
50.50																				
51.00	SX	51.00/	UDS17/1																	
		51.30/ 51.60	UDS17/2						Very dense, greyish brown, silty SAND	SM	00	78	← 22 →		17.25	← NP →			--	1.86
51.50																				
52.00																				
52.50		52.50/ 53.10	SPT18	(82) 26/35/47/51																
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.50m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-109	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 05/09/2013 TO 10/09/2013
CO-ORDINATES	: N : 3257172.609, E : 561774.118	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.833m	CASING	: SX Ø Upto 51.60m Below EGL.
GROUND W. T.	: 2.30m Below EGL.	BOREHOLE DEPTH	: 51.60m.Below EGL.

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1						Very stiff, brownish, clayey SILT											
0.50		0.50																		
1.00																				
1.50																				
2.00																				
2.50																				
3.00		3.00	UDS1							ML	10	30	53	07	12.62	30	24	06	--	1.95
3.50		3.50/ 4.10	SPT1	(21) 07/09/12/21					Very stiff, greyish brown, clayey SILT of low compressibility											
4.00																				
4.50																				
5.00																				
5.50																				
6.00		6.00/	UDS2							ML	00	47	48	05	18.59	27	24	03	--	1.62
6.50		6.40/ 7.00	SPT2	(22) 09/10/12/14					Very stiff greyish brown, clayey SILT of low compressibility											
7.00																				
7.50																				
8.00																				
8.50																				
9.00		9.00	UDS3							ML	00	47	49	04	19.21	26	24	02	--	1.91
9.50		9.45/ 10.05	SPT3	(38) 12/18/20/24					Hard, brownish grey, clayey SILT of low compressibility											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
10.50																					
11.00									Hard, brownish grey, clayey SILT of low compressibility												
11.50																					
12.00	SX	12.00	UDS4																		
		12.40/ 13.00	SPT4	(38) 11/17/21/26						ML	00	25	64	11	18.94	33	25	08	--	1.79
12.50																					
13.00									Hard brownish grey, clayey SILT of low compressibility												
13.50																					
14.00																					
14.50																					
15.00		15.00	UDS5																		
		15.42/ 16.02	SPT5	(46) 14/21/25/31						SM	00	59	38	03	18.71	27	25	02	--	1.99
15.50																					
16.00																					
16.50									Dense, greyish brown, silty sand												
17.00																					
17.50																					
18.00		18.00	UDS6																		
		18.38/ 18.98	SPT6	(71) 17/31/40/49						SM	00	82	← 18 →		21.61	← NP →			--	1.75
18.50																					
19.00									Very dense, brownish grey, silty SAND												
19.50																					
20.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
20.50																				
21.00		21.00	UDS7																	
		21.35/ 21.95	SPT7	(72) 19/30/42/48						SM	00	81	← 19 →		23.21	← NP →			--	1.84
21.50																				
22.00	SX																			
22.50																				
23.00																				
23.50									Very dense, brownish grey, silty SAND											
24.00		24.00	UDS8																	
		24.35/ 24.93	SPT8	(78) 21/34/44/52						SM	00	75	← 25 →		14.63	← NP →			--	1.74
24.50																				
25.00																				
25.50																				
26.00																				
26.50																				
27.00		27.00	UDS9																	
		27.32/ 27.88	SPT9	(89) 20/39/50/52						SM	00	84	← 16 →		22.02	← NP →			--	1.91
27.50																				
28.00																				
28.50									Very dense, greyish brown, silty SAND											
29.00																				
29.50																				
30.00		30.00/ 30.35	UDS10																	

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50	SX	30.35/30.85	SPT10	(81) 24/40/41/52																	
31.00																					
31.50																					
32.00																					
32.50																					
33.00		33.00	UDS11/1						Very dense, brownish grey, silty SAND	SM	00	75	← 25 →		21.90	--	--	--	--	1.97
		33.30	UDS11/2																		
33.50		33.60/34.11	SPT11	(88) 28/38/50/52																	
34.00																					
34.50																					
35.00																					
35.50																					
36.00		36.00	UDS12/1							SM	00	78	← 22 →		22.39	--	--	--	--	1.89
		36.30	UDS12/2																		
36.50		36.60/37.05	SPT12	(>50) 31/39/52/--																	
37.00									Very dense, greyish brown, silty SAND												
37.50																					
38.00																					
38.50																					
39.00		39.00	UDS13/1							SM	00	73	← 27 →		19.21	--	--	--	--	1.86
		39.30	UDS13/2																		
39.50		39.60/40.12	SPT13	(89) 30/41/48/52					Very dense, brownish grey, silty SAND												
40.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50									Very dense, brownish grey, silty SAND											
41.00																				
41.50																				
42.00	SX	42.00	UDS14/1																	
		42.30	UDS14/2							SM	00	72	← 28 →		21.11	--	--	--	--	1.87
42.50		42.60/ 43.04	SPT14	(>50) 33/39/52/--																
43.00																				
43.50																				
44.00																				
44.50																				
45.00		45.00	UDS15/1							SM	00	74	← 26 →		14.60	--	--	--	--	1.79
		45.30	UDS15/2																	
45.50		45.60/ 46.11	SPT15	(77) 27/33/44/52					Very dense, greyish brown, silty SAND											
46.00																				
46.50																				
47.00																				
47.50																				
48.00		48.00	UDS16/1							SM	00	79	← 21 →		13.54	--	--	--	--	1.79
		48.30	UDS16/2																	
48.50		48.60/ 49.20	SPT16	(82) 30/34/48/52																
49.00																				
49.50																				
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-109 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00	UDS17/1						Very dense, greyish brown, silty SAND	SM	00	64	← 36 →		21.41	--	--	--	--	1.86
		51.30	UDS17/2																	
51.50		51.60/ 52.05	SPT17	(95) 37/43/52/--																
52.00																				
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 51.60m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-110	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 04/06/2013 TO 08/06/2013
CO-ORDINATES	: N : 3257191.945, E : 561760.189	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.929m	CASING	: SX Ø Upto 52.00m EGL.
GROUND W. T.	: --	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1						Loose, brownish, silty SAND											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(11) 02/05/06/06																
2.00																				
2.50																				
3.00		3.00/ 3.37	UDS1							ML	00	48	45	07	14.09	25	22	03	--	1.82
3.50									Stiff, brownish grey, clayey SILT of low compressibility											
4.00																				
4.50		4.50/ 5.10	SPT2	(15) 04/07/08/10																
5.00																				
5.50																				
6.00		6.00/ 6.55	UDS2							MI	00	03	74	23	24.56	37	26	11	--	1.80
6.50									Very stiff, greyish brown, clayey SILT of medium compressibility											
7.00																				
7.50		7.50/ 8.10	SPT3	(29) 08/12/17/22																
8.00																				
8.50																				
9.00		9.00/ 9.53	UDS3							ML	00	38	47	15	17.37	27	23	04	--	1.83
9.50									Very stiff, greyish brown, clayey SILT of low compressibility											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 2 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
10.50		10.50/11.10	SPT4	(32) 10/13/19/25					Very stiff, greyish brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/12.57	UDS4						Hard, greyish brown, clayey SILT of medium compressibility	MI	00	04	78	18	27.97	35	26	09	--	1.81
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(32) 10/13/19/25																
14.00									Hard, greyish brown, clayey SILT of low compressibility											
14.50																				
15.00		15.00/15.38	UDS5							ML	00	42	49	09	22.2	33	24	09	--	1.82
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(43) 06/17/26/35					Hard, greyish brown, clayey SILT of low compressibility											
17.00																				
17.50																				
18.00		18.00/18.32	UDS6							SM	00	70	← 30 →		20.79	← NP →			--	1.85
18.50																				
19.00									Dense, brownish grey, silty SAND											
19.50		19.50/20.10	SPT7	(42) 09/17/25/37																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 3 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Dense, brownish grey, silty SAND											
21.00		21.00/ 21.46	UDS7							SM	00	81	← 19 →		19.98	← NP →			--	1.83
21.50																				
22.00	SX																			
22.50		22.50/ 23.10	SPT8	(46) 11/18/28/39																
23.00									Dense, greyish brown, silty SAND											
23.50																				
24.00		24.00/ 24.30	UDS8							SM	00	84	← 16 →		25.15	← NP →			--	1.81
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(47) 13/19/28/40																
26.00																				
26.50																				
27.00		27.00/ 27.51	UDS9						Dense, brownish grey, silty SAND	SM	00	84	← 16 →		16.46	← NP →			--	1.86
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(50) 14/21/29/42																
29.00									Very dense, grey, silty SAND											
29.50																				
30.00		30.00/ 30.38	UDS10							SM	00	85	← 15 →		10.56	← NP →			--	1.92

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50									Very dense, grey, silty SAND											
31.00																				
31.50		31.50/32.03	SPT11	(77) 20/32/45/52																
32.00	SX																			
32.50																				
33.00		33.00/33.54	UDS11							MI	00	15	72	13	19.85	35	26	09	--	1.85
33.50									Hard, brownish grey, clayey SILT of medium compressibility											
34.00																				
34.50		34.50/34.93	SPT12	(>50) 18/39/52/--																
35.00																				
35.50																				
36.00		36.00/36.45	UDS12							ML	21	15	55	09	18.94	28	24	09	--	1.87
36.50																				
37.00																				
37.50		37.50/37.92	SPT13	(>50) 20/40/52/--					Hard, brown, clayey SILT of low compressibility											
38.00																				
38.50																				
39.00		39.00/39.30	UDS13							SM	00	77	← 23 →		22.28	← NP →			--	1.85
39.50									Very dense, greyish brown, silty SAND											
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 39.10m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 5 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/ 40.92	SPT14	(>50) 22/41/52/--					Very dense, greyish brown, silty SAND										
41.00																			
41.50																			
42.00	SX	42.00/ 42.30	UDS14							SM	00	70	← 30 →		22.95	← NP →			--	1.84
42.50																			
43.00									Very dense, greyish brown, silty SAND										
43.50		43.50/ 43.94	SPT15	(>50) 22/42/52/--															
44.00																			
44.50																			
45.00		45.00/ 45.98	UDS15							SM	01	65	← 34 →		24.30	← NP →			--	1.89
45.50																			
46.00									Very dense, brown, silty SAND with gravels										
46.50		46.50/ 46.90	SPT16	(>50) 23/43/52/--															
47.00																			
47.50																			
48.00		48.00/ 48.35	UDS16							SM	00	68	← 32 →		23.76	← NP →			--	1.86
48.50																			
49.00									Very dense, greyish brown, silty SAND										
49.50		49.50/ 49.88	SPT17	(>50) 26/45/52/--															
50.00																			

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-110 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50	SX	51.00/ 51.25	UDS17						Very dense, greyish brown, silty SAND	SM	00	67	33		20.93	NP			--	1.89
51.00																				
51.50																				
52.00		52.00/ 52.35	SPT18	(>50) 28/47/52/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-111	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 23/04/2014 TO 26/04/2014
CO-ORDINATES	: N 3257214.114, E 561750.994	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.941m	CASING	: SX mm Ø Upto 52.50m BGL.
GROUND W. T.	: 2.55m Below EGL.	BOREHOLE DEPTH	: 52.50m.Below EGL.

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(06) 02/03/03/05																
2.00																				
2.50									Medium stiff, brown,clayey SILT of medium compressibility											
3.00		3.00/	UDS1/1							MI	00	04	82	14	19.10	37	28	09	--	1.85
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(22) 05/09/13/16																
5.00																				
5.50																				
6.00		6.00/	UDS2/1							MI	00	05	70	25	20.57	38	29	09	--	1.84
		6.30/ 6.60	UDS2/2																	
6.50																				
7.00									Very stiff, brown, clayey SILT of medium compressibility											
7.50		7.50/ 8.10	SPT3	(24) 08/09/15/18																
8.00																				
8.50																				
9.00		9.00/	UDS3/1							ML	01	34	57	08	20.68	34	26	08	--	1.85
		9.30/ 9.60	UDS3/2																	
9.50									Very stiff, brownish grey, clayey SILT of low compressibility											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/ 11.10	SPT4	(35) 15/16/19/21					Hard, brownish grey, clayey SILT of low compessibility											
11.00																				
11.50																				
12.00		12.00/	UDS4/1							ML	00	28	61	11	14.17	32	26	06	--	1.87
		12.30/ 12.60	UDS4/2																	
12.50																				
13.00																				
13.50		13.50/ 14.10	SPT5	(36) 14/17/19/22																
14.00																				
14.50																				
15.00		15.00/	UDS5/1							MI	00	12	76	12	19.49	36	27	09	--	1.85
		15.30/ 15.60	UDS5/2																	
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(39) 12/18/21/28					Hard, brownish grey, clayey SILT of medium compressibility											
17.00																				
17.50																				
18.00		18.00/	UDS6/1							MI	00	12	75	13	27.42	41	29	12	--	1.83
		18.30/ 18.60	UDS6/2																	
18.50																				
19.00																				
19.50		19.50/ 20.10	SPT7	(42) 17/20/22/31																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN)	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00	SX	21.00/	UDS7/1																	
		21.30/ 21.60	UDS7/2							MI	00	05	79	16	24.37	40	28	12	--	1.82
21.50																				
22.00									Hard, brown, clayey SILT of medium compressibility											
22.50		22.50/ 23.10	SPT8	(50) 15/22/28/35																
23.00																				
23.50																				
24.00		24.00/	UDS8/1							SM	00	79	← 21 →		15.79	← NP →			--	1.86
		24.30/ 24.60	UDS8/2																	
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(58) 18/26/32/38																
26.00																				
26.50																				
27.00		27.00/	UDS9/1						Very dense, brownish grey, silty SAND	SM	00	73	← 27 →		15.02	← NP →			--	1.87
		27.30/ 27.60	UDS9/2																	
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(66) 19/28/38/42																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10/1							SM	00	73	← 27 →		13.58	← NP →			--	1.86

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
30.50		30.30/ 30.60	UDS10/2																	
31.00	SX																			
31.50		31.50/ 32.10	SPT11	(67) 19/29/38/44																
32.00									Very dense, brownish grey, silty SAND											
32.50																				
33.00		33.00/	UDS11/1							SM	00	86	← 14 →		23.04	← NP →			--	1.86
		33.30/ 33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/ 35.10	SPT12	(71) 20/32/39/48																
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SM	00	83	← 17 →		15.42	← NP →			--	1.87
		36.30/ 36.60	UDS12/2																	
36.50																				
37.00									Very dense, greyish brown, silty SAND											
37.50		37.50/ 38.10	SPT13	(71) 19/30/41/52																
38.00																				
38.50																				
39.00		39.00/	UDS13/1							SM	00	76	← 24 →		17.46	← NP →			--	1.88
		39.30/ 39.60	UDS13/2																	
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/41.10	SPT14	(70) 20/30/40/48																
41.00	SX								Very dense, brownish grey, silty SAND											
41.50																				
42.00		42.00/42.30	UDS14/1							SM	00	80	← 20 →		19.60	← NP →			--	1.86
		42.30/42.60	UDS14/2																	
42.50																				
43.00																				
43.50		43.50/44.00	SPT15	(74) 21/33/41/49																
44.00																				
44.50																				
45.00		45.00/45.30	UDS15/1							SM	00	83	← 17 →		20.75	← NP →			--	1.85
		45.30/45.60	UDS15/2																	
45.50																				
46.00																				
46.50		46.50/47.10	SPT16	(77) 20/32/45/51					Very dense, greyish brown, silty SAND											
47.00																				
47.50																				
48.00		48.00/48.30	UDS16/1							SM	00	67	← 33 →		20.89	← NP →			--	1.84
		48.30/48.60	UDS16/2																	
48.50																				
49.00																				
49.50		49.50/50.03	SPT17	(82) 22/38/44/52																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-111 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/	UDS17/1																	
		51.30/ 51.60	UDS17/2						Very dense, brownish grey,SAND	SM	00	78	← 22 →		21.93	← NP →			--	1.85
51.50																				
52.00																				
52.50		52.50/ 52.98	SPT18	(74) 20/32/42/52																
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.50m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-115	SHEET NO.	: 1 OF 5
LOCATION	: TB-1	DATE	: 06/12/2013 TO 08/12/2013
CO-ORDINATES	: N : 3257195.985, E : 561829.965	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.740m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.70m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.00	SX	0.00	DS1						Medium stiff, reddish brown, clayey SILT of low compressibility											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(06) 02/03/03/05																
2.00																				
2.50																				
3.00		3.00/ 3.40	UDS1							ML	00	30	61	09	12.32	34	26	08	--	1.84
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(29) 09/13/16/18																
5.00																				
5.50																				
6.00		6.00/ 6.42	UDS2						Very stiff, brownish, clayey SILT of low compressibility	ML	00	49	47	04	19.88	24	22	02	--	1.89
6.50																				
7.00		7.00/ 7.60	SPT3	(32) 12/16/16/21																
7.50																				
8.00									Hard, brownish yellow, clayey SILT of low compressibility											
8.50																				
9.00		9.00/ 9.45	UDS3							ML	00	46	48	06	18.99	31	25	06	--	1.85
9.50																				
10.00																				

ABBREVIATIONS :

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UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 2 OF 5

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/ 11.10	SPT4	(51) 16/21/30/34					Hard, brownish grey, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/ 12.35	UDS4							ML	00	44	49	07	21.81	27	24	03	--	1.86
12.50																				
13.00																				
13.50		13.60/ 14.20	SPT5	(65) 18/29/36/41																
14.00																				
14.50																				
15.00		15.00/ 15.34	UDS5							SM	00	70	← 30 →		23.07	← NP →			--	1.89
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(76) 20/34/42/48					Very dense, brownish grey, silty SAND											
17.00																				
17.50																				
18.00																				
18.50		18.60/ 18.93	UDS6							SM	00	73	← 27 →		22.70	← NP →			--	1.89
19.00																				
19.50		19.50/ 20.08	SPT7	(>50) 24/35/45/52																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.:	GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 3 OF 5

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
20.50																				
21.00		21.00/ 21.32	UDS7							SM	00	78	← 22 →		24.84	← NP →			--	1.90
21.50									Very dense, brownish grey, silty SAND											
22.00	SX	22.00/ 22.45	SPT8	(>50) 23/37/52/--																
22.50																				
23.00																				
23.50																				
24.00		24.00/ 24.30	UDS8							SM	00	80	← 20 →		19.86	← NP →			--	1.89
24.50									Very dense, , brownish, silty SAND											
25.00																				
25.50		25.50/ 26.10	SPT9	(62) 10/25/37/48																
26.00																				
26.50																				
27.00		27.00/ 27.21	UDS9							SM	00	74	← 26 →		17.93	← NP →			--	1.95
27.50									Very dense, brownish grey, silty SAND											
28.00																				
28.50		28.60/ 28.90	SPT10	(>50) 35/52/--/--																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10							SM	00	82	← 18 →		--	← NP →			--	1.96

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 4 OF 5

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50									Very dense, brownish grey, silty SAND											
31.00																				
31.50	SX	31.50/ 31.70	SPT11	(>50) 38/52/--/--																
32.00																				
32.50																				
33.00		33.00/	UDS11/1						Very dense, greyish, silty SAND	SP	00	96	← 04 →		--	--	--	--	--	1.98
		33.30/ 33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/ 34.75	SPT12	(>50) 40/52/--/--																
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SM	00	74	← 26 →		15.50	← NP →			--	1.89
		36.30/ 36.60	UDS12/2																	
36.50																				
37.00									Very dense, brownish grey, silty SAND											
37.50		37.50/ 37.74	SPT13	(>50) 44/52/--/--																
38.00																				
38.50																				
39.00		39.00/	UDS13/1							SM	00	83	← 17 →		20.00	← NP →			--	1.92
		39.30/ 39.60	UDS13/2																	
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 5 OF 5

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
40.50		40.50/ 40.80	SPT14	(>50) 34/52/--/--																
41.00																				
41.50																				
42.00	SX	42.00/	UDS14/1																	
		42.30/ 42.60	UDS14/2							SM	00	75	← 25 →		23.43	← NP →			--	1.92
42.50																				
43.00																				
43.50		43.50/ 43.95	SPT15	(>50) 25/38/52/--																
44.00																				
44.50																				
45.00		45.00/	UDS15/1																	
		45.30/ 45.60	UDS15/2						Very dense, greyish, silty SAND	SM	00	88	← 12 →		--	← NP →			--	1.89
45.50																				
46.00																				
46.50		46.50/ 46.95	SPT16	(>50) 25/42/52/--																
47.00																				
47.50																				
48.00		48.00/	UDS16/1																	
		48.30/ 48.60	UDS16/2							SM	00	85	← 15 →		16.52	← NP →			--	1.94
48.50																				
49.00																				
49.50		49.50/ 49.91	SPT17	(>50) 31/46/52/--																
50.00																				
49.50																				
51.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-115 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/	UDS17/1						Very dense, brownish, silty SAND	SM	00	76	← 24 →		22.35	← NP →			--	1.97
51.50		51.30/ 51.60	UDS16/2																	
52.00		52.00/ 52.35	SPT18	(>50) 28/35/52/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-116	SHEET NO.	: 1 OF 6
LOCATION	: TB-1	DATE	: 05/06/2013 TO 10/06/2013
CO-ORDINATES	: N : 3257239.399, E : 561811.959	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.939m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.70m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50							Brownish, clayey SILT											
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/05																
2.00																				
2.50									Medium stiff, greyish brown, clayey SILT of low compressibility											
3.00		3.00/ 3.39	UDS1							ML	00	43	51	06	11.01	30	25	05	--	1.88
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(18) 05/07/11/13																
5.00																				
5.50									Very stiff, brownish, clayey SILT of low compressibility											
6.00		6.00/ 6.42	UDS2							ML	03	41	51	05	11.81	32	25	07	--	1.87
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(17) 06/07/10/14																
8.00																				
8.50									Very stiff, greyish brown, clayey SILT of low compressibility											
9.00		9.00/ 9.45	UDS3							ML	00	47	47	06	12.90	28	24	04	--	1.86
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(61) 16/26/35/41																	
11.00																					
11.50																					
12.00		12.00/12.18	UDS4							ML	00	49	47	06	17.85	27	24	03	--	1.85
12.50									Hard, greyish brown, clayey SILT of low compressibility												
13.00																					
13.50		13.50/14.10	SPT5	(61) 17/25/36/41																	
14.00																					
14.50																					
15.00		15.00/15.37	UDS5							ML	00	41	49	10	19.70	33	26	07	--	1.84
15.50									Hard, brownish, clayey SILT of low compressibility												
16.00																					
16.50		16.50/17.10	SPT6	(54) 20/25/29/31																	
17.00																					
17.50																					
18.00		18.00/18.33	UDS6						Very dense, brownish grey, silty SAND	SM	00	81	← 19 →		15.67	← NP →			--	1.87
18.50																					
19.00																					
19.50		19.50/20.10	SPT7	(38) 11/15/23/34																	
20.00									Dense, brownish grey, silty SAND												

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 3 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Dense, greyish brown, silty SAND											
21.00		21.00/ 21.30	UDS7							SM	00	75	← 25 →		18.03	← NP →			--	1.86
21.50																				
22.00	SX								Very dense, brownish grey, silty SAND											
22.50		22.50/ 23.10	SPT8	(57) 17/24/33/35																
23.00																				
23.50																				
24.00		24.00/ 24.25	UDS8							SM	00	72	← 28 →		19.26	← NP →			--	1.85
24.50																				
25.00									Very dense, greyish brown, silty SAND											
25.50		25.50/ 26.10	SPT9	(61) 16/29/32/33																
26.00																				
26.50																				
27.00		27.00/ 27.30	UDS9							ML	00	19	67	14	20.65	34	26	08	--	1.84
27.50									Hard, greyish brown, clayey SILT of low compressibility											
28.00																				
28.50		28.50/ 28.95	SPT10	(99) 14/27/52/--																
29.00									Very dense, greyish brown, silty SAND											
29.50																				
30.00		30.00/ 30.30	UDS10							SM	00	72	← 28 →		21.50	← NP →			--	1.83

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 4 OF 6

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50	SX	31.50/31.90	SPT11	(80) 15/30/50/--					Very dense, brownish grey, silty SAND											
32.00																				
32.50																				
33.00		33.00/33.30	UDS11							SP-SM	00	92	← 08 →		11.29	--	--	--	--	1.91
33.50																				
34.00																				
34.50		34.50/34.85	SPT12	(82) 17/31/51/--																
35.00																				
35.50																				
36.00		36.00/36.32	UDS12						Very dense, greyish brown, silty SAND	SP-SM	00	93	← 07 →		13.35	--	--	--	--	1.88
36.50																				
37.00																				
37.50		37.50/37.90	SPT13	(89) 19/39/50/--																
38.00																				
38.50																				
39.00		39.00/39.33	UDS13							SM	08	71	← 21 →		17.12	← NP →			--	1.86
39.50									Very dense, greyish brown, silty SAND											
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 5 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/ 40.86	SPT14	(>50) 27/37/52/--					Very dense, brownish grey, silty SAND											
41.00																				
41.50																				
42.00	SX	42.00/ 42.30	UDS14							SM	00	79	← 21 →		13.89	← NP →			--	1.87
42.50																				
43.00																				
43.50		43.50/ 43.84	SPT15	(>50) 27/45/52/--																
44.00																				
44.50																				
45.00		45.00/ 45.32	UDS15							SM	00	81	← 19 →		17.82	← NP →			--	1.86
45.50																				
46.00																				
46.50		46.50/ 46.77	SPT16	(>50) 34/52/--/--					Very dense, greyish brown, silty SAND											
47.00																				
47.50																				
48.00		48.00/ 48.40	UDS16							SM	00	84	← 16 →		16.99	← NP →			--	1.88
48.50																				
49.00																				
49.50		49.50/ 49.65	SPT17	(>50) 62/--/--/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-116 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/ 51.24	UDS17						Very dense, brownish grey, silty SAND	SM	00	78	← 22 →		19.86	← NP →			--	1.66
51.50																				
52.00		52.00/ 52.27	SPT18	(>50) 23/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-107	SHEET NO.	: 1 OF 2
LOCATION	: GT Area-1	DATE	: 27/04/2014 TO 28/04/2014
CO-ORDINATES	: N 3257119.883, E 561811.178	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.709m	CASING	: SX mm Ø Upto 18.00m BGL.
GROUND W. T.	: 2.65m Below EGL.	BOREHOLE DEPTH	: 18.00m.Below EGL.

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1						Medium stiff, brownish yellow, clayey SILT											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/06																
2.00																				
2.50									Medium stiff, brownish grey, clayey SILT of low compressibility											
3.00		3.00/	UDS1/1							ML	00	45	49	06	12.28	28	24	04	--	1.86
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(14) 05/06/08/11																
5.00									Stiff, brownish grey, clayey SILT											
5.50																				
6.00		6.00/	UDS2/1							ML	01	46	48	05	16.25	28	25	03	--	1.84
		6.30/ 6.60	UDS2/2																	
6.50									Stiff, greyish brown, clayey SILT of low compressibility											
7.00																				
7.50		7.50/ 8.10	SPT3	(23) 08/11/12/15																
8.00																				
8.50									Very stiff, brownish, clayey SILT of low compressibility											
9.00		9.00/	UDS3/1							ML	00	48	48	04	14.63	27	24	03	--	1.85
		9.30/ 9.60	UDS3/2																	
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-107 | SHEET NO. : 2 OF 2

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/ 11.10	SPT4	(30) 12/14/16/22																	
11.00																					
11.50																					
12.00	SX	12.00/	UDS4/1																		
		12.30/ 12.60	UDS4/2							ML	00	45	49	06	17.42	27	24	03	--	1.82
12.50																					
13.00									Hard, brownish, clayey SILT of low compressibility												
13.50		13.50/ 14.10	SPT5	(40) 15/19/21/28																	
14.00																					
14.50																					
15.00		15.00/	UDS5/1																		
		15.30/ 15.60	UDS5/2							ML	00	47	49	04	19.36	26	23	03	5.34×10^{-6}	1.82
15.50																					
16.00																					
16.50		16.50/ 17.10	SPT6	(46) 18/22/24/31																	
17.00																					
17.50									Dense, grey, silty SAND												
18.00		18.00/	UDS6/1																		
		18.30/ 18.60	UDS6/2							SM	00	74	26		21.90	NP			--	1.85
18.50																					
19.00																					
19.50																					
20.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 18.60m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-105	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 27/03/2013 TO 06/04/2013
CO-ORDINATES	: N : 3257237.853 , E : 561675.110	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.800m	CASING	: SX Ø Upto 52.00m BGL.
GROUND W. T.	: 3.00m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL..

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.50	SX	0.00 / 0.50	DS1						Medium stiff, brownish, clayey SILT											
1.00																				
1.50		1.50 / 2.10	SPT1	(04) 02/02/02/03					Medium stiff, greyish yellow, clayey SILT											
2.00																				
2.50																				
3.00		3.00 / 3.42	UDS1						Medium stiff, greyish brown, clayey SILT of low compressibility	ML	29	14	50	07	18.32	31	25	06	2.86 X 10 -6	1.87
3.50																				
4.00																				
4.50		4.50 / 5.10	SPT2	(31) 07/13/18/19					Hard, clayey SILT of low compressibility											
5.00																				
5.50																				
6.00		6.00 / 6.30	UDS2						Hard, yellowish grey, clayey SILT of low compressibility	ML	00	24	61	15	15.52	33	25	08	--	1.91
6.50																				
7.00																				
7.50		7.50 / 8.10	SPT3	(31) 10/20/11/21																
8.00																				
8.50																				
9.00		9.00 / 9.50	UDS3						Hard, yellowish grey, clayey SILT of low compressibility	ML	00	34	57	09	18.66	31	26	05	2.38 X 10 -6	1.88
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 2 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN)	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(24) 07/08/16/24					Hard, yellowish grey, clayey SILT of low compressibility											
11.00									Very stiff, yellowish grey, clayey SILT											
11.50																				
12.00		12.00/12.54	UDS4							MI	01	02	64	33	27.08	40	28	12	2.26×10^{-6}	1.78
12.50									Hard, greyish brown, clayey SILT of medium compressibility											
13.00																				
13.50		13.50/13.73	SPT5	(>50) 14/52/--/--																
14.00																				
14.50																				
15.00		15.00/15.60	SPT6	(45) 11/20/25/35					Hard, greyish brown, clayey SILT											
15.50																				
16.00																				
16.50		16.50/16.74	SPT7	(>50) 27/52/--/--																
17.00									Hard, brownish, clayey SILT											
17.50																				
18.00		18.00/18.39	SPT8	(>50) 19/32/52/--																
18.50									Hard, greyish brown, clayey SILT											
19.00																				
19.50		19.50/19.91	SPT9	(>50) 19/40/52/--																
20.00									Very dense, greyish, silty SAND											

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL %	PL %	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00		21.00/ 21.37	SPT10	(>50) 33/42/52/--																
21.50																				
22.00	SX								Very dense, greyish, silty SAND											
22.50		22.50/ 22.78	SPT11	(>50) 31/52/--/--																
23.00																				
23.50																				
24.00		24.00/ 24.23	SPT12	(>50) 35/52/--/--																
24.50									Hard, greyish, clayey SILT											
25.00																				
25.50		25.50/ 26.10	SPT13	(45) 12/21/24/40																
26.00									Hard, brownish, clayey SILT											
26.50																				
27.00		27.00/ 27.28	SPT14	(>50) 35/52/--/--																
27.50									Very dense, greyish brown, silty SAND											
28.00																				
28.50		28.50/ 28.90	SPT15	(>50) 40/45/52/--																
29.00									Hard, greyish brown, clayey SILT											
29.50																				
30.00		30.00/ 30.12	SPT16	(>50) 30/40/52/--																

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50	SX								Very dense, greyish, SAND											
32.00																				
32.50																				
33.00		33.00/ 33.37	SPT17	(>50) 24/38/52/--																
33.50																				
34.00																				
34.50																				
35.00																				
35.50																				
36.00		36.00/ 36.29	SPT18	(>50) 28/52/--/--					Hard, brownish, clayey SILT with gravels											
36.50																				
37.00																				
37.50																				
38.00																				
38.50																				
39.00		39.00/ 39.21	SPT19	(>50) 37/52/--/--																
39.50									Hard, greyish brown, clayey SILT with gravels											
40.00																				

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 39.10m.BELOW EGL..

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
40.50																					
41.00									Hard, greyish brown, clayey SILT with gravels												
41.50																					
42.00	SX	42.00/ 42.10	SPT20	(>50) 52/--/--/--																	
42.50																					
43.00									Hard, brownish grey, clayey SILT with gravels												
43.50																					
44.00																					
44.50																					
45.00		45.00/ 45.14	SPT21	(>50) 52/--/--/--																	
45.50																					
46.00									Hard, brownish, clayey SILT												
46.50																					
47.00																					
47.50																					
48.00		48.00/ 48.25	SPT22	(>50) 38/52/--/--																	
48.50																					
49.00									Hard, brownish, clayey SILT												
49.50																					
50.00																					

SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-105 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50									Hard, brownish, clayey SILT	SOIL CLASSIFICATION IS AS PER FIELD OBSERVATIONS AS NO UDS IS RECOVERED										
51.00		51.00/ 51.14	SPT23	(>50) 52/--/--/--																
51.50									Hard, greyish brown, clayey SILT with gravels											
52.00	SX	52.00/ 52.20	SPT24	(>50) 42/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-106	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 26/03/2013 TO 30/04/2013
CO-ORDINATES	: N : 3257282.191, E : 561656.720	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.994m	CASING	: SX Ø Upto 52.00m BGL.
GROUND W. T.	: 2.60m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL..

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.00	SX	0.00	DS1						Loose, brownish, silty SAND											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(05) 02/02/03/04																
2.00																				
2.50									Loose, greyish yellow, silty SAND											
3.00		3.00/ 3.40	UDS1							SM	00	68	← 32 →		19.49				--	1.86
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(30) 08/13/17/20																
5.00																				
5.50																				
6.00		6.00/ 6.42	UDS2							SM	00	57	38	05	18.96	26	23	03	--	1.83
6.50																				
7.00									Dense, greyish yellow, silty SAND											
7.50		7.50/ 8.10	SPT3	(47) 14/20/27/33																
8.00																				
8.50																				
9.00																				
9.50		9.60/ 9.92	UDS3							SM	00	70	← 30 →		19.12				--	1.86
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 2 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(47) 14/20/27/33					Dense, greyish yellow, silty SAND											
11.00																				
11.50																				
12.00																				
12.50		12.60/12.90	UDS4						Hard, brownish, clayey SILT of medium compressibility	MI	00	03	74	23	27.14	37	27	10	--	1.86
13.00		13.00/13.60	SPT5	(56) 17/24/32/39																
13.50																				
14.00																				
14.50																				
15.00																				
15.50		15.60/15.90	UDS5							SM	00	80	← 20 →		24.79	← NP →			--	1.87
16.00																				
16.50		16.50/17.10	SPT6	(48) 14/21/27/34					Dense, brownish, silty SAND											
17.00																				
17.50																				
18.00		18.00/18.32	UDS6							SM	00	85	← 15 →		20.37	← NP →			--	1.89
18.50																				
19.00																				
19.50		19.50/20.10	SPT7	(65) 23/27/38/45					Very dense, brownish, silty SAND											
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00																				
21.50	SX	21.00/21.90	UDS7						Very dense, brownish grey, silty SAND	SM	00	88	← 12 →		20.46	← NP →			--	1.88
22.00																				
22.50		22.50/22.95	SPT8	(>50) 26/34/52/--																
23.00																				
23.50																				
24.00																				
24.50		24.60/24.90	UDS8							SM	00	80	← 20 →		21.34	← NP →			--	1.84
25.00																				
25.50		25.50/25.90	SPT9	(>50) 29/42/52/--																
26.00																				
26.50																				
27.00																				
27.50		27.50/27.90	UDS9						Very dense, brownish grey, silty SAND	SM	00	86	← 14 →		18.78	← NP →			--	1.89
28.00		28.00/28.42	SPT10	(>50) 33/48/52/--																
28.50																				
29.00																				
29.50																				
30.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50		30.60/	UDS10/1																	
		30.90/ 31.20	UDS10/2																	
31.00										SM	00	85	← 15 →		22.20	← NP →			--	1.91
31.50		31.50/ 31.85	SPT11	(>50) 39/40/52/--																
32.00	SX																			
32.50																				
33.00									Very dense, greyish, brown, silty SAND											
33.50		33.60/	UDS11/1																	
		33.90/ 31.20	UDS11/2							SM	00	82	← 18 →		16.97	← NP →			--	1.89
34.00																				
34.50		34.50/ 35.10	SPT12	(66) 16/28/38/50																
35.00																				
35.50																				
36.00																				
36.50		36.60/	UDS12/1																	
		36.90/ 37.20	UDS12/2							ML	00	21	67	12	22.81	31	25	06	--	1.82
37.00									Hard, brownish, clayey SILT of low compressibility											
37.50		37.50/ 37.85	SPT13	(>50) 20/34/52/--																
38.00																				
38.50																				
39.00																				
39.50		39.60/	UDS13/1						Hard, greyish brown, clayey SILT with gravels	ML	08	39	46	07	19.93	28	25	03	--	1.84
40.00		39.90/ 40.20	UDS13/2																	

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 5 OF 6

FIELD DATA										DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG			CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50	SX	40.50/40.90	SPT14	(>50) 25/39/52/--						Hard, greyish brown, clayey SILT with gravels											
41.00																					
41.50																					
42.00																					
42.50		42.60/42.90	UDS14/1 UDS14/2																		
43.00		43.20									SM	00	82	← 18 →		16.97	← NP →			--	1.89
43.50		43.50/43.88	SPT15	(>50) 29/40/52/--																	
44.00																					
44.50																					
45.00																					
45.50		45.60/45.90	UDS15/1 UDS15/2																		
46.00		46.20									SM	00	82	← 18 →		16.97	← NP →			--	1.89
46.50		46.50/46.85	SPT16	(>50) 32/45/52/--						Very dense, silty SAND											
47.00																					
47.50																					
48.00																					
48.50		48.60/48.90	UDS16/1 UDS16/2																		
49.00		49.20									SM	00	82	← 18 →		16.97	← NP →			--	1.89
49.50		49.50/49.85	SPT17	(>50) 37/48/52/--																	
50.00																					

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-106 | SHEET NO. : 6 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
50.50																				
51.00									Very dense, silty SAND											
51.50		51.60/	UDS17/1																	
	SX	51.90/ 52.20	UDS17/2							SM	00	74	← 26 →		19.42	← NP →			--	1.89
52.00																				
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.:	GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-112	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 22/04/2014 TO 25/04/2014
CO-ORDINATES	: N 3257262.915, E 561733.438	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.998m	CASING	: SX mm Ø Upto 54.00m BGL.
GROUND W. T.	: 2.55m Below EGL.	BOREHOLE DEPTH	: 54.00m.Below EGL.

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(06) 02/03/03/05																
2.00									Medium stiff, brownish,clayey SILT of low compressibility											
2.50																				
3.00		3.00/	UDS1/1							ML	01	42	51	06	12.49	28	24	04	--	1.86
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(20) 04/08/12/14																
5.00									Very stiff, brownish, clayey SILT											
5.50																				
6.00		6.00/	UDS2/1							ML	00	34	58	08	11.06	30	25	05	--	1.86
		6.30/ 6.60	UDS2/2																	
6.50																				
7.00									Very stiff, brownish grey, clayey SILT of low compressibility											
7.50		7.50/ 8.10	SPT3	(49) 08/21/28/38																
8.00																				
8.50																				
9.00		9.00/	UDS3/1						Hard, brownish grey, clayey SILT of low compressibility	ML	01	32	57	10	13.96	31	25	06	--	1.85
		9.30/ 9.60	UDS3/2																	
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By :	Drawn By:	SCALE : 1: 50
Prajit Nagrale	Jitin More	JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 2 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50	SX	10.50/11.10	SPT4	(47) 14/20/27/33																
11.00																				
11.50																				
12.00		12.00/	UDS4/1						Hard, brownish grey, clayey SILT of low compressibility	ML	00	35	57	08	15.41	30	25	05	--	1.86
		12.30/12.60	UDS4/2																	
12.50																				
13.00																				
13.50		13.50/14.10	SPT5	(56) 17/24/32/39																
14.00									Hard, greyish brown, clayey SILT											
14.50																				
15.00		15.00/	UDS5/1							SM	00	79	← 21 →		17.52	← NP →			--	1.84
		15.30/15.60	UDS5/2																	
15.50																				
16.00																				
16.50		16.50/17.10	SPT6	(48) 14/21/27/34																
17.00									Dense, brownish grey, silty SAND											
17.50																				
18.00		18.00/	UDS6/1							SM	00	86	← 14 →		17.01	← NP →			--	1.84
		18.30/18.60	UDS6/2																	
18.50																				
19.00																				
19.50		19.50/20.10	SPT7	(62) 23/27/35/45																
20.00									Very dense,brownish grey,silty SAND											

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
20.50																				
21.00	SX	21.00/	UDS7/1																	
		21.30/ 21.60	UDS7/2							SM	00	68	← 32 →		15.89	← NP →			--	1.86
21.50																				
22.00																				
22.50		22.50/ 23.10	SPT8	(48) 18/20/28/38					Dense, brownish grey, silty SAND											
23.00																				
23.50																				
24.00		24.00/	UDS8/1																	
		24.30/ 24.60	UDS8/2							SM	00	85	← 15 →		13.46	← NP →			--	1.88
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(55) 18/22/33/42																
26.00																				
26.50																				
27.00		27.00/	UDS9/1						Very dense, greyish brown, silty SAND											
		27.30/ 27.60	UDS9/2							SM	00	77	← 23 →		14.36	← NP →			--	1.87
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(55) 17/24/31/38																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10/1							ML	00	31	60	09	12.72	32	26	06	--	1.88

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 4 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50	SX	30.30/30.60	UDS10/2						Hard, brownish grey, clayey SILT of low compressibility											
31.00																				
31.50		31.50/32.10	SPT11	(51) 16/21/30/34																
32.00																				
32.50																				
33.00		33.00/	UDS11/1																	
		33.30/33.60	UDS11/2							SM	00	80	← 20 →		18.76	← NP →			--	1.84
33.50																				
34.00									Very dense, brownish grey, silty SAND											
34.50		34.50/35.10	SPT12	(65) 18/29/36/45																
35.00																				
35.50																				
36.00		36.00/	UDS12/1																	
		36.30/36.60	UDS12/2							SM	00	81	← 19 →		15.61	← NP →			--	1.86
36.50																				
37.00																				
37.50		37.50/37.95	SPT13	(>50) 23/37/52/--																
38.00																				
38.50									Hard, brownish, clayey SILT of low compressibility											
39.00		39.00/	UDS13/1																	
		39.30/39.60	UDS13/2							ML	00	42	51	07	18.82	28	24	04	--	1.83
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 5 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/40.98	SPT14	(87) 23/38/49/52																
41.00	SX																			
41.50																				
42.00		42.00/	UDS14/1																	
		42.30/42.60	UDS14/2						Hard, brownish grey, clayey SILT of medium compressibility	MI	05	04	77	14	23.38	36	27	09	--	1.83
42.50																				
43.00																				
43.50		43.50/43.95	SPT15	(95) 28/43/52/--																
44.00																				
44.50																				
45.00		45.00/	UDS15/1																	
		45.30/45.60	UDS15/2							ML	00	33	59	08	13.38	31	25	06	--	1.87
45.50																				
46.00																				
46.50		46.50/46.98	SPT16	(73) 21/31/42/52					Hard, brownish, clayey SILT of low compressibility											
47.00																				
47.50																				
48.00		48.00/	UDS16/1																	
		48.30/48.60	UDS16/2							SM	00	76	← 24 →		18.56	← NP →			--	1.85
48.50																				
49.00									Very dense, brownish grey, silty SAND											
49.50		49.50/50.00	SPT17	(65) 19/27/38/52																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-112 | SHEET NO. : 6 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50									Very dense, brownish grey, silty SAND										
51.00		51.00/	UDS17/1																
		51.30/ 51.60	UDS17/2							SM	00	82	← 18 →		18.16	← NP →		--	1.84
51.50	SX																		
52.00																			
52.50		52.50/ 52.45	SPT17	(86) 21/34/52/--					Very dense, brown,silty SAND										
53.00																			
53.50																			
54.00		54.00/	UDS18/1																
		54.30/ 54.60	UDS18/2							SM	00	73	← 27 →		11.88	← NP →		--	1.87
54.50																			
55.00																			
55.50																			
56.00																			
56.50																			
57.00																			
57.50																			
58.00																			
58.50																			
59.00																			
59.50																			
60.00																			

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 54.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-113	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 10/03/2013 TO 13/03/2013
CO-ORDINATES	: N : 3257283.392, E : 561722.261	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.093m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.71m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL %	PL %	PLASTICITY INDEX		
0.00	SX	0.00	DS1						Medium stiff, brownish, clayey SILT of low compressibility											
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(05) 02/02/03/04																
2.00																				
2.50																				
3.00		3.00/ 3.50	UDS1							ML	0	35	57	08	13.64	26	23	03	--	1.88
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(09) 03/04/05/07																
5.00																				
5.50									Stiff, brown, clayey SILT of low compressibility											
6.00		6.00/ 6.50	UDS2							ML	0	39	53	08	17.91	28	24	04	--	1.87
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(20) 06/08/12/15																
8.00																				
8.50									Very stiff, greyish brown, clayey SILT of low compressibility											
9.00		9.00/ 9.50	UDS3							ML	0	27	61	12	11.86	32	25	07	--	1.89
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/ 11.10	SPT4	(30) 09/12/18/21					Hard, greyish brown, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00/ 12.50	UDS4							MI	0	04	80	16	25.86	37	26	11	--	1.84
12.50									Hard, greyish brown, clayey SILT of medium compressibility											
13.00																				
13.50		13.50/ 14.10	SPT5	(34) 08/13/21/26																
14.00																				
14.50																				
15.00		15.00/ 15.36	UDS5						Dense, greyish brown, silty SAND	SM	00	65	← 35 →		18.74	← NP →			--	1.89
15.50																				
16.00																				
16.50		16.50/ 17.00	SPT6	(47) 09/19/28/52																
17.00																				
17.50																				
18.00		18.00/ 18.31	UDS6						Dense, brown, silty SAND	SM	00	68	← 32 →		18.94	← NP →			--	1.86
18.50																				
19.00																				
19.50		19.50/ 19.90	SPT7	(>50) 12/26/52/--																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 3 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50	SX								Very dense, brownish grey, silty SAND											
21.00		21.00/ 21.40	UDS7							SM	00	86	← 14 →		24.98	← NP →			--	1.88
21.50																				
22.00																				
22.50		22.50/ 22.90	SPT8	(>50) 12/21/52/--																
23.00									Very dense, brownish grey, silty SAND											
23.50																				
24.00		24.00/ 24.32	UDS8							SM	00	84	← 16 →		22.64	← NP →			--	1.91
24.50																				
25.00																				
25.50		25.50/ 25.94	SPT9	(>50) 15/28/52/--																
26.00																				
26.50																				
27.00		27.00/ 27.31	UDS9						Very dense, brownish grey, silty SAND	SM	00	86	← 14 →		22.87	← NP →			--	1.54
27.50																				
28.00																				
28.50		28.50/ 28.88	SPT10	(>50) 18/28/52/--																
29.00																				
29.50																				
30.00		30.00/ 30.31	UDS10							SM	00	85	← 15 →		21.63	← NP →			--	1.90

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
30.50																				
31.00																				
31.50		31.50/31.86	SPT11	(>50) 19/41/52/--																
32.00	SX																			
32.50																				
33.00		33.00/33.30	UDS11							SM	00	86	← 14 →		19.89	← NP →			--	1.86
33.50																				
34.00																				
34.50		34.50/34.92	SPT12	(>50) 25/28/52/--					Very dense, greyish brown, silty SAND											
35.00																				
35.50																				
36.00		36.00/36.35	UDS12							SM	00	82	← 18 →		19.73	← NP →			--	1.85
36.50																				
37.00		37.00/37.96	SPT13	(49) 17/21/28/52																
37.50																				
38.00																				
38.50																				
39.00		39.00/39.28	UDS13							SM	00	62	← 38 →		30.15	← NP →			--	1.82
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 5 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX (%)		
40.50		40.50/ 40.85	SPT14	(>50) 2144/52/--																
41.00																				
41.50									Very dense, greyish brown, silty SAND											
42.00	SX	42.00/ 42.20	UDS14							SM	00	83	← 17 →		20.95	← NP →			--	1.83
42.50																				
43.00																				
43.50		43.50/ 43.84	SPT15	(>50) 26/46/52/--																
44.00																				
44.50																				
45.00		45.00/ 45.28	UDS15						Hard, greyish brown, clayey SILT of low compresibility	ML	18	10	61	11	25.17	← NP →			--	1.81
45.50																				
46.00																				
46.50		46.50/ 46.90	SPT16	(>50) 28/46/52/--																
47.00																				
47.50																				
48.00		48.00/ 48.35	UDS16							SM	13	50	← 37 →		20.58	← NP →			--	1.80
48.50									Very dense, greyish brown, silty SAND with gravels											
49.00																				
49.50		49.50/ 49.82	SPT17	(>50) 31/41/52/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-113 | SHEET NO. : 6 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
50.50																				
51.00	SX	51.00/ 51.26	UDS17						Very dense, greyish brown, silty SAND	SM	00	82	← 18 →		20.68	← NP →			--	1.85
51.50																				
52.00		52.00/ 52.30	SPT18	(>50) 40/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL..

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-114	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 18/04/2014 TO 02/04/2014
CO-ORDINATES	: N 3257306.490, E 561715.377	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.415m	CASING	: SX mm Ø Upto 53.00m BGL.
GROUND W. T.	: 2.93m Below EGL.	BOREHOLE DEPTH	: 53.00m.Below EGL.

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/04																
2.00									Medium stiff, brown,clayey SILT of low compressibility											
2.50																				
3.00		3.00/	UDS1/1							ML	00	35	58	07	11.38	31	25	06	--	1.87
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2																	
5.00									Medium stiff, brownish grey, clayey SILT											
5.50																				
6.00		6.00/	UDS2/1							ML	01	12	72	15	22.73	34	26	08	--	1.84
		6.30/ 6.60	UDS2/2																	
6.50																				
7.00									Brownish, clayey SILT of low compressibility											
7.50		7.50/ 8.10	SPT3	(13) 03/06/07/10																
8.00																				
8.50																				
9.00		9.00/	UDS3/1						Stiff, brownish grey, clayey SILT of low compressibility	ML	00	30	62	08	14.96	32	25	07	--	1.86
		9.30/ 9.60	UDS3/2																	
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 2 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
10.50		10.50/ 11.10	SPT4	(16) 04/08/08/09																
11.00									Very stiff, brownish grey, clayey SILT											
11.50																				
12.00	SX	12.00/	UDS4/1							ML	00	35	58	07	14.09	30	25	05	--	1.85
		12.30/ 12.60	UDS4/2																	
12.50																				
13.00																				
13.50		13.50/ 14.10	SPT5	(16) 05/07/09/11					Very stiff, brownish, clayey SILT of low compressibility											
14.00																				
14.50																				
15.00		15.00/	UDS5/1							SM	00	88	← 12 →		20.48	← NP →			--	1.83
		15.30/ 15.60	UDS5/2																	
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(38) 06/18/20/22					Dense, brownish grey, silty SAND											
17.00																				
17.50																				
18.00		18.00/	UDS6/1							SM	00	77	← 23 →		18.41	← NP →			--	1.85
		18.30/ 18.60	UDS6/2																	
18.50																				
19.00																				
19.50		19.50/ 20.10	SPT7	(49) 08/21/28/38																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 3 OF 6

FIELD DATA										LABORATORY DATA									
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50																				
21.00	SX	21.00/	UDS7/1						Dense, brownish grey, silty SAND											
		21.30/ 21.60	UDS7/2							SM	00	87	← 13 →		12.17	← NP →			--	1.86
21.50																				
22.00																				
22.50		22.50/ 23.10	SPT8	(52) 09/23/29/32																
23.00																				
23.50																				
24.00		24.00/	UDS8/1																	
		24.30/ 24.60	UDS8/2							SM	00	81	← 19 →		20.83	← NP →			--	1.83
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(54) 20/22/32/37																
26.00									Very dense, brownish grey, silty SAND											
26.50																				
27.00		27.00/	UDS9/1																	
		27.30/ 27.60	UDS9/2							SM	00	85	← 15 →		22.35	← NP →			--	1.83
27.50																				
28.00																				
28.50		28.50/ 29.10	SPT10	(58) 14/27/31/38																
29.00																				
29.50																				
30.00		30.00/ 30.30	UDS10/1							SM	00	81	← 19 →		11.15	← NP →			--	1.87

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
30.50		30.30/30.60	UDS10/2																	
31.00	SX																			
31.50		31.50/32.10	SPT11	(59) 16/28/31/42																
32.00									Very dense, brownish grey, silty SAND											
32.50																				
33.00		33.00/	UDS11/1							SM	00	88	← 12 →		11.41	← NP →			--	1.87
		33.30/33.60	UDS11/2																	
33.50																				
34.00																				
34.50		34.50/35.10	SPT12	(77) 22/33/44/51																
35.00																				
35.50																				
36.00		36.00/	UDS12/1							SP-SM	00	92	← 08 →		19.14	--	--	--	--	1.86
		36.30/36.60	UDS12/2																	
36.50																				
37.00																				
37.50		37.50/38.10	SPT13	(67) 19/28/39/45					Very dense, brownish grey, silty SAND											
38.00																				
38.50																				
39.00		39.00/	UDS13/1							SP-SM	00	90	← 10 →		11.97	--	--	--	--	1.87
		39.30/39.60	UDS13/2						Very dense, grey, silty SAND											
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 5 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/41.00	SPT14	(78) 22/33/45/52																
41.00	SX																			
41.50																				
42.00		42.00/42.30	UDS14/1							SM	00	87	← 13 →		16.13	← NP →			--	1.86
		42.30/42.60	UDS14/2																	
42.50																				
43.00																				
43.50		43.50/44.00	SPT15	(86) 24/38/48/52																
44.00																				
44.50																				
45.00		45.00/45.30	UDS15/1						Very dense, brownish grey, silty SAND	SM	00	85	← 15 →		12.30	← NP →			--	1.88
		45.30/45.60	UDS15/2																	
45.50																				
46.00																				
46.50		46.50/46.90	SPT16	(>50) 22/35/52/--																
47.00																				
47.50																				
48.00		48.00/48.30	UDS16/1							SM	00	89	← 11 →		11.84	← NP →			--	1.86
		48.30/48.60	UDS16/2																	
48.50																				
49.00																				
49.50		49.50/49.85	SPT17	(>50) 21/37/52/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-114 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00		51.00/	UDS17/1																	
		51.30/ 51.60	UDS17/2						Very dense, brownish grey, silty SAND	SM	00	89	← 11 →		11.64	--	--	--	--	1.86
51.50	SX																			
52.00																				
52.50		52.50/ 52.80	SPT18	(>50) 28/52/--/--																
53.00		53.00/	UDS18/1							SM	00	55	41	04	20.37	27	24	03	--	1.84
		53.30/ 53.60	UDS18/2																	
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 53.00m.BELOW EGL.

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: BH-117	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 05/06/2013 TO 11/06/2013
CO-ORDINATES	: N : 3257286.508, E : 561792.420	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.036m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.70m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/05					Medium stiff, brownish, clayey SILT											
2.00																				
2.50																				
3.00		3.00/ 3.35	UDS1							ML	00	40	54	06	12.03	33	26	07	--	1.83
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(17) 06/07/10/14																
5.00																				
5.50																				
6.00		6.00/ 6.34	UDS2						Very stiff, greyish brown, clayey SILT of low compressibility	ML	00	23	66	11	18.13	34	26	08	--	1.81
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(18) 06/08/10/11																
8.00																				
8.50																				
9.00		9.00/ 9.32	UDS3							SM	00	69	← 31 →		15.80	← NP →			--	1.86
9.50									Medium dense, greyish brown, silty SAND											
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 2 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
10.50		10.50/ 11.10	SPT4	(25) 10/12/13/18					Medium dense, greyish brown, silty SAND											
11.00																				
11.50																				
12.00	SX	12.00/ 12.30	UDS4							SM	00	68	← 32 →		13.87	← NP →			--	1.87
12.50																				
13.00																				
13.50		13.50/ 14.10	SPT5	(30) 12/14/16/21																
14.00																				
14.50																				
15.00		15.00/ 15.36	UDS5						Dense, greyish brown, silty SAND	SM	00	80	← 20 →		17.12	← NP →			--	1.88
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(39) 13/18/21/28																
17.00									Dense, brownish grey, silty SAND											
17.50																				
18.00		18.00/ 18.21	UDS6							MI	00	16	66	18	27.19	36	27	09	--	1.81
18.50																				
19.00									Hard, brownish grey, clayey SILT of medium compressibility											
19.50		19.50/ 20.10	SPT7	(40) 16/19/21/28																
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 3 OF 6

FIELD DATA									LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50									Hard, brownish grey, clayey SILT of medium compressibility											
21.00		21.00/ 21.27	UDS7							SM	00	51	43	06	19.24	26	23	03	--	1.86
21.50																				
22.00	SX																			
22.50		22.50/ 23.10	SPT8	(45) 19/22/23/26					Dense brownish grey, silty SAND											
23.00																				
23.50																				
24.00		24.00/ 24.27	UDS8							SM	00	80	← 20 →		19.55	← NP →			--	1.85
24.50																				
25.00																				
25.50		25.50/ 26.10	SPT9	(60) 13/26/34/39																
26.00																				
26.50																				
27.00		27.00/ 27.30	UDS9							SM	00	89	← 12 →		17.05	← NP →			--	1.89
27.50									Very dense, greyish brown, silty SAND											
28.00																				
28.50		28.50/ 29.10	SPT10	(67) 19/30/37/41																
29.00																				
29.50																				
30.00		30.00/ 30.25	UDS10							SM	04	15	← 81 →		16.90	← NP →			--	1.82

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50																				
31.00																				
31.50		31.50/32.10	SPT11	(74) 23/32/42/52																
32.00	SX																			
32.50																				
33.00		33.00/33.34	UDS11						Very dense, greyish brown, silty SAND	SM	00	79	← 21 →		13.16	← NP →		--	1.85
33.50																				
34.00																				
34.50		34.50/35.05	SPT12	(81) 26/35/46/52																
35.00																				
35.50																				
36.00		36.00/36.35	UDS12							SM	00	71	← 29 →		10.22	← NP →		--	1.93
36.50																				
37.00																				
37.50		37.50/37.95	SPT13	(>50) 32/48/52/--																
38.00									Very dense, brown, silty SAND											
38.50																				
39.00		39.00/39.39	UDS13							SM	00	74	← 26 →		20.22	← NP →		--	1.86
39.50																				
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 5 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50		40.50/ 40.68	SPT14	(>50) 44/52/--/--																
41.00																				
41.50																				
42.00	SX	42.00/ 42.26	UDS14							SM	00	73	← 27 →		19.93	← NP →			--	1.84
42.50																				
43.00																				
43.50		43.50/ 43.75	SPT15	(>50) 40/52/--/--					Very dense, brownish grey, silty SAND											
44.00																				
44.50																				
45.00		45.00/ 45.23	UDS15							SM	00	73	← 27 →		18.38	← NP →			--	1.87
45.50																				
46.00																				
46.50		46.50/ 46.82	SPT16	(>50) 24/35/52/--																
47.00																				
47.50																				
48.00		48.00/ 48.25	UDS16							SM	00	75	← 25 →		20.27	← NP →			--	1.85
48.50																				
49.00									Very dense, greyish brown, silty SAND											
49.50		49.50/ 49.95	SPT17	(>50) 28/42/52/--																
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : BH-117 | SHEET NO. : 6 OF 6

FIELD DATA										LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL%	CONSISTENCY LIMIT: PL%	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00/ 51.27	UDS17						Very dense, greyish brown, silty SAND	SM	00	85	← 15 →		20.36	← NP →			--	1.89
51.50																				
52.00		52.00/ 52.13	SPT18	(>50) 52/--/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-118	SHEET NO.	: 1 OF 6
LOCATION	: TB-2	DATE	: 08/09/2013 TO 12/09/2013
CO-ORDINATES	: N : 3257328.963, E : 561770.526	METHOD	: ROTARY DRILLING
GROUND R. L.	: 213.930m	CASING	: SX Ø Upto 52.00m Below EGL.
GROUND W. T.	: 2.50m Below EGL.	BOREHOLE DEPTH	: 52.00m.Below EGL.

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
0.50	SX	0.00 – 0.50	DS1						Medium stiff, brownish, clayey SILT											
1.00																				
1.50																				
2.00																				
2.50																				
3.00		3.00	UDS1							ML	00	44	51	05	16.35	29	25	04	--	1.95
3.50		3.50/ 4.10	SPT1	(09) 02/03/06/09					Stiff, brownish, clayey SILT of low compressibility											
4.00																				
4.50																				
5.00																				
5.50																				
6.00		6.00/	UDS2							ML	00	40	55	05	18.73	26	23	03	--	1.89
6.50		6.40/ 7.00	SPT2	(26) 06/12/14/16					Very stiff, brownish grey, clayey SILT of low compressibility											
7.00																				
7.50																				
8.00																				
8.50																				
9.00		9.00/	UDS3							ML	02	45	49	04	23.36	27	23	04	--	1.87
9.50		9.37/ 9.97	SPT3	(21) 07/09/12/14																
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 2 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
10.50									Very stiff, brownish grey, clayey SILT of low compressibility											
11.00																				
11.50																				
12.00	SX	12.00	UDS4							ML	06	24	62	08	22.66	29	24	05	--	1.93
12.50		12.40/ 13.00	SPT4	(58) 10/23/35/43																
13.00																				
13.50																				
14.00																				
14.50									Hard, brownish grey, clayey SILT of low compressibility											
15.00		15.00	UDS5							ML	01	06	71	22	17.31	34	26	08	--	1.89
15.50		15.30/ 15.90	SPT5	(61) 12/24/37/42																
16.00																				
16.50																				
17.00																				
17.50																				
18.00		18.00	UDS6							SM	00	70	← 30 →		19.56	← NP →			--	1.98
18.50		18.35/ 18.80	SPT6	(39) 14/17/22/31																
19.00									Dense, greyish brown, silty SAND											
19.50																				
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 3 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPTN')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
20.50	SX								Dense, greyish brown, silty SAND											
21.00		21.00	UDS7																	
		21.24/ 21.82	SPT7	(75) 18/34/41/52						SM	00	78	← 22 →		20.47	← NP →			--	1.99
21.50																				
22.00									Very dense, brownish grey, silty SAND											
22.50																				
23.00																				
23.50																				
24.00		24.00	UDS8																	
		24.30/ 24.80	SPT8	(71) 17/28/43/52						SM	00	84	← 16 →		23.10	← NP →			--	1.93
24.50																				
25.00									Very dense, greyish brown, silty SAND											
25.50																				
26.00																				
26.50																				
27.00		27.00	UDS9																	
		27.28/ 27.88	SPT9	(53) 19/26/27/41						SM	00	74	← 26 →		21.41	← NP →			--	1.87
27.50																				
28.00									Very dense, brownish grey, silty SAND											
28.50																				
29.00																				
29.50																				
30.00		30.00/ 30.24	UDS10							SM	00	85	← 15 →		21.13	← NP →			--	1.97

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 4 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
30.50	SX	30.24/30.84	SPT10	(62) 17/24/38/47					Very dense, brownish grey, silty SAND											
31.00																				
31.50																				
32.00																				
32.50																				
33.00		33.00	UDS11/1							SM	00	79	← 21 →		20.04	← NP →			--	1.98
		33.30	UDS11/2																	
33.50		33.60/34.20	SPT11	(70) 19/28/42/52					Very dense, brownish yellow, silty SAND											
34.00																				
34.50																				
35.00																				
35.50																				
36.00		36.00	UDS12/1							SM	00	69	← 31 →		19.37	← NP →			--	1.84
		36.30	UDS12/2																	
36.50		36.60/37.20	SPT12	(42) 12/20/22/44					Very dense, greyish brown, SAND											
37.00																				
37.50																				
38.00																				
38.50																				
39.00		39.00	UDS13/1																	
		39.30	UDS13/2							SM	00	67	← 33 →		20.78	← NP →			--	1.93
39.50		39.60/40.00	SPT13	(>50) 28/42/52/--																
40.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 5 OF 6

FIELD DATA									DESCRIPTION	LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG		CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
40.50																				
41.00																				
41.50																				
42.00	SX	42.00	UDS14/1																	
		42.30	UDS14/2							SM	00	63	← 37 →		17.76	← NP →			--	1.84
42.50		42.60/ 42.95	SPT14	(>50) 36/43/52/--																
43.00																				
43.50									Very dense, greyish brown, SAND											
44.00																				
44.50																				
45.00		45.00	UDS15/1																	
		45.30	UDS15/2							SM	00	78	← 22 →		16.82	← NP →			--	1.86
45.50		45.60/ 45.80	SPT15	(>50) 42/52/--/--																
46.00																				
46.50																				
47.00																				
47.50																				
48.00		48.00	UDS16/1																	
		48.30	UDS16/2							SM	00	68	← 32 →		19.38	← NP →			--	1.86
48.50		48.60/ 48.78	SPT16	(>50) 48/52/--/--					Very dense, brownish grey, silty SAND											
49.00																				
49.50																				
50.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-118 | SHEET NO. : 6 OF 6

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	SAND %	SILT %	CLAY %	NMC	CONSISTENCY LIMIT: LL%	PL%	PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
50.50																				
51.00	SX	51.00	UDS17/1						Very dense, brownish grey, silty SAND	SM	00	83	← 17 →		18.90	← NP →			--	1.90
		51.30	UDS17/2																	
51.50		51.60/ 51.72	SPT17	(>50) 52/--/--/--																
52.00		52.00/ 52.28	SPT18	(>50) 49/52/--/--																
52.50																				
53.00																				
53.50																				
54.00																				
54.50																				
55.00																				
55.50																				
56.00																				
56.50																				
57.00																				
57.50																				
58.00																				
58.50																				
59.00																				
59.50																				
60.00																				
60.50																				
61.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 52.00m.BELOW EGL.

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO.	: RBH-108	SHEET NO.	: 1 OF 2
LOCATION	: GT Area-2	DATE	: 25/04/2014 TO 26/04/2014
CO-ORDINATES	: N 3257361.084, E 561698.594	METHOD	: ROTARY DRILLING
GROUND R. L.	: 214.046m	CASING	: SX mm Ø Upto 18.00m BGL.
GROUND W. T.	: 2.85m Below EGL.	BOREHOLE DEPTH	: 18.00m.Below EGL.

FIELD DATA									LABORATORY DATA										
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS: GRAVELS %	GRAIN SIZE ANALYSIS: SAND %	GRAIN SIZE ANALYSIS: SILT %	GRAIN SIZE ANALYSIS: CLAY %	NMC	CONSISTENCY LIMIT: LL %	CONSISTENCY LIMIT: PL %	CONSISTENCY LIMIT: PLASTICITY INDEX	Permeability (cm/sec)	Wet Density (gm/cm³)
0.00	SX	0.00	DS1																	
0.50		0.50																		
1.00																				
1.50		1.50/ 2.10	SPT1	(07) 02/03/04/05					Medium stiff, brown, clayey SILT of low compressibility											
2.00																				
2.50																				
3.00		3.00/	UDS1/1							ML	00	32	59	09	11.24	32	25	07	--	1.87
		3.30/ 3.60	UDS1/2																	
3.50																				
4.00																				
4.50		4.50/ 5.10	SPT2	(25) 07/11/14/19					Very stiff, brown, clayey SILT											
5.00																				
5.50																				
6.00		6.00/	UDS2/1							ML	00	49	46	05	12.84	26	24	02	--	1.91
		6.30/ 6.60	UDS2/2																	
6.50																				
7.00																				
7.50		7.50/ 8.10	SPT3	(67) 11/29/38/42					Hard, brownish grey, clayey SILT of low compressibility											
8.00																				
8.50																				
9.00		9.00/	UDS3/1							ML	01	39	54	06	14.33	30	25	05	3.38 X 10 $^{-6}$	1.88
		9.30/ 9.60	UDS3/2																	
9.50																				
10.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.	: GROUND WATER TABLE	LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : CONTINUED ON NEXT PAGE

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Checked By : Prajit Nagrale | Drawn By: Jitin More | SCALE : 1: 50 | JOB NO. : 3087

CLIENT : **NUCLEAR POWER CORPORATION OF INDIA LIMITED**

PROJECT : Geotechnical Investigation works for proposed 2 X 700 MWe Nuclear Power Project (GAPP) at Gorakhpur, Dist. Fatehabad, Haryana.

BORE HOLE NO. : RBH-108 | SHEET NO. : 2 OF 2

FIELD DATA										LABORATORY DATA											
DEPTH BELOW EGL (m)	DIA OF BOREHOLE	SAMPLE & IN-SITU TEST DEPTH (m)	SAMPLE TYPE & NO.	FIELD TEST RESULT (SPT'N')	TCR (%)	RQD (%)	ELEVATION (m)	LOG	DESCRIPTION	CLASSIFICATION	GRAIN SIZE ANALYSIS				NMC	CONSISTENCY LIMIT			Permeability (cm/sec)	Wet Density (gm/cm³)
											GRAVELS %	SAND %	SILT %	CLAY %		LL%	PL%	PLASTICITY INDEX		
10.50		10.50/ 11.10	SPT4	(31) 05/13/18/22																
11.00																				
11.50																				
12.00	SX	12.00/	UDS4/1						Hard, brownish grey, clayey SILT of low compressibility	ML	01	25	64	10	16.06	33	26	07	--	1.87
		12.30/ 12.60	UDS4/2																	
12.50																				
13.00																				
13.50		13.50/ 14.10	SPT5	(41) 08/19/22/31																
14.00																				
14.50																				
15.00		15.00/	UDS5/1							ML	13	32	48	07	12.38	28	24	04	--	1.88
		15.30/ 15.60	UDS5/2						Hard, brownish grey, clayey SILT of low compressibility with gravels											
15.50																				
16.00																				
16.50		16.50/ 17.10	SPT6	(45) 19/21/24/33																
17.00																				
17.50									Hard, greyish brown, clayey SILT of low compressibility											
18.00		18.00/	UDS6/1							ML	02	39	53	06	11.92	29	24	05	--	1.89
		18.30/ 18.60	UDS6/2																	
18.50																				
19.00																				
19.50																				
20.00																				

ABBREVIATIONS :

DS	: DISTURBED SAMPLE	SPT	: STD. PENETRATION TEST	PL(%)	: PLASTIC LIMIT	RQD	: ROCK QUALITY DESIGNATION (%)
UDS	: UNDISTURBED SOIL SAMPLE	R	: REFUSAL 'N' VALUE	NMC	: NATURAL MOISTURE CONTENT	TCR	: TOTAL CORE RECOVERY (%)
N	: SPT VALUE	GROUND W. T.: GROUND WATER TABLE		LL (%)	: LIQUID LIMIT	NP	: NON PLASTIC

REMARKS : BORE HOLE IS TERMINATED AT DEPTH 18.60m.BELOW EGL.

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1. Geotechnical Properties of Natural Soil

1.1 Turbine Building -1:

1.1.1 Static Young's modulus (Es)

Structure	Test Depth Below Existing Ground Level	E_s	Gs
		MPa	MPa
Turbine Building, TB-1	3.6m	16.24	6.01
	8.6m	20.22	7.49
	13.6m	29.86	11.06
	18.6m	48.86	18.1
	23.6m	220.68	81.73
	28.6m	284.06	105.21
	29.4m	229.06	84.84
	34.4m	147.84	54.75
	39.4m	106.57	53.36
	44.4m	277.53	102.79
	49.4m	213.07	78.91
	59.4m	196.62	72.83
	69.4m	352.96	130.72
	79.4m	377.76	139.91

1.1.2 Angle of Internal Friction (ϕ)

Depth below FGL		Depth below EGL		Avg. Density	Angle of Internal Friction based on Corrected SPT, Φ in Degrees
From	To	From	To		
5.4m	8.4m	0.0m	3.0m	1.87	29
8.4m	11.4m	3.0m	6.0m	1.87	32
11.4m	14.4m	6.0m	9.0m	1.85	32
14.4m	17.4m	9.0m	12.0m	1.83	35
17.4m	20.4m	12.0m	15.0m	1.88	35
20.4m	23.4m	15.0m	18.0m	1.84	35
23.4 m	26.4m	18.0m	21.0m	1.85	35
26.4 m	29.4m	21.0m	24.0m	1.83	35
29.4m	32.4m	24.0m	27.0m	1.87	36
32.4m	35.4m	27.0m	30.0m	1.88	36
35.4m	38.4m	30.0m	33.0m	1.90	36
38.4m	41.4m	33.0m	36.0m	1.88	37
41.4m	44.4m	36.0m	39.0m	1.87	36
44.4m	47.4m	39.0m	42.0m	1.87	37
47.4m	50.4m	42.0m	45.0m	1.86	37
50.4m	53.4m	45.0m	48.0m	1.86	36
53.4m	56.4m	48.0m	51.0m	1.88	36

56.4m	59.4m	51.0m	54.0m	1.86	36
59.4m	62.4m	54.0m	57.0m	1.85	37
62.4m	65.4m	57.0m	60.0m	1.89	37
65.4m	71.4m	60.0m	66.0m	1.88	37
71.4m	77.4m	66.0m	72.0m	1.88	37
77.4m	83.4m	72.0m	78.0m	1.89	37
83.4m	89.4m	78.0m	84.0m	1.88	37
89.4m	95.4m	84.0m	90.0m	1.89	38
95.4m	101.4m	90.0m	96.0m	1.87	38
101.4m	107.4m	96.0m	102.0m	1.87	38

1.2 Turbine Building -2:

1.2.1 Static Young's modulus (Es)

Structure	Test Depth Below Existing Ground Level	E_s	G_s
		MPa	MPa
Turbine Building, TB-2	4.5m	24.5	9.07
	9.5m	19.94	7.39
	14.5m	46.2	17.11
	19.5m	94.1	34.85
	24.5m	190.48	70.55
	29.5m	96.9	35.89
	34.4m	147.84	54.75
	39.4m	106.57	53.36
	44.4m	277.53	102.79
	49.4m	213.07	78.91
	59.4m	196.62	72.83
	69.4m	352.96	130.72
	79.4m	377.76	139.91

1.2.2 Angle of Internal Friction (ϕ)

Depth below FGL		Depth below EGL		Avg. Density	Angle of Internal Friction based on Corrected SPT, Φ in Degrees
From	To	From	To		
5.4m	8.4m	0.0m	3.0m	1.87	29
8.4m	11.4m	3.0m	6.0m	1.86	32
11.4m	14.4m	6.0m	9.0m	1.87	33
14.4m	17.4m	9.0m	12.0m	1.85	34
17.4m	20.4m	12.0m	15.0m	1.87	34
20.4m	23.4m	15.0m	18.0m	1.87	34
23.4 m	26.4m	18.0m	21.0m	1.89	37
26.4 m	29.4m	21.0m	24.0m	1.87	36
29.4m	32.4m	24.0m	27.0m	1.87	35
32.4m	35.4m	27.0m	30.0m	1.89	35

35.4m	38.4m	30.0m	33.0m	1.88	37
38.4m	41.4m	33.0m	36.0m	1.86	35
41.4m	44.4m	36.0m	39.0m	1.86	37
44.4m	47.4m	39.0m	42.0m	1.84	38
47.4m	50.4m	42.0m	45.0m	1.86	39
50.4m	53.4m	45.0m	48.0m	1.86	38
53.4m	56.4m	48.0m	51.0m	1.87	37
56.4m	59.4m	51.0m	54.0m	1.86	36
59.4m	62.4m	54.0m	57.0m	1.85	37
62.4m	65.4m	57.0m	60.0m	1.89	37
65.4m	71.4m	60.0m	66.0m	1.88	37
71.4m	77.4m	66.0m	72.0m	1.88	37
77.4m	83.4m	72.0m	78.0m	1.89	37
83.4m	89.4m	78.0m	84.0m	1.88	37
89.4m	95.4m	84.0m	90.0m	1.89	38
95.4m	101.4m	90.0m	96.0m	1.87	38
101.4m	107.4m	96.0m	102.0m	1.87	38

1.3 Turbine Building -1&2

1.3.1 Density (ρ), Poisson's Ratio (μ), Dynamic Young's modulus (E_d)

Depth(m)	Average velocity		Vp/Vs	Density (Kg/m^3)	Poisson's Ratio	E_d(MPa)	G_d(MPa)
	Vs	Vp					
1.5	250.81	479.68	1.91	1850	0.31	310	120
3	261.14	521.11	2.00	1850	0.33	340	130
4.5	266.56	547.61	2.05	1850	0.34	350	130
6	287.08	577.76	2.01	1835	0.34	400	150
7.5	296.29	604.08	2.04	1835	0.34	430	160
9	309.46	632.66	2.04	1860	0.34	480	180
10.5	331.59	661.69	2.00	1860	0.33	540	200
12	358.68	711.46	1.98	1825	0.33	620	230
13.5	390.10	770.10	1.97	1825	0.33	740	280
15	419.73	807.18	1.92	1855	0.31	860	330
16.5	403.31	759.56	1.88	1855	0.30	790	300
18	389.58	726.98	1.87	1855	0.30	730	280
19.5	393.48	724.75	1.84	1855	0.29	740	290
21	405.04	746.56	1.84	1855	0.29	790	300
22.5	404.34	732.55	1.81	1855	0.28	780	300
24	404.29	746.16	1.85	1860	0.29	790	300
25.5	399.54	739.90	1.85	1860	0.29	770	300
27	412.10	758.19	1.84	1875	0.29	820	320
28.5	424.58	786.90	1.85	1875	0.29	880	340
30	467.65	873.70	1.87	1910	0.30	1090	420

31.5	460.85	866.90	1.88	1910	0.30	1060	410
33	469.60	892.16	1.90	1855	0.31	1070	410
34.5	478.15	901.95	1.89	1855	0.30	1110	420
36	459.23	848.86	1.85	1860	0.29	1010	390
37.5	489.63	896.43	1.83	1860	0.29	1150	450
39	513.53	945.45	1.84	1835	0.29	1250	480
40.5	545.79	996.24	1.83	1835	0.29	1410	550
42	569.35	1045.34	1.84	1835	0.29	1530	590
43.5	583.95	1074.66	1.84	1835	0.29	1620	630
45	591.89	1119.08	1.89	1850	0.31	1690	650
46.5	582.78	1098.14	1.88	1850	0.30	1640	630
47	535.69	1010.04	1.89	1854.375	0.29	1380	530
48.5	535.13	1004.80	1.88	1874.286	0.29	1380	540
50	487.30	926.65	1.90	1837.5	0.31	1140	440
51.5	498.09	920.75	1.85	1796.25	0.29	1150	450
53	484.14	918.17	1.90	1788.125	0.30	1090	420
54.5	486.54	922.97	1.90	1794.065	0.30	1110	420
56	484.79	923.98	1.91	1792.03	0.31	1100	420
57.5	489.43	946.48	1.93	1830	0.31	1150	440
59	497.16	933.68	1.88	1885	0.30	1210	470
60.5	496.38	974.97	1.96	1922.5	0.32	1250	470
62	492.79	954.68	1.94	1936.25	0.31	1240	470
63.5	513.86	955.98	1.86	1943.125	0.29	1330	510
65	529.58	996.27	1.88	1946.565	0.31	1430	550
66.5	526.01	1007.93	1.92	1940	0.32	1410	540
68	541.58	1017.65	1.88	1962.5	0.30	1500	580
69.5	531.00	1023.92	1.93	1973.75	0.32	1470	560
71	539.60	1047.20	1.94	1979.375	0.32	1520	580
72.5	542.85	1056.60	1.95	1967.19	0.32	1520	580
74	550.05	1094.62	1.99	1968.595	0.32	1580	600
75.5	528.95	1046.02	1.98	1969.295	0.32	1460	550
77	545.09	1043.02	1.91	1969.65	0.31	1540	590
78.5	553.38	1055.38	1.91	1975	0.31	1590	600
80	547.84	1036.38	1.89	1950	0.31	1530	590
81.5	546.56	1059.77	1.94	1937.5	0.32	1530	580
83	583.91	1094.00	1.87	1931.25	0.31	1720	660
84.5	577.33	1075.53	1.86	1943.125	0.30	1680	650
86	573.29	1090.50	1.90	1941.565	0.31	1670	640
87.5	575.86	1092.52	1.90	1940.78	0.31	1680	640
89	581.85	1116.78	1.92	1940.39	0.31	1720	660
90.5	569.14	1116.10	1.96	1910	0.32	1630	620
92	563.89	1106.53	1.96	1890	0.32	1590	600

93.5	571.15	1164.05	2.04	1880	0.33	1640	610
95	580.45	1186.12	2.04	1875	0.34	1690	630
96.5	606.61	1215.18	2.00	1902.5	0.33	1860	700
98	596.35	1233.37	2.07	1901.25	0.34	1810	680
99.5	601.71	1263.48	2.10	1900.625	0.35	1860	690
101	593.94	1273.63	2.14	1900.315	0.35	1810	670
102.5	595.15	1269.00	2.13	1870	0.35	1790	660
104	582.05	1258.75	2.16	1902.5	0.35	1740	640
105.5	595.75	1263.33	2.12	1918.75	0.34	1830	680
107	600.63	1278.40	2.13	1926.875	0.35	1870	700
108.5	622.53	1341.52	2.15	1945.94	0.35	2040	750
109.5	625.41	1331.37	2.13	1950	0.35	2050	760

1.4 Cohesion (C_u):

Soil is considered cohesion-less for analysis. However, for the stability in the software application, a minimum value of cohesion may be used.

ANNEXURE - 1A

1. Geotechnical Properties of Improved Soil (Soil – Cement Mix)

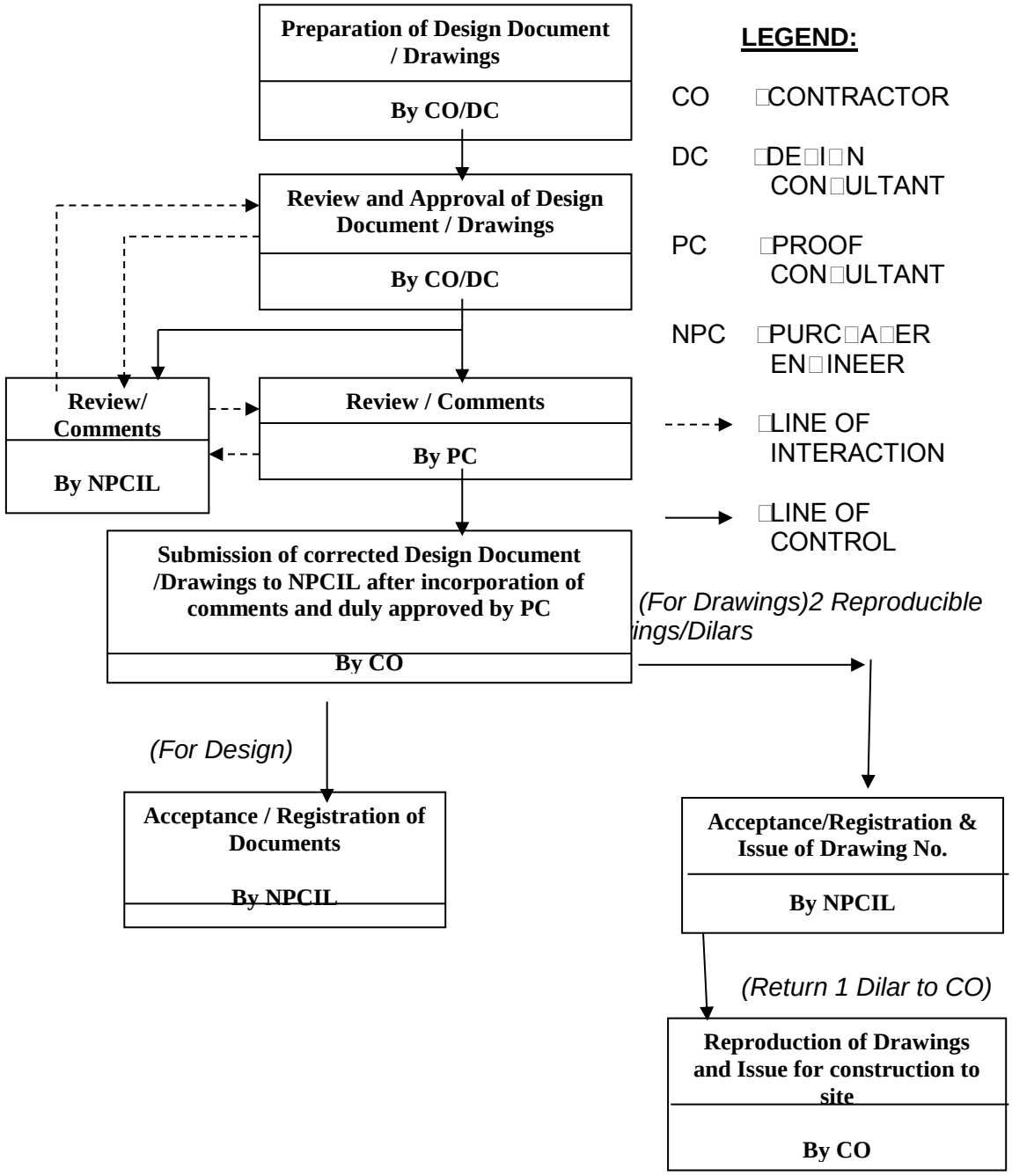
Sr. No.	Properties	Values	Unit	Remark
1	Static Modulus of Elasticity (Es)	777	MPa	
2	Improved Bulk Density, ρ	2	T/m^2	
3	Poisson's Ratio, μ, (Static/Dynamic)	0.38	-	
4	Cohesion, C	1.82	Kg/cm^2	For Static analysis
		3.44	Kg/cm^2	For Dynamic analysis
5	Angle of Internal Friction, ϕ	51.01	Degrees	For Static analysis
		47.37	Degrees	For Dynamic analysis
6	Dilation Angle, ψ = ϕ - 30	21.01	Degrees	For Static analysis
		17.37	Degrees	For Dynamic analysis
7	Shear Wave Velocity, Vs	1157	m/sec	
8	G/Gmax correction	0.4	-	

Note 1 - Reduction factor of 0.75 (this factor is applied to cohesion and tanΦ) shall be multiplied as per Euro Code-7 to take care of the spatial variation.

Note 2 - To take care of tension effect in soil-cement, a tension cut-off value of $2C_u*\cot\alpha$ (where $\alpha=45+\Phi/2$) shall be considered in the analysis.

ANNEXURE - 2

FLOW CHART FOR ISSUE OF CIVIL DESIGN DOCUMENT/DRAWING



ANNEXURE - 3

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
0.100	0.029	0.023	0.016	0.013	0.012	0.011	0.010	0.008	0.006
0.105	0.032	0.025	0.018	0.015	0.013	0.012	0.011	0.009	0.006
0.110	0.035	0.028	0.020	0.016	0.014	0.013	0.012	0.009	0.007
0.116	0.039	0.031	0.022	0.018	0.016	0.015	0.013	0.010	0.008
0.122	0.043	0.034	0.025	0.020	0.018	0.016	0.014	0.011	0.008
0.128	0.047	0.037	0.027	0.022	0.020	0.018	0.016	0.013	0.009
0.134	0.052	0.041	0.030	0.024	0.022	0.020	0.017	0.014	0.010
0.141	0.058	0.045	0.033	0.027	0.024	0.022	0.019	0.015	0.011
0.148	0.064	0.050	0.036	0.030	0.026	0.024	0.021	0.017	0.012
0.155	0.070	0.055	0.040	0.033	0.029	0.026	0.023	0.019	0.013
0.163	0.077	0.060	0.044	0.036	0.032	0.029	0.026	0.021	0.015
0.171	0.085	0.067	0.049	0.040	0.036	0.032	0.028	0.023	0.016
0.180	0.094	0.074	0.054	0.044	0.040	0.035	0.031	0.025	0.018
0.189	0.104	0.081	0.060	0.049	0.044	0.039	0.034	0.028	0.020
0.198	0.115	0.089	0.066	0.053	0.048	0.043	0.038	0.030	0.022
0.208	0.127	0.099	0.073	0.059	0.053	0.047	0.042	0.033	0.024
0.218	0.139	0.108	0.080	0.065	0.059	0.052	0.046	0.037	0.026
0.229	0.154	0.119	0.089	0.072	0.065	0.057	0.050	0.041	0.029
0.241	0.170	0.132	0.098	0.079	0.072	0.063	0.056	0.045	0.032
0.253	0.188	0.146	0.109	0.088	0.079	0.070	0.062	0.049	0.036
0.265	0.206	0.160	0.119	0.096	0.087	0.077	0.068	0.054	0.039
0.279	0.229	0.178	0.132	0.107	0.097	0.085	0.075	0.060	0.043
0.293	0.252	0.196	0.146	0.118	0.107	0.094	0.083	0.066	0.048
0.307	0.277	0.216	0.160	0.130	0.117	0.104	0.091	0.073	0.053
0.323	0.307	0.239	0.178	0.144	0.130	0.115	0.100	0.081	0.058
0.339	0.339	0.263	0.196	0.159	0.143	0.127	0.111	0.089	0.064
0.356	0.374	0.291	0.216	0.176	0.157	0.141	0.122	0.098	0.071
0.373	0.410	0.319	0.237	0.194	0.173	0.155	0.134	0.108	0.078
0.392	0.453	0.353	0.262	0.214	0.191	0.171	0.148	0.119	0.086
0.412	0.501	0.390	0.290	0.237	0.211	0.190	0.164	0.132	0.095
0.432	0.525	0.409	0.304	0.249	0.221	0.199	0.172	0.138	0.100
0.454	0.552	0.430	0.320	0.262	0.233	0.209	0.180	0.145	0.105
0.476	0.579	0.451	0.335	0.274	0.244	0.219	0.189	0.152	0.110
0.500	0.608	0.474	0.352	0.288	0.256	0.231	0.199	0.160	0.115
0.525	0.639	0.497	0.370	0.303	0.269	0.242	0.208	0.168	0.121
0.552	0.671	0.523	0.389	0.318	0.283	0.254	0.219	0.177	0.127
0.579	0.704	0.549	0.408	0.334	0.297	0.267	0.230	0.185	0.133
0.608	0.740	0.576	0.428	0.350	0.311	0.280	0.241	0.195	0.140
0.639	0.777	0.605	0.450	0.368	0.327	0.295	0.254	0.205	0.147

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
0.670	0.815	0.635	0.472	0.386	0.343	0.309	0.266	0.215	0.154
0.704	0.856	0.667	0.496	0.406	0.361	0.325	0.279	0.225	0.162
0.739	0.899	0.700	0.520	0.426	0.379	0.341	0.293	0.237	0.170
0.776	0.944	0.735	0.546	0.447	0.397	0.358	0.308	0.248	0.179
0.815	0.991	0.772	0.574	0.470	0.417	0.376	0.324	0.261	0.188
0.856	1.018	0.791	0.588	0.481	0.428	0.385	0.331	0.268	0.193
0.899	1.046	0.811	0.602	0.494	0.438	0.395	0.339	0.274	0.198
0.943	1.073	0.831	0.616	0.506	0.449	0.404	0.347	0.281	0.203
0.991	1.103	0.851	0.631	0.519	0.460	0.414	0.356	0.288	0.208
1.040	1.132	0.872	0.646	0.531	0.471	0.425	0.364	0.296	0.213
1.092	1.163	0.894	0.661	0.545	0.483	0.435	0.373	0.303	0.219
1.147	1.194	0.916	0.677	0.559	0.495	0.446	0.382	0.311	0.224
1.204	1.226	0.938	0.693	0.572	0.507	0.457	0.391	0.319	0.230
1.264	1.259	0.962	0.709	0.587	0.519	0.468	0.400	0.327	0.236
1.327	1.293	0.985	0.726	0.601	0.532	0.480	0.410	0.335	0.242
1.394	1.328	1.010	0.743	0.617	0.545	0.492	0.420	0.344	0.248
1.464	1.364	1.035	0.761	0.632	0.558	0.504	0.430	0.352	0.255
1.537	1.401	1.060	0.779	0.648	0.572	0.517	0.440	0.361	0.261
1.614	1.438	1.086	0.798	0.664	0.586	0.529	0.451	0.371	0.268
1.694	1.477	1.113	0.817	0.681	0.600	0.542	0.461	0.380	0.275
1.779	1.517	1.141	0.836	0.698	0.615	0.556	0.472	0.389	0.282
1.868	1.558	1.169	0.856	0.715	0.630	0.570	0.484	0.399	0.289
1.961	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.059	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.162	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.270	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.384	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.503	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.628	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.760	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
2.898	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.043	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.195	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.355	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.522	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.698	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
3.883	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.077	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.281	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
4.495	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.720	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
4.956	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
5.204	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
5.464	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
5.737	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
6.024	1.599	1.197	0.876	0.733	0.645	0.584	0.495	0.409	0.296
6.325	1.500	1.130	0.840	0.705	0.622	0.564	0.480	0.400	0.291
6.642	1.407	1.066	0.804	0.678	0.599	0.544	0.466	0.391	0.286
6.974	1.320	1.006	0.771	0.653	0.577	0.525	0.452	0.382	0.281
7.322	1.238	0.950	0.739	0.628	0.556	0.507	0.439	0.373	0.276
7.689	1.162	0.896	0.708	0.604	0.536	0.489	0.426	0.364	0.271
8.073	1.090	0.846	0.678	0.581	0.516	0.472	0.413	0.356	0.267
8.477	1.022	0.798	0.650	0.559	0.497	0.456	0.401	0.348	0.262
8.901	0.959	0.753	0.622	0.537	0.479	0.440	0.389	0.340	0.257
9.346	0.899	0.711	0.596	0.517	0.462	0.425	0.377	0.332	0.253
9.813	0.844	0.671	0.571	0.497	0.445	0.410	0.366	0.324	0.248
10.303	0.792	0.633	0.547	0.478	0.429	0.396	0.355	0.317	0.244
10.819	0.751	0.606	0.526	0.461	0.414	0.383	0.345	0.309	0.240
11.360	0.712	0.579	0.506	0.445	0.399	0.370	0.335	0.301	0.236
11.928	0.676	0.554	0.486	0.429	0.386	0.358	0.325	0.293	0.232
12.524	0.641	0.530	0.467	0.413	0.372	0.346	0.315	0.286	0.227
13.150	0.608	0.507	0.449	0.399	0.359	0.335	0.306	0.279	0.223
13.808	0.577	0.485	0.431	0.384	0.347	0.324	0.297	0.272	0.220
14.498	0.548	0.464	0.414	0.371	0.335	0.313	0.289	0.265	0.216
15.223	0.519	0.444	0.398	0.357	0.323	0.303	0.280	0.259	0.212
15.984	0.493	0.424	0.383	0.345	0.312	0.293	0.272	0.252	0.208
16.783	0.468	0.406	0.368	0.332	0.301	0.284	0.264	0.246	0.205
17.622	0.444	0.388	0.353	0.320	0.290	0.274	0.257	0.240	0.201
18.504	0.421	0.371	0.339	0.309	0.280	0.265	0.249	0.234	0.198
19.429	0.399	0.355	0.326	0.298	0.271	0.257	0.242	0.228	0.194
20.400	0.379	0.340	0.313	0.287	0.261	0.248	0.235	0.222	0.191
21.420	0.362	0.326	0.302	0.278	0.254	0.242	0.230	0.218	0.189
22.491	0.345	0.313	0.291	0.269	0.247	0.236	0.225	0.214	0.187
23.616	0.330	0.300	0.281	0.260	0.241	0.231	0.220	0.210	0.185
24.797	0.315	0.288	0.271	0.252	0.234	0.225	0.216	0.206	0.183
26.036	0.300	0.276	0.261	0.243	0.228	0.219	0.211	0.202	0.182
27.338	0.287	0.265	0.252	0.236	0.222	0.214	0.206	0.199	0.180
28.705	0.274	0.254	0.243	0.228	0.216	0.209	0.202	0.195	0.178

Digitalized values of Ground Acceleration Spectra normalized w.r.t "g" for different values of damping (GHAVP-1&2 site for SSE level earthquake)

Freq (Hz)	Percentage of critical damping								
	0.5%	l%	2%	3%	4%	5%	7%	10%	20%
30.140	0.261	0.244	0.234	0.220	0.210	0.204	0.198	0.191	0.176
31.647	0.250	0.234	0.226	0.213	0.204	0.199	0.193	0.188	0.175
33.230	0.238	0.225	0.218	0.206	0.199	0.194	0.189	0.184	0.173
34.000	0.233	0.220	0.214	0.203	0.196	0.192	0.187	0.183	0.172
37.000	0.215	0.205	0.201	0.192	0.187	0.184	0.180	0.177	0.169
40.000	0.200	0.192	0.190	0.182	0.179	0.177	0.174	0.172	0.166
45.000	0.181	0.177	0.175	0.172	0.170	0.169	0.168	0.167	0.164
50.000	0.166	0.165	0.163	0.163	0.163	0.163	0.163	0.162	0.162
60.000	0.165	0.164	0.163	0.162	0.162	0.162	0.162	0.162	0.162
70.000	0.163	0.163	0.162	0.162	0.162	0.161	0.161	0.161	0.161
80.000	0.162	0.162	0.161	0.161	0.161	0.161	0.161	0.161	0.161
90.000	0.161	0.161	0.161	0.161	0.160	0.160	0.160	0.160	0.160
100.000	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160

ANNEXURE - 4

INFORMATION TO BE SUBMITTED ALONGWITH THE BID FOR THE PROPOSED AGENCY FOR CIVIL WORKS

The proposed agency for civil design and construction shall meet the qualification criteria specified in the relevant section of the tender. The following information shall be supplied along with the bid:

1. The name of the proposed agency to execute the Civil works alongwith its credentials & capability to execute the works, within the scope of this tender. The proposed agencies for civil works are given below:

a) Larson & Turbo Ltd.

b) Hindustan Construction Company

c) Simplex Infrastructures Ltd

d) AFCONS Infrastructures Ltd

Any other agency may also be accepted subjected to meeting the "qualification criteria for agency for civil works" specified in the relevant clause of the tender.

The proposed agency for civil should meet the relevant mandatory qualification criteria . The bidder shall submit the credential of the proposed agency to establish, the civil work executing agency's competence to successfully complete the scope of job within this contract as per the terms & conditions stipulated in the tender.

2. Reference list of similar works carried out along with year of award, year of completion & value of work .(Specific details of works related to design & construction of turbine building & TG Deck considering seismic effects in soil sites shall be provided) .

3. Detailed credentials of prospective Design Consultant along with supporting documents of his earlier experience for designing the Turbine Building with Turbogenerator foundation for a power plant of minimum 500 MWe capacity in soil sites .

4. Detailed credentials of Proof Consultant having experience in design & review of machine foundation & framed structures.

5. Drawing showing G.A. of all the structures & allied works within the scope of this tender.

6. Drawings showing longitudinal and transverse sections, architectural elevation of above structures including foundation details.

7. Details of fire protection measures to be adopted for steel structures. Bidder shall also submit the details of agency and his experience to carry out the similar job to protect the steel structure for fire rating as specified in the tender specifications.

8. The Technical , Financial & Other data as per annexure-5 TO 7 for the proposed agency for executing the civil works. It may be noted that, only some of the important information about civil works is sought , under the following Annexure 5 TO 7. For