2 X 660 MW CSPGCL HTPS KORBA WEST TPP

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER (NDCT)

BOOK 2 OF 2

(CIVIL SPECIFICATION)

SPECIFICATION No. **PE-TS-530-165-W001**
REV NO. 00

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA, INDIA

CHATTISGARH STATE POWER GENERATION COMPANY LIMITED

2 X 660 MW SUPER CRITICAL THERMAL POWER PROJECT HTPS, KORBA WEST

OWNER'S CONSULTANT

NTPC LIMITED

TECHNICAL SPECIFICATION

FOR CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

FOR NATURAL DRAUGHT COOLING TOWER

DOCUMENT NO. PE-TS-530-165-W001

(REVISION R0)

EPC Contractor

BHARAT HEAVY ELECTRICALS LTD

Project Engineering Management

Power Sector, Plot No. 25, Sector 16A,

Noida (U.P.)-201301

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(PART -A)

SCOPE OF WORK

EPC Contractor
BHARAT HEAVY ELECTRICALS LTD
Project Engineering Management
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1. Scope of work

The scope of the work for cooling tower shall include the design and construction of reinforced concrete double curvature hyperbolic shell, raker columns, ring beams, foundations including piling work (if applicable, vertical/ raker piles), cold water basin with partition walls, hot water ducts, drain sumps, external drain chamber with associated pipe work, cold water discharge channels for each cooling towers (as specified elsewhere) along with trash rack & stop-log gate and its lifting arrangement, hoists and monorails, primary and secondary hot water distribution troughs, fill support systems including columns & beams, testing of cold water basin for water tightness, external stairs, ladders, platforms, walkways as specified or required for operation and maintenance, access doors, Two (2) numbers Pultruded FRP staircase for approach to hot water distribution level of each cooling tower. RCC Paved walkway of minimum 10 m clear width all around the periphery of each cooling tower, Doors and suitable permanent walkways for access into distribution system, drift eliminator and fill packs shall be provided for each cooling tower, Pultruded FRP handrails, steel fittings/fixtures/inserts including fabrication, galvanizing and erection of associated steel work, providing protective measures in concrete and steel materials against effects of chemicals on the completed structure etc. all complete as per specifications, drawings and directions of Engineer.

Wind tunnel model test for Natural Draught Cooling Tower shall be carried out by the bidder as per technical specifications.

Customer (CSPGCL) has carried out detailed Soil investigation of the proposed NDCT area. Bore logs data and bearing capacity for design of foundations are given in tender specification. In case, bidder feels that the available data is inadequate, he may carry out his own geotechnical investigation. Further, if there is any change in layout or for any area not covered in the provided geotechnical data, the bidder has to carry out geotechnical investigation in the area at no cost. The onus of correct assessment/interpretation and understanding of the existing sub-soil condition/data lies with the bidder. Any variation in the data between the one furnished and to that found during execution of the work at site shall not constitute a valid reason in affecting the terms & conditions of this bid and the bidder shall note that nothing extra will be payable on this account. The bidder shall fully satisfy himself about the nature of sub-strata expected to be encountered including the type of foundation, ground water table and construction methodology to be adopted etc prior to the submission of the bid.

If the bidder desires to carry out additional geo-technical investigation he/she may do so with prior information/permission of BHEL/owner at no extra cost to BHEL/owner. No extension in time schedule shall be permitted on this account. The bidder shall obtain approval on the agency for conducting geo-technical investigation work, field and laboratory testing schedule proposed by the bidder etc from BHEL/owner before undertaking the geo-technical investigation work. However, the net safe bearing capacity (SBC) of shallow foundation/allowable load carrying capacity of pile to be adopted for the design of foundations during detailed engineering shall be limited to the values mentioned elsewhere in the specification and any value of net SBC/load carrying capacity of pile higher than the one indicated shall not be accepted. However, bidder shall note that the net safe bearing capacity/pile capacity and foundation depth to be adopted for design during detailed engineering stage shall be got approved by BHEL/owner.

Area survey and any other works not mentioned herein, but sufficiently implied and are necessary for completion and proper functioning of the cooling tower shall also be included in the scope of bidder.

CHATTISGARH STATE POWER GENERATION COMPANY LIMITED

2 X 660 MW SUPER CRITICAL THERMAL POWER PROJECT HTPS, KORBA WEST

OWNER'S CONSULTANT

NTPC LIMITED

TECHNICAL SPECIFICATION

FOR CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

FOR NATURAL DRAUGHT COOLING TOWER

DOCUMENT NO. PE-TS-530-165-W001 (REV. 0)

(SECTION -C)

CUSTOMER TECHNICAL SPECIFICATIONS FOR CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

EPC Contractor
BHARAT HEAVY ELECTRICALS LTD
Project Engineering Management
Power Sector, Plot No. 25, Sector 16A,
Noida (U.P.)-201301

CHHATTISGARH STATE POWER GENERATION COMPANY LIMITED

EPC PACKAGE FOR 2 X 660 MW SUPER CRITICAL THERMAL POWER PROJECT, HTPS, KORBA WEST

TECHNICAL SPECIFICATION

FOR

EPC PACKAGE

PART – B

(BOOK 4 OF 5 – CIVIL)

SECTION - VI

BIDDING DOCUMENT NO.: 03-05 / 2X660 MW / T-13 / 2023

PART – B (CIVIL) (BOOK 4 OF 5)	
D – 01	CIVIL WORKS

INDEX

SUB-SECTION-D-1-1

GENERAL

The brand names mentioned in Civil Works, Technical Specification, Section-VI, Part-B, Subsection to D-1-1 to D-1-12 shall be read as null and void..
(Amendment No 01, D-1-07)

D-1-1 GENERAL

1.01.00 This specification is to cover, survey works, geotechnical investigation works, site leveling works, design, preparation of general arrangement drawings, construction and fabrication drawings, supply of labour & materials and construction of all civil, structural and architectural works by the Bidder.

Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope is referred to as civil works. Various buildings, structures, plant and systems, facilities, etc., covered under the scope is given in Part-A and herein.

The work to be performed under this specification consists of Survey, Geotechnical investigation , design, engineering, construction, erection and providing all labour, materials, consumables, equipment, temporary works, temporary storage sheds, temporary colony for labour and staff, temporary site offices, constructional plants, fuel supply, transportation and all incidental items not shown or specified but reasonably implied or necessary for the completion and proper functioning of the plant, all in strict accordance with the specifications including revisions and amendments thereto as may be required during the execution of work.

All construction materials including cement, reinforcement steel, coarse & fine aggregate, structural steel, and construction water etc., shall be arranged by the Bidder.

The scope shall also include setting up by the Bidder a complete testing laboratory in the field to carry out all relevant tests for structural steel, reinforcement steel & reinforced concrete (RCC) works.

Geotechnical investigation has been carried out for Korba west 2x250 MW area (in vicinity to the proposed 2x660 MW area) by the Owner and the bore-log data is furnished in Annexure ‘C’.

The work shall be carried out according to the design/drawings to be developed by the Bidder and approved by the Employer. For all buildings, facilities, systems, structures, etc., necessary layout and details are to be developed by the Bidder keeping in view the statutory and functional requirements and providing enough space and access for operation, use and maintenance. The Bidder’s work shall cover the complete requirements as per IS codes, fire safety norms, requirements of various statutory bodies, International Standards, best prevailing practices and to the complete satisfaction of the Employer.

The Bidder shall make the layout and levels of all structures from the general grid of the plot and the nearest GSI benchmark or other acceptable benchmark of Government department/Owner. As per the directions of the Engineer. The Bidder shall be solely responsible for the correctness of the layout and levels and shall also provide necessary instruments, materials, access to works, etc., to the Engineer for general checking of the correctness of the civil works.

All the quality standards, tolerances, welding standards and other technical requirements shall be strictly adhered to.

The Bidder shall fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, soil conditions, local conditions and site-specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications.

In case of any conflict between stipulations in various portions of the specification, most stringent stipulation would be applicable for implementation by the Bidder without any extra cost to the Employer.

Wherever there is an anomaly in the design concept between the data furnished in the General Design Criteria & Design Concept of Buildings, the data furnished in the design concept of buildings shall be treated as final.

Bidder or his agencies engaged as detailer for fabrication drawings should have the experience of detailing for powerhouse structures or steel plant or Industrial structures like Petro/Chemical/Refinery/Cement etc.

SUB-SECTION-D-1-2

SCOPE OF WORK

CLAUSE NO.	TECHNICAL REQUIREMENTS
D-1-2	**SCOPE OF WORK**
	The scope of work for the EPC contractor shall include the analysis, design, construction, erection of all civil, structural & architectural works and all other items mentioned in Part-A of this Specification.
2.01.00	**Construction Facilities**
	For details of construction facilities refer to Part-A of this specification.
2.02.00	**Exclusions:**
	The details of exclusions and terminal points refer to Part-A of this specification.

SUB-SECTION-D-1-3

SUBMISSIONS

D-1-3 **SUBMISSIONS**

3.01.00 The drawings included in the Bidding Document provide a general idea about the work to be performed under the scope of this contract. These are preliminary drawings for bidding purposes only and are by no means the final drawings or show the full range of the work under the scope. Work has to be executed according to drawings prepared by the contractor. The following documents and drawing shall be submitted and got approved before commencement of detailed engineering. The list given below is not exhaustive but indicative only.

a) Project design intent, design criteria which shall cover all design aspects, design parameters, material of construction and its specifications, structural idealization including framing system for gravity loads and lateral loads(wind and seismic), load cases, load combinations, assumptions, references, basis of analysis & design of all buildings, machine foundations, facilities, systems and structures etc.

b) Survey drawings indicating spot levels for the area under the scope of work.

c) Plants 'General Layout Plan' drawing with coordinates of roads, boundary wall, buildings and facilities, pipe/cable corridors, railway lines, Green Belt etc..

d) Geotechnical investigation scheme

e) Geotechnical Investigation report including foundation system recommendations.

f) Typical design of pile, if applicable, in terms of type, rated capacity, length, diameter and the termination criteria to locate the founding level.

g) Scheme for initial and routine load test of Pile foundation high strain dynamic load test and pile integrity test methodology.

h) Details of corrosion protection measures for all structures, foundations etc.

i) Architectural concept designs which shall cover all concept plans and elevations, finishes and area statements of all buildings and facilities

j) The following sequence of submission of drawings/ documents is to be followed:
- Architectural drawings, wherever applicable
- Relevant GA drawings & loading document
- Analysis & design of structures/ buildings/ facilities with drawings.
- Analysis & design of foundations with drawings.

3.02.00 Detailed construction drawings and design calculations for all civil works for static as well as dynamic analysis shall be submitted for approval prior to undertaking construction work. All drawings shall be submitted in PDF as well as AutoCAD format

3.03.00 Design calculations shall be done in M.S. Office (latest version) and Drawings shall be prepared in Auto Cad (latest version). The analysis shall be done by using STAAD PRO / ANSYS/SAP2000 (latest version). However, design may be carried out manually, using computer work sheets or by using suitable software programs, as mutually agreed by Employer. Final calculations and drawings shall be submitted as mentioned in General technical specification.

3.04.00	Civil Task drawings indicating various equipment loading and supporting arrangement and floor loads shall be submitted along with design calculations. Soft copies of all STAAD/Other Softwares input and output files shall be submitted along with the design calculations for all revisions.
3.05.00	Structural steel fabrication drawings to be prepared by the contractor will not be approved by the Employer. However, the Contractor shall submit all fabrication drawings for Employer's reference. Copy of detailed bar bending schedule as prepared by contractor shall also be submitted to Engineer in charge for the reference.
3.06.00	Approval of construction drawings prepared by the contractor shall not relieve the Contractor of his responsibility regarding the safety and adequacy of design and correctness of the drawing.
3.07.00	"As-built" drawings in AutoCad & PDF format shall be prepared and submitted to Owner by the Contractor after completion of construction / erection, incorporating all the changes, if any. Final executed quantities of RCC and structural Steel shall be incorporated in the As-Built drawing.

SUB-SECTION-D-1-4

GENERAL LAYOUT PLAN

D-1-4 **GENERAL LAYOUT PLAN**

4.01.00 The preliminary layout plan proposed for the project is shown in the drawing titled "General Layout Plan".

It shall form the basis for further elaboration by the Bidder for the plant facilities, which are in his scope. Area identified for facilities remain same as indicated in GLP, however, minor modification of location of building may be done to optimize layout.

Bidder shall prepare the detailed layout of the plant facilities which are in his scope and shall submit the same for Owner's approval.

While preparing the detailed layout, planning his facilities and deciding upon the transportation and erection strategy he shall ensure the following aspects.

a) All Statutory requirements including safe distances between various facilities as per applicable rules/acts/laws including local bye-laws are met.

b) Face of the buildings and facilities are located in such a way so as to have an offset of minimum 15m with respect to center line of double lane road and 12 meter with respect to center line of single lane road. The entire construction activity shall take into account the commissioning of the unit in phases matching with the phased commissioning of the plant.

c) The interface requirements with the plant construction/erection activities of other contracting agencies engaged by Owner. These agencies engaged will be working simultaneously with the Bidder within the plant premises.

d) Available Area for laydown, preassembly and fabrication yard have been earmarked on the General Layout Plan.

e) No permanent facility shall be located within the safety zone limit around the fuel Oil storage tanks etc., except those permitted by Owner.

f) Transportation of all equipment and materials shall be by road as envisaged. Any other mode envisaged by the bidder may be proposed.

g) All parts of the buildings and facilities shall be approachable by fire tenders.

h) Main roads /peripheral roads are only shown in GLP and road layout tender drawing. Approach made of heavy-duty paving/passage to buildings/structures/facilities in the scope of bidder from nearby plant road/peripheral road/grid road/internal access road shall be provided. Multiple numbers of access to different parts of any building /facility like main plant building, control room, transformer yard, service building etc. should be provided.

4.02.00 **VOID**

4.03.00 **Site Levelling and Slope Protection Work**

4.03.01 Complete levelling of entire plant area as shown in drawing Titled ‘Site Levelling Plan’ shall be done by the Bidder.

Bidder shall carry out the topographical survey before he commences detailed design and site leveling. This survey shall cover the entire plant area including the areas earmarked for,

ash based units, ash silos, railyard, the diversion drains in Bidder's scope of work. Based on field observations the contractor shall prepare and submit the survey maps of the surveyed site on suitable scale, indicating grid lines, contour lines and demarcating all permanent features like roads, railways, water-ways, buildings, power lines, natural streams, trees etc. For each area survey maps shall be prepared and submitted, one showing the spot levels and contours with grid lines and the other showing the grid lines, contours and permanent features.

Established methods of surveying like triangulation, traversing, fly leveling etc. shall be adopted for the survey work. Spot levels shall be taken at 25 meter interval and at closer intervals where pits, undulations etc. are met with. These levels shall be taken in two orthogonal directions. Contours shall be plotted at 5m interval.

It is proposed that for the purposes of site leveling the entire plant and associated areas will be divided into various blocks as defined in the drawing titled, "Site Levelling Plan". Each block shall be finished to the formation level as specified in drawing. Bidder shall deploy adequate number of experienced site leveling contracting agency(s) with requisite earth moving and compacting equipment to complete the work as per schedule.

Preparation of leveling & grading as per proposed finished ground level (FGL) is in the Bidder scope.

Bidder shall ensure that road access and drainage facilities for each block is available when site leveling in that block is completed. Unless otherwise mentioned, all roads and drains within a block shall be constructed by the bidder within a month from the date of completion of site leveling of that block.

The specified formation level(s) shall be achieved either by excavation where the existing ground levels are higher than the specified formation level or by raising by controlled filling with borrowed earth where the existing ground levels are lower than the specified level.

The excavation shall be in all types of soils or rock or a mixture of these. Bidder should assess and satisfy himself about the actual nature of soil present at site, before submitting his bid.

All natural materials arising out of site clearance and excavation shall be the property of owner. They shall be dealt with in the manner specified by the Engineer. Earth / boulders / rock etc. excavated and useful portion (serviceable materials) of trees cut shall be stacked at suitable places within Owner's acquired land for the plant in a manner as directed by the engineer. Woods, branches, trunks of trees shall be termed as serviceable material. Other materials like twigs, leaves, roots, vegetable and organic matters etc. shall be termed as unserviceable material and shall be sorted out from the serviceable materials before disposal. They shall be cleared from the area and disposed off at places within Owner's acquired land for the plant in a manner as directed by the engineer.

If the excavated material is suitable and accepted by the Engineer as fill material, the same can be used for filling in other areas were raising by filling is required. Otherwise, the same shall be taken and stacked at places(s) within the plant boundary as directed by the Engineer.

Filling with rock shall be done only after the written permission of the Engineer in the following manner:

For filling the areas involving water bodies, dewatering, removal of much, dismantling of existing slope protection of water including all other scope of work required for filling of area to be done by the bidder.

- Filling with rock shall be done only in areas identified for laydown and preassembly and ash based units.
- Maximum size of rock used for filling should not be more than 150mm in all direction.
- Original ground after removal of all organic and vegetable matters shall be consolidated by rolling as directed by the engineer subject to a minimum of six passes of 8-10 tonne roller.
- Over the compacted layer of rock (300mm), soil shall be filled in horizontal layers not exceeding 300mm in compacted thickness. The soil shall be compacted as specified elsewhere.
- It shall be ensured that the top soil layer is in minimum 3 layers of 300 mm each. To achieve this the thickness and number of rockfill layers below can be suitably adjusted.

Materials of any kind obtained from excavation on the Site shall remain the property of the Employer and shall be disposed of as the Project Manager may direct.

In case of in-plant excavation and backfilling the excavated material can be used for backfilling if it meets the technical requirements. However, any royalty or statutory charges involved as per local laws have to be borne by the vendor.

Excavated material (like rock, boulders, sand, moorum, etc.), which meets the technical requirements of construction material, can be used by the vendor on directions of EIC, subject to payment of requisite charges as decided by Owner. Any royalty or statutory charges involved as per local laws have to be borne by the vendor.

If the excavated material is to be disposed outside plant boundary, as stipulated in the technical specifications, all clearances and permissions has to be obtained by the vendor. No extra charges for the same, including statutory charges and taxes, would be payable by Owner to the vendor. Owner would only extend support for obtaining the clearances and permissions.

Contour map and spot levels of the area based on the preliminary survey carried out by Owner is enclosed for the purpose of guidance of Bidder. Refer tender drawing titled Topographical Survey". However, Owner does not take any responsibility about the accuracy of the survey details furnished and any variation of the said data shall not constitute a valid reason for changing the terms and conditions of the contract. Bidder is requested to carry out his independent assessment of the existing ground levels before furnishing his bid. Detailed survey shall be carried out by Bidder after award of work and all findings as stated earlier shall be submitted for Owner's review.

4.03.02 All existing drains/channels in the plant and other areas associated with the plant except

	those proposed to be constructed by the Owner shall be suitably diverted by the Bidder before taking up any construction. These diversions shall be so designed as to ensure effective disposal of water without any accumulation or flooding within the limits of overall land acquisition line and in adjoining areas.
4.03.03	Before commencement of cutting/filling, all organic and vegetable matters like grass, plants, shrubs bushes, weeds, trees etc. in the areas to be filled, shall be completely removed along with their roots and disposed off. It shall also be ensured that the area to be filled is clear of any water, slush etc. Original ground shall be compacted by rolling as directed by the Engineer subject to a minimum of six passes of 8 to 10 tonne roller. The earth shall then be spread in horizontal layers not exceeding 300 mm in compacted thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction of 95% or more of Standard Proctor's maximum dry density. The moisture content of the fill material shall be controlled to obtain near optimum moisture content during compaction. The fill material shall be tested for determining optimum moisture content and maximum dry density by Standard Proctor Test as per IS: 2720 (Part-VII). The fill material shall also be tested for determining moisture content before compaction as per IS: 2720 (Part-II). For each of the above tests, one sample for every 10,000 cubic metre of fill material shall be tested. Additional samples shall be tested, whenever there is a change in the source or type of fill material. The compacted soil shall be tested for its dry density as per IS: 2720 (Part-XXIX) or Part-XXVIII). Samples shall be taken at the rate of one sample for every 10,000 sq.m. area for each compacted layer. In addition, random checks shall be carried out in compacted soils by means of Proctor needle penetration. Bidder shall submit to the Engineer, the test results immediately after completion of the tests. A sample shall be deemed to have passed the test when the in-situ dry density is equal to or more than the specified percentage of maximum dry density. If a sample taken from a layer fails to pass the test, the layer shall be further compacted till two samples taken and tested from this layer pass without any negative deviation. Only after this. spreading of further layers shall be taken up.
4.03.04	Before start of filling, the Bidder shall submit to the Owner his proposal for the methodology to be adopted for compaction for each type of fill material. The Bidder shall also carry out compaction trials to establish the proposed methodology. The Bidder shall start the compaction work only after approval of the methodology by the Owner
4.03.05	The surface of the cut/filled up areas after reaching final level shall be dressed to the required levels and slopes. The difference in levels shall not be more than +/- 10cm locally.
4.03.06	The borrow areas outside the overall plant boundary limits for obtaining suitable fill material which is required over and above the earth available after cutting high grounds within the plant area, for site levelling shall be arranged by the Bidder himself and all expenses in respect of royalties, taxes, duties, etc. for borrow areas/fill material shall be borne by him. He shall also obtain and submit to the Owner the necessary clearances/permission from the concerned authorities for the borrow areas/fill material.
4.03.07	Material suitable for filling shall be loaded and transported to the filling site by the Bidder. Any coarse grained or fine grained low plastic soil, free from shingle, salts, organic matter, sod or any other foreign substances, may be used for filling. The Bidder shall

	test the fill material to establish its suitability and submit its results to the Owner. Fill material shall be approved by the Owner. The following types of materials shall not be used for filling: a) Material from swamps, marshes and bogs. b) Expansive clays c) Peat, logs, stumps, sod and perishable materials. d) Materials susceptible to combustion e) Any material or industrial and domestic produce which will adversely affect other materials in the work. f) Materials from prohibited areas
4.03.08	Bidder shall include in his offer any extra filling that may be required on account of subsidence of the original ground due to overburden of filling above and/or compaction works for site levelling.
4.03.09	After levelling, the contractor shall establish concrete pillars at the intersection points of the grid lines for future reference. These pillars shall project at least 450 mm above the formation level and shall be labelled permanently with their respective coordinates and reduced levels.
4.03.10	Filling upto the specified formation level shall extend at least 2.0 m beyond the outside face of boundary wall/fence. Thereafter, it shall be finished at a suitable slope (not steeper than 1 Vertical: 2 Horizontal) with Rip-Rap. For slope steeper than 1:2 encountered anywhere, slope protection shall be provided at slope with gabion wall/RCC retaining wall as per the requirement.
4.03.11	Site levelling of railway siding area shall also comply to Railway Design & Standards Organisation (RDSO) guidelines.

SUB-SECTION-D-1-5

SALIENT FEATURES & DESIGN CONCEPT

D-1-5 **SALIENT FEATURES & DESIGN CONCEPT**

This section of specification covers salient features and design concepts of Civil, Structural, and architectural works pertaining to Power Plant components as detailed below.

5.01.00 **Architectural Concepts &Design:**

a) All the Architectural design works shall be carried out by professionally qualified architects having adequate experience (minimum five years) in the design and detailing of architectural work of power plant buildings. Bidder may have in-house Architects with the required experience for the above or engage Architect Consultant having similar experience.

b) Power plant buildings shall be architecturally treated, based on functional requirements, in such a way that they retain the desired scale, and present a pleasing composition of mass and void. The overall impact of the buildings shall be one of aesthetically unified architectural treatment having a comprehendible scale, blending colour scheme with the surroundings.

c) All buildings and structures shall be architecturally treated in such a way that completes the harmony with the main plant building, surrounding structures and environment. Due considerations shall be given to orientation, landscape design, and interior design. All finishes for floors, walls, ceiling, structural elements, partitions for offices and industrial areas shall be suitable for their aesthetics, durability and functional requirements and shall include the latest building material & technology. Consideration shall be given for achieving standardization & fast track construction.

d) Overall colour scheme of the buildings shall be designed judiciously and in a comprehensive manner considering the mass and void of buildings, its facade, equipment, exposed structural elements, piping, trestles, bus ducts, and other service elements. Architectural design of all power plant buildings shall be suitable for installation of photovoltaic panel on rooftop for renewable energy purpose. Proposal for the same to be submitted to Owner for approval.

e) For adequate light and ventilation, National Building Code recommendations shall be followed. All buildings having height more than 4.0 m shall have fixed glazed ventilators.

f) Architectural design of all Power Plant Building shall be suitable for installation of solar photovoltaic panels on roof tops for renewable energy purpose.

g) All the buildings shall be architecturally designed to meet the National Building Code requirement & Fire Safety Regulations.

h) All public buildings shall be designed incorporating the provision of barrier free environment for physically disabled persons.

i) All the buildings and site development shall be designed to take care of rainwater harvesting & ground water recharging. Development of rainwater harvesting scheme for

the project and obtaining approval of the scheme from Central Ground water board is in bidder's scope

j) For Control Rooms, CER, UPS Charger Room area in MPH dry wall construction technology shall be incorporated. Control room shall be designed as designer control room with ACP Cladded wall paneling for housing LVS.

k) Full glass wall partition with aluminium frame over solid wall with skirting 150 mm high to be provided between CCR and CER of AHP CR, WS CR & CHP control room and MPH Control room.

l) All control room shall be provided with air lock lobby.

m) The development of green belt is not in bidder scope. However, bidder has to plan the facilities leaving the space for green belt as indicated in "General Layout Plan". In addition to that laydown areas and other vacant land of the plant will be used by owner for the development of green belt.

n) All floor areas indicated in subsequent pages shall be total floor area required.

The total floor Area shall be area enclosed under the outside walls, including the wall thickness, of the building but excluding the following:

Lift shaft, Open staircase, Rainwater downcomer incasements, Sunshades, any floor/ roof projection, terrace area, any other shaft (Electrical/ HVAC, Plumbing), Atrium, porch, balconies, patios and same area multiplied by number of floors.

The total floor area shall be maximum of floor area mentioned in technical specifications or Floor area as per tender drawings.

5.02.00 **Main plant Buildings/Structures shall comprise of:**

a) Mill Bunker Building
b) Transfer Points, Conveyor Galleries & Trestles
c) Machine Foundations in Main Plant
d) Boiler Structure
e) Compressor House
f) ESP Structure
g) ESP Control Building
h) Pipe & Cable Gallery
i) Main Power House Building
j) Service building

The Main Power House, Bunker building, transfer points, conveyor galleries and trestles, boiler supporting structure, compressor house, ESP supporting structures including inlet and exhaust duct support structures, Pipe cable Galleries & trestles shall have structural steel framed super structure.

All other buildings may have either RCC or structural steel framework.

Brief description of the above mentioned Main Plant Buildings is furnished herein:

5.02.01 **Mill and Bunker building**

i. Salient Features

The mill bunker building shall house coal mills, feeders, Cylindrical Coal Bunker & Conical Hopper, Tripper Conveyor & its drive and monorails. All columns, main beams and secondary beams shall be made of structural steel. The RCC floor slabs (supporting the Feeder and Tripper Conveyors) shall comprise RCC slab supported on profiled metal deck sheet (to be used as permanent shuttering) not to be considered for design of RCC slab as composite slab) and shear anchor studs welded to the top flange plate of secondary & main structural steel beams, (which supports the RCC slab & metal deck sheet).

Bidder may integrate the Mill & Bunker Building with boiler supporting structure.

Access platforms shall be provided at minimum one (1) level above bunker supporting level for inspection and testing of bunker and hopper connections. Minimum (1) Nos. of manhole/ access window shall be provided for maintenance of silo.

The bottom level of base plates of columns shall be 1.20 m below the finished paving level in the Boiler Area. The columns of Mill-Bunker building shall consist of built-up structural steel I-sections. Rolled sections with additional cover plates on column flange shall not be acceptable for column sections.

The cylindrical coal bunker and conical hopper shall be made of structural steel. The inside surface of hopper shall be lined with stainless steel plates the details of which are mentioned hereafter in this specification.

Structural steel brackets with PTFE bearings shall be provided at the end columns to support the external gallery of the Tripper Conveyor

The Mill-Bunker building roof shall be provided with Pre-fabricated insulated metal sandwich panels. Composition of Insulated Metal Sandwich Panels shall be as described in Clause 9.08.00, Part-B (Civil) of Technical Specification. Adequate slope shall be provided for quick drainage of rain water.

The RCC floor supporting the Tripper Conveyor shall be fully covered up to the Roof level with single skin metal sheet (& structural steel runners).

ii. Design Concept

The Mill Bunker Building shall be conceptualized as moment resisting frames in transverse direction and braced in longitudinal direction. In the transverse direction the bracings may be provided, wherever feasible, in order to meet the deflection requirement specified elsewhere in this section. Bracing member shall be connected to column flange plate through gusset plate (minimum 12mm thick).

Minimum thickness of structural steel Bunker plates shall be 12mm inclusive of 4mm corrosion allowance. Minimum wall thickness of Hopper shall be 8mm. Minimum thickness of stainless steel liners on the entire inner surface of hopper wall shall be 4mm conforming to ASTM A240 S304 (Type 304) with Mill finish 2B cold rolled, annealed, descaled (pickled) and skin passed. To ensure smooth flow of coal, the hopper surface shall be provided with minimum angle of 73^{o} with the horizontal plane.

The top of the cylindrical bunker shall bear no load/ reaction from the tripper floor and accordingly neoprene bellow strap shall be provided at the interface between the two structures to allow free deflection of the tripper floor. Neoprene bellow strap shall be

provided all-round the bunker to effectively seal the gap between top of bunker and sealing plate below bunker.

For all other design methodology, refer to Design Criteria specified hereafter in this specification.

iii. Architectural Features

The Mill & Bunker Building shall be a structural steel framed structure having RCC floors and prefabricated insulated metal sandwiched panel sloped roof. The tripper floor side cladding shall be Single skin Metal cladding with steel louvered windows and fixed windows with poly carbonate sheet glazing. Area of windows shall be minimum 10 % of floor area. Rainwater down comer shall be of galvanized MS pipes and shall be located at every column location.

5.02.02 **VOID**

5.02.03 **Machine Foundations in Main Plant Area**

A. SG Area

i. Salient Features

The scope of work of the Bidder shall be design and construction of all Civil & Structural Works of Machine Foundations including supply of all materials.

PA/ FD/ID Fan and Mill foundations:

PA/ FD/ ID Fan and Mill foundations shall be RCC block foundation directly resting on virgin soil/ pile below Ground level. The vertical faces of this block foundation shall be isolated from adjacent footings by providing minimum 100mm thick polystyrene board of type-1 conforming to IS: 4671 with density 20 Kg/cum sandwiched between the vertical face of block foundation and 230 thick brick wall all round.

ii. Design Concept:

a) For the foundations of Fans (ID, FD and PA), Mills, etc. detailed static and dynamic analysis shall be done.

b) Wherever block foundation is adopted by the bidder, suitable provisions to be ensured by the bidder in their General Arrangement and design to prevent transmission of vibration from these machine foundations to other nearby structures / foundations.

c) The bidder or his consultant should have adequate prior experience in design of machine foundations and the machines should be in successful operation for at least one year prior to the date of submission of bid.

B. STG Area

i. Salient Features

The scope of work of the Bidder shall be design and construction of all Civil & Structural Works of Machine Foundations including supply of all materials, springs & viscous dampers.

Turbo-Generator (TG) foundation:

Alternative-1

The TG foundation shall comprise of RCC top deck supported on steel helical springs & viscous dampers (called herein as the Vibration Isolation System – VIS) and shall be located in the Turbine bay of Main Power House. The springs-cum-viscous dampers shall be placed on a group of RCC/ Structural Steel columns. These TG

columns can be interconnected to the Main Power House Building frame either rigidly or connected through PTFE bearings on corbels/ brackets of the TG Columns. The general arrangement & details of springs/ viscous dampers and supporting group of columns and beams shall be based on TG Equipment detail of the Bidder.

Alternative-2

The TG foundation shall be conventional machine foundations comprising of RCC top deck directly supported on substructure comprising of columns and beams without any steel helical springs and viscous dampers. The columns shall be rigidly connected to the RCC deck at top and shall rest on open / pile supported foundation at bottom. The entire foundation system (including deck, columns and raft) shall be isolated from the main plant building structural system and no connection between the main plant structure and TG foundation is permitted.

Bidder has the option to choose either Alternative -1 or Alternative-2 based on his design philosophy and practice. However, in case Alternative-2 is adopted by bidder, then the bidder has to furnish extended warranty of five years for satisfactory static and dynamic performance of the foundation system.

TDBFP & MDBFP foundations:

Alternative-1

TDBFP & MDBFP foundations shall consist of RCC top deck supported on steel helical springs & viscous dampers inside Main Power House. In case the top deck is located at operating floor/mezzanine floor level, the springs/ viscous dampers shall be supported on a group of structural steel columns-beam grid which shall be rigidly integrated with the Main Power House Structural frame.

Alternative-2

TDBFP & MDBFP foundations shall consist of RCC top deck directly supported on RCC/ structural beams and columns without any steel helical springs & viscous dampers inside Main Power House. The structural columns and beams supporting the TDBFP / MDBFP shall be independent of the Main Power House Structural frame and shall also have independent foundation without any connection to other nearby foundations. Further each TDBFP / MDBFP shall have independent supporting structural arrangement without any interconnection among themselves.

Bidder has the option to choose either Alternative-1 or Alternative-2 based on his design philosophy and practice. However, in case Alternative-2 is adopted by bidder, then the bidder has to furnish extended warranty of five years for satisfactory static and dynamic performance of the foundation system.

BFPs in ground floor

In case the MDBFP/TDBFP foundation is envisaged to be located at ground floor of Main Power House, then these shall be designed as block foundations directly resting on soil / pile. Vertical facing of this block foundation shall be isolated from adjacent footings by providing minimum 100mm thick polystyrene board of type-1 conforming to IS: 4671 with density 20 Kg/Cum sandwiched between the vertical face of block foundation and 230 thick brick wall all round.

ii. Design Concept:

a) For the foundations of Turbo-generator, Boiler feed pumps, etc. detailed static and dynamic analysis shall be done.

b) The vibration isolation system (where ever applicable) supplied shall be of proven make and shall be in successful operation supporting machines like steam turbo-generators, BFPs, etc.,

c) Wherever alternative-2 is adopted by the bidder for TG or BFPs, suitable provisions to be ensured by the bidder in their General Arrangement and design to prevent transmission of vibration from these machine foundations to other nearby structures / foundations.

d) The bidder or his consultant should have adequate prior experience in design of machine foundations for the respective alternative to be adopted by the bidder and the machines should be in successful operation for at least one year prior to the date of submission of bid.

For detailed specification of steel helical springs and viscous dampers refer General Specification Chapter.

5.02.04 **Boiler Structure**

i. Salient Features

The Boiler supporting structure shall be structural steel framed superstructure adequately braced in vertical planes in both the orthogonal directions. The general arrangement & details of structural steel columns, beams, bracings, ceiling girders etc shall be as per the Bidders Boiler Structure design and detailed engineering scheme.

The bottom base plates of Boiler structure columns shall be 1.20m below the finished paving level in the Boiler area. The RCC pedestals supporting the column base plates shall be extended in order to provide RCC encasement to the structural steel columns up to at least 350mm above the top of the paving RCC slab. Steam Generator roof (pent house)/canopy/side cladding shall have single skin troughed profile permanent colour coated sheet. Cladding for Boiler elevator enclosure except its machine room shall be with single skin troughed profile permanently colour coated sheet.

Bidder shall integrate the boiler supporting structure with Mill & Bunker Building Structure.

Waterless Bio Urinals with enclosure are to be provided by the contractor on each floor elevation of each boiler. Maintenance of toilet in hygienic condition till COD of the unit shall be the responsibility of the bidder.

All supporting steel structure for Boiler elevator, cladding for elevator enclosure, machine room for elevator including structural steel beam for machine room floor, roof & wall beams, etc. All interconnecting steel platforms, between Boiler & main power house and Boiler & Mill bunker building, with associated ladders/stairs, gratings, hand rail, etc. Fixing supports, filling and finishing of openings for pipes/cables/ducts in floors/walls/cladding/roof, etc. All facilities/structures that would be required, as per the system requirements covered under various sections/chapters of this specification but not covered here above.

ii. Design Concept

Boiler supporting structure shall be designed by the Bidder based on provisions of IS 800for structural steel and IS: 456 for RCC works.

Boiler Elevator Machine Room

Floor of Machine Room shall be provided with profiled metal decking sheet. Trough shall be filled with Insulating Material (glass wool or rock wool) and thereafter finished with Minimum 50 mm thick wooden flooring, consisting of 37 mm thick hardwood planks, finished with 11mm thick laminated wooden flooring (of 'pergo' or equivalent) with plank size 193x1195mm (material class shall be 34 as per EN13329), over 2 mm expanded polystyrene foam and polythene sheet under laying.

Roof and Side enclosure of Machine Room shall be provided with Prefabricated Insulated Metal Sandwich panels. Composition of Insulated Metal Sandwich Panels shall be as described in Clause 9.08.00 of Part-B (Civil) of Technical Specification.

Doors of Machine Room shall be Double Plate Steel flush doors of thickness 45 mm with steel sheets of 18 gauge with necessary stiffeners. Space between two sheets shall be filled with mineral wool insulation. Frame of doors shall be pressed steel sheets of 16 gauge. All necessary fittings for the doors shall be provided by the Bidder. Rubber sealing, for making the Doors airtight shall also be provided.

Windows/ventilators shall be of standard extruded anodised Aluminium Sections of minimum 2 mm thickness with 24 mm hermitically sealed double glazing consisting of two 6 mm thick toughened glass separated by 12 mm. gap.

Technical requirements of prefabricated insulated metal sandwich panels/decking sheets shall be same as given elsewhere in this specification.

5.02.05 **Compressor House**

i. Salient Features:

The compressor house shall be a structural steel framed superstructure with an overhead crane as per requirements specified in Part-A Sub Section IIA-19 and Part-B Sub Section A-25 of Technical Specification. The gantry girder for the crane shall have walkway with chequered plate on both rows and cage ladder access.
The roof slab shall consist of 40mm thick RCC slab (minimum above the crest of metal deck sheet) with additional water proofing supported on profiled metal deck sheet. The metal deck sheet shall be supported on structural steel purlins. Water proofing to be done over RCC slab. The ground floor slab shall comprise of all RCC block foundations, cable trenches and pipe trenches. The building shall be completely covered with vertical cladding and roof.

Design Concept:

The Design of Compressor House steel structure shall be based on provisions of IS 800& IS 456 for RCC works. The structural frame shall be moment resisting sway frame in the lateral direction and longitudinally braced in the longitudinal direction. Design shall also be based on the Design Criteria specified elsewhere in this specification.

ii. Architectural Features

This building shall be steel framed structure with brick wall up to window sill height & Single Skin Metal Panel cladding above it. The roof system shall be as per the detail furnished in the salient features of this building

Cut-outs and opening shall be provided in floors and walls as per requirements.

Metal Panel cladding shall be composed of different colour shades to match with the existing surroundings. External finish shall be of Premium Acrylic Smooth Paint with Silicone additives over Texture Coat.

The size, height, door/window/rolling shutter details and building size shall be as per the approved equipment layout plan of the bidder.

5.02.06 **ESP Structure**

i. Salient Features

The ESP structure shall be a structural steel superstructure with vertical bracings in the required vertical planes in both longitudinal and transverse directions, the details of which shall be as per the approved ESP equipment GA & details of the bidder.

The bottom of base plate for ESP structure columns shall be 300mm above the finished paving level in ESP area. The RCC pedestals supporting the column base plates shall be extended accordingly above the top of the paving RCC slab. Further, the gusset plate / base plate shall be encased in concrete up to the top of bolts. ESP roof (penthouse)/canopy/side cladding shall be single skin troughed profile permanently colour coated sheet.

ii. Design Concept

Design of ESP structure shall be based on provisions of IS 800for structural steel and IS 456 for RCC works. It shall be an axially braced structure in both orthogonal directions. The ESP supporting columns shall be suitably strengthened about the minor axis for sliding movement of the base plate of ESP due to thermal movement.

5.02.07 **ESP Control Building**

i. Salient Features

ESP Control Building can either be structural steel superstructure or RCC framed structure with RCC floors at ground floor level and upper levels. The RCC floors at upper levels shall support the Switchgears, cable galleries and Control Room. The RCC floors at upper levels shall be cast in situ RCC slabs.

For steel framed building the RCC floors shall be supported on profiled metal deck sheet and structural steel beams and roof of the building shall comprise of minimum 40mm thick RCC slab supported on profiled metal deck sheet and structural steel beams.

The rainwater down comers shall be as per specification and shall be suitably concealed.

The external Transformer Yard of the building shall comprise the transformer foundations and cable slit below ground level.

The building shall have Lift structure with lift pit below ground level and staircase at each gable end of the building.

ii. Design Concept

The Design of ESP Control Building shall be based on provisions of IS 800 for Structural Steel & IS 456 for RCC works.

iii. **Architectural Features**

This building shall be completely covered with Light Weight Autoclaved aerated concrete blocks on all four sides except for the portion in front of the external Transformer Yard and toilet and pantry block. Provision for glazed/ fire proof doors &

windows shall be included. Minimum 345mm thick brick wall shall be provided for the external brick wall facing the adjacent transformer yard and the brick wall height shall be 600mm above the highest point of the transformer. Inside the building, AHU rooms, UAF Room& Battery rooms shall have brick masonry of one brick thickness. The internal walls of air-conditioned area shall be finished with 2 hour fire rated Aluminum Composite Panel Cladding.

Entire transformer yard, which shall be adjacent to the building, shall be provided with metal fencing with gates.

The building shall accommodate cable vault, toilet, staircase, switchgear rooms, control rooms and AHU room. An auxiliary transformer yard with fencing and gate shall be provided adjoining to the building. Control room and VFD room shall be air-conditioned and shall have false ceiling. Windows& Ventilators all shall be provided with Aluminium sections. All doors, windows in air conditioned area shall be provided with hermetically sealed toughened glass glazing in Aluminium frame work Steel doors and Fire proof doors shall be provided as per requirements. Internal columns in Control Room shall be encased with Aluminium Composite Panel cladding.

Minimum 2 Nos. of stairs and 2 Nos. of Toilets shall be provided as per requirement. Cut-outs and opening shall be provided in floors and walls as per requirements.

External finish shall be of Aluminum Composite Panel Cladding except Transformer area where premium smooth Acrylic Paint shall be provided.

5.02.08 **Pipe & Cable Galleries**

i. Salient Features

The Pipe- Cable Gallery shall be Structural Steel Superstructure with Steel Truss (Lattice Girder) having a general span of 15.0m/20.0m. The steel truss shall be supported on 2 legged/ 4 legged trestles the arrangement of which shall be developed by the Bidder. Trestles for pipe and cable galleries shall also be of structural steel.

The width of the Gallery shall vary depending on the functional requirement. A walkway of minimum width 600mm shall be provided along the Cable Trays supporting floor of the gallery. The walkway shall comprise 40mm thick MS grating and 1.0m high handrail made of 32NB MS pipes. For pipe cable galleries carrying ash pipes, galvanized MS grating shall be provided over entire width of the gallery.

Plan bracings shall be provided at all chord levels of the cable gallery truss. Minimum gusset plate thickness shall be 8mm for all connections.

The level of the bottom chord (bottom of steel) of the gallery shall be at least 3.0m above the finished paving level in general. However, at all road/rail crossings, the level of bottom of steel of the gallery shall be at least 8.0m from the top of road surface and 8.5 m from top of rail track. Before and after the road/rail crossings, a barrier of suitable height shall be constructed so as to prevent the approach of cranes (having height more than 8 m) up to the pipe/cable racks/trestles.

The Caged structural steel ladder shall be provided at an interval of 200m for access to the Pipe-Cable Gallery Walkway.

At the inter-connection of Pipe/Cable gallery with Plant buildings, Pipe/Cable gallery shall be terminated at a maximum distance of 1.50m from the building. The foundation of the Pipe/Cable Trestle shall be constructed at a distance of 4.0M from center line of the plant building. Cantilever of 2.50m shall be taken from pipe-cable gallery/ trestle structure.

The foundation for Pipe-Cable gallery trestles shall be open foundation or pile

foundation depending upon bearing capacity requirements. For specification regarding open, clause. 7.00.00 is to be referred. The grade of concrete for RCC footing & pedestals shall be M25. The structural trestles shall not be supported on paving RCC slab.

ii. Design Concept

The pipe-cable structure shall be designed as a 3-dimensional space frame for all the relevant load cases mentioned in the design criteria chapter.

The gallery being an unclad building, wind load shall be evaluated based on the projected frontal area of the structural members and cable tray depth.

The end portals shall be designed as rigid frames hinged (pinned support) at the base plate level (on top of the trestle column). Deflection of end portal due to wind shall be evaluated at the portal column-rafter joint. The gallery vertical truss shall be designed as simply supported girders on trestles and detailing of end portals shall be done accordingly.

Suitable expansion gap shall be provided in the gallery structure by providing twin two-legged trestles at the expansion gap. The expansion gap shall be provided at an interval of 100 to 120m. Expansion gap shall also be provided at location where changes in plan dimensions (gallery width) take place abruptly.

5.02.09 **Main Power House**

(i) Salient Features:

Main Power House shall consist of the Turbine bay, adjacent Deaerator Bay, electrical bay & common control room building (CCR Building) (as stipulated elsewhere in this specification). The turbo – generator (TG) foundation, boiler feed pumps foundations and shall be located inside the power house and their foundation system shall be as per design concept of machine foundation. All other equipment foundations (including Heaters & Deaerators) shall be supported on RCC floors with structural steel beams. The RCC floors shall comprise RCC slab over profiled metal deck sheets (to be used as permanent shuttering but not to be considered for design of RCC slab as composite slab). Shear anchor studs shall be provided through metal deck at regular interval on all top flange / flange plate of structural beams. However, steel gratings, chequered plate flooring as well as precast RCC covers shall be provided as per the functional requirements. All RCC pits & trenches below ground floor slab (including Condensate Extraction Pump (CEP) pit) shall be covered with minimum 40 mm thick MS grating supported on structural steel beams. The RCC pits shall also be provided with a sump at the corner for dewatering with submersible pumps. Staircases & ladders shall be provided for access to these pits. Electrically Operated Travelling (EOT) cranes shall be placed in the turbine bay with the gantry girders (supporting crane wheel loads) supported on structural steel brackets on A & B row columns). Walkway with chequered plate shall be provided at crane girder level at both ‘A’ row & ‘B’ row side with caged ladder access from the operating floor.

All main columns & beams of Main Power House shall be of structural steel girder (open web or solid web) with base plate level of columns 1.20m below ground floor slab level in general except for other pit areas where structural steel column shall be extended below upto a depth lower than the pit top surface such that the column base plate & stiffeners are concealed below the pit raft level are concealed below the pit raft level. Auxiliary columns in main power house shall be either of structural steel construction.

The roof system in turbine bay shall comprise a structural steel girder (open web or solid web) for the entire bay width. The roof slab shall consist of 40mm thick (min. above the crest of metal deck sheet) RCC slab supported on profiled metal deck sheet. The metal

deck sheet shall be supported on structural steel purlins. The purlins shall be in turn be supported on turbine bay roof girder top chord at regular interval. Additional waterproofing shall be provided above the roof RCC slab as per details mentioned elsewhere in this specification. 1 in 100 slope shall be provided for the turbine bay roof sloping downwards towards the A-row (towards transformer yard). Minimum 150mm dia. galvanized mild steel pipes shall be used at A-row & C-row as Rainwater Down comers. Staircases in main power house shall be of structural steel. Treads of each staircase shall be 40mmthick MS grating and handrail/ hand post shall be 32mmNB circular hollow sections unless specified otherwise in architectural section of the specification. All staircases in turbine Bay and Deaerator Bay shall be enclosed with minimum one brickthick masonry wall with fireproof doors at all floor landing levels. The parapet wall shall be of minimum 1m height and shall be provided all the around roof of main plant building.

All edges of openings shall have edge protection angles (minimum ISA 75x75x6) and handrails with hand posts (Hand post spacing 1m maximum).

All supporting steel structures/foundations for all major/minor equipment/systems, all operating/maintenance platforms, interconnecting platforms required for equipment valves, etc at any elevation with associated ladders/stairs to and / or from the main floor levels, gratings, handrails, etc of this area.

ii. Design Concept:

Main Power House shall be designed as moment resisting sway frame in the transverse direction and braced in the longitudinal direction. However, due to functional requirement, vertical bracings to the column in CCR Building not to be provided at (& above) the operating floor level and CCR Building frames shall be designed as moment resisting frames in both transverse and longitudinal directions.

All beam column moment connections shall be designed for adequate ductility. The building shall have connectivity with walkways from Boiler & Service Building through sliding bearing only. The connectivity with cable gallery shall be as specified in Pipe & cable gallery section of this chapter. Floor level acceleration spectra shall be generated during seismic analysis for design of pipe supports / equipment located at the elevated floors. Adequate number of thermal expansion gap (minimum 2.00m) between adjacent structural frames at expansion joint and minimum 50mm between RCC slabs at expansion joint) shall be provided between the units and Common Control Building.

In the RCC floor/ roof slabs, the spacing of shear anchor studs on structural beams shall be minimum of the spacing required for

i) Restraining the compression flanges of beams and

ii) Transfer of the horizontal shear at floor/roof to the supporting beams.

The roof girder in Turbine Bay shall be provided with a camber to take care of deflection due to dead weight.

The Main columns in A, B &C rows of Main Power House Building shall be built-up I-sections. Rolled sections/ I-sections with additional flange plates shall not be acceptable for main columns & auxiliary columns. The roof girder (open web or solid web) to column connection shall be bolted connection using high strength bolts (grade 8.8/ IS 1367). The roof girder of Turbine Hall shall be adequately braced in plan using Tie level and rafter level bracings. The longitudinal bracing shall comprise a pair of members connected to the column flanges and detailing shall be adequate to restrain the entire column cross-section. Minimum gusset plate thickness for bracings shall be 12mm.

Common Control Room at operating floor shall have minimum 60% free space for movement, control room to be free of any auxiliary/stub columns other than the C-row

central column with minimum depth as possible

For all other design methodology, refer to Design Criteria specified elsewhere in this specification.

iii. Architectural Features

This building shall be of Structural Steel Framed structure and shall be completely covered with external cladding and RCC roof. The external vertical face (herein stated as 'A' row) of main power house facing (& adjacent to) the transformer yard and also the two gable ends shall be completely covered with vertical cladding comprising 3.0m high brick wall (on ground floor slab) and single skin profiled vertical metal sheet for the remaining height except for the vertical segment between operating floor &gantry girder bracket level where double skin vertical metal sheet shall be provided.

In case of routing of bus-duct is done outside the A-row (part/full), there shall be a continuous cladding of metal sheeting covering steel structure supporting the bus duct to match the entire A-row elevation. The metal cladding shall be designed to suit the aesthetics of the entire main plant building.

In front of the power transformers, RCC fire barrier wall shall be provided as per functional requirement in lieu of brick wall at A-row. The above mentioned RCC wall shall be attached with single skin metal sheet on external face.

The 'A' row & Gable End columns projecting inside the turbine hall shall be concealed with single skin profiled metal sheet from operating floor level to crane girder bracket top level.

The external vertical face (herein stated as 'C' row) facing (& adjacent to) the Boiler area shall be completely covered upto the Deaerator floor level with vertical cladding comprising 3.0m high brick wall on ground floor followed by either single skin metal sheeting with runners or brick wall sandwiched with single skin metal sheeting on external face (for all floors requiring 2 hours of fire rating e.g. cable spreader room, ventilation/ air washer room, AHU Rooms and air conditioned areas)

The internal vertical interface plane between Turbine bay & Deaerator bay (herein stated as 'B' row shall have brick masonry Wall from RCC roof slab level of turbine bay (AB bay) upto specified floor level below such that Turbine bay & Part of Deaerator bay below the Deaerator supporting floor level is completely covered on all sides.

Glazing for A Row & gable end shall be reflective 6mm thick clear toughened glass with Aluminium frame. Hermetically sealed double glazing shall be provided between air conditioned & non air conditioned areas. Internal glazed partition inside CCR/CER/Offsite Control Room and B-Row at operating floor level shall be of fire resistant glass having 2 (Two) hour fire rating and with suitable frame. Light weight aerated concrete panels over that 50 mm thick mineral wool insulation with Single Skin Metal Panel cladding shall be provided in exterior of UPS Battery room area and Control Equipment Room area. All internal side of Aerated concrete panel and columns in air-conditioned areas other than CCR in MPH shall be encased with Aluminium Composite panel cladding from inside.

Inside the main power house building, brick masonry wall (and fire proof doors) shall be provided for switchgear rooms, cable spreader rooms, MCC rooms, AHU rooms, Air Washer room & Oil rooms and all other rooms where fire protection is envisaged.

Cut-outs and opening shall be provided in floors and walls as per functional requirement.

All door, windows in air conditioned area and all windows glazing shall be provided with Aluminium frame work Steel door and Fire Proof doors shall be provided as per requirements.

Stairs in BC Bay and on A-Row shall be provided as per functional requirement and as per National Building Code and Factories Act.

All stairs in BC Bay lift lobby Area shall be in RCC. Stainless steel railing shall be provided at TG floor level for all cut-outs/ openings, walkways, cut-outs at lower level that are visible from TG floor level and stairs near lift lobby. M.S. railing shall be provided for all other locations. All peripheral edges of floor cut-outs / openings at T.G floor level and covered with gratings/ chequered plates, expansion joints along T.G deck, structural expansion joints shall be covered with minimum 2mm thick stainless steel plate of grade SS 316.

For each unit minimum one no. gent's toilet with adequate facilities including drinking water space and janitor's space shall be provided at each level of power house building, in addition one no ladies toilet shall be provided in each unit at 0.00M and mezzanine floor level and CCR level. A separate ladies and gent's toilet and pantry shall be provided for CCR approachable from CCR / CER / Offsite Control Rooms.

B Row portion in TG Hall fronting Control Room & CER and glazed partitions in CER/ CCR/Offsite Control room shall be of 30 mm thick(Minimum) Hermetically sealed double glass of Fire resistant of min 14 mm thick clear, toughened, interlayered 120 minute fire rated for both integrity & radiation control and 6 mm thick toughened tinted glass with **10 mm** gap and with suitable fire resistant frame of 1.6 mm thick powder coated steel sheet. The partitions shall be up to false ceiling level and wall above up to the soffit of floor slab above control room and shall be finished with Aluminum Composite panels claddingand shall also have FRP mural of theme matching to local art and Culture.

Glass partition between AC areas in CCR/CER and other areas in associated with CCR/ CER shall be single Fire Resistant glass in line with technical specs as per fire zoning requirement. It shall be single toughned glass minimum 10 mm thick if not within fire zone.

In CCR, EIC Room, Conference Room, Programmer's Room and Visitors Gallery etc. a theme based coordinated false ceiling shall be provided with latest state of art design.

In CCR, EIC Room, Conference Room, Programmer's Room and Visitor's Gallery etc., vitrified flooring shall be designed with theme and color coordination in line with the designed false ceiling.

Mullion-less glass wall with motorized curtain shall be provided in between the control room and the Visitor's gallery.

The fire resistant glass partition in between CER/PADO room & control room (control room left hand side wall) and shift in-charge room/Conference room & control room (control room right hand side wall) shall have motorized blinds (with provision of remote control from Unit in-charge desk) with central metallic panel column having Owner's signature icon.

The rest of the walls including LVS wall shall have coordinated design keeping in mind the overall theme of the control room using metallic panels with calcium silicate boards.

The control room gates shall have biometric physical security feature with double layer of sliding doors with air locked lobby.

Control room interiors shall be designed and executed by M/s EVANS / M/s Pyrotech or equivalent vendor who are specialized in control room interior design.

Control room/ Control Equipment Room / Offsite Control Rooms, entire area, False Ceiling shall have Cat Walk Way above for service/ maintenance.

Main power house building shall be provided with passenger lift in BC way as specified elsewhere in technical specification.

Adequate partitioning as per functional requirement above false ceiling in control Room& CER shall be provided for Inert Gas zoning.

Internal steel columns in Air Conditioned Area of Main Power House Building (CER, UPS charger room, SWAS room, etc.) shall be encased with Aluminium Composite Paneling up to false ceiling.

Functionally the very heart of Power House Building is its Control Rooms. Special attention shall be given for conceptualization of interior design of the Control Rooms. Control rooms design shall be both functional and ergonomic for ensuring reliable and error free operation of the plant. Control room shall have metallic panels with calcium silicate boards cladded video wall housing large video screens and a separate visitor viewing gallery. A walk through view of the control rooms shall be submitted along with bill of quantity to illustrate the design scheme.

Metal Panel Cladding shall be composed of Different Colour shades to match with the surroundings. External finish of Masonry wall shall be premium acrylic smooth exterior paint with silicon additives finish over Texture Coat.

5.02.10 **Service Building**

i. Salient Features

This building shall be an RCC structure having RCC frame with RCC floors and roof slab. For the building, floor-to-floor height shall be as per architectural features. A connecting corridor with MPH building shall be provided at operating floor level. The building walls shall comprise aerated concrete blocks from ground floor to roof level. The grade of concrete for RCC frame (including foundation) shall be M25.

Architectural Features

This building shall be five storied (Ground + 4 stories above) and shall be provided with floor area of 5000 Sqm with RCC framed structure. Autoclave Aerated Concrete Block masonry wall shall be provided for the full height of the building for both external and internal walls. Floor-to-floor height shall be minimum 4.25m. A connecting corridor with Main Power House building shall be provided at operating floor level. The floor of the connecting corridor shall have vitrified ceramic tiles flooring, stainless steel hand rail & fixed structural gazing with reflective toughened glass. The connecting corridor shall have double skin Aluminium Composite Panel (ACP) cladding & insulated metal sheet sloped roof.

Hermetically sealed double glazing with toughened glass shall be provided for external glazing.

A minimum 70 mm margin for floor finish to be kept for providing of metallic raceway.

This building shall provide offices for Operation staff, Conference room for 50 persons, C&I Laboratory, Exhibition Hall, VIP Lounge etc. This will be fully air-conditioned building with adequate provision of toilets, pantry, cabins for senior executives and separate rooms for executives, supervisors etc. Lift structure with RCC lift pits shall be located inside the service building. Separate toilet facilities shall be provided for ladies and gents in each floor. One toilet shall be provided for persons with disabilities on each floor. Attached toilets shall be provided with cabin of senior executives cabin (10 nos.) and conference rooms. 2 nos of staircases and 2 nos of lifts with adequate capacity shall be provided. One store room shall be provided.

Covered parking space for 10 nos. cars shall be provided. Covered parking shall be of RCC construction. Open parking space for 40nos. cars & 70 nos. scooters shall be provided. Minimum 23 sq.m./car (including circulation area) and 5 sq.m./Scooter (including circulation area) shall be considered for working out parking space.

The service building shall be fully IT enabled. 300x40 mm Stainless Steel Raceway with standard length 2500 mm single compartment trunking raceways made from 14 gauge (minimum) Stainless Steel sheet including fasteners, floor support, connectors, bends cross-way, earthing stud for fixing etc. complete as per requirement, drawings and instructions of EIC shall be laid under floors of service building for IT enablement. 350x350x50 mm Junction boxes of Stainless Steelsheet with cover plate for raceways shall also be provided. Solar PV panel of 17% efficiency shall be provided on roof of service building.

External finishing shall be of Coloured Aluminium Composite panel, GRG Panels, Structural Glazing in combination.

The Service building shall be designed keeping in mind the Green building features, such as Bio climatic Architecture including shading, daylighting, efficient envelop design ,orientation with respect to sun path and wind pattern etc., to ensure that building is climatically responsive and consumes less energy.

ii. Design Concept

This building shall be analysed & designed as RCC framed structure considering loads & load combinations mentioned in clause 6.02.0. Loads due to Solar PV panels also to be considered on roof slab of the building. Use of shear walls can be made in the building, in case peripheral road of BTG block is to be routed through the building. The design of RCC structure, foundations & slabs shall be carried out as per provisions of IS 456.

5.02.11 CPU CIVIL WORKS

5.02.11.01 **Design Concepts for Buildings/ Shed**

i. All Buildings shall have RCC framed structure with cast-in-situ RCC roof slabs with brick cladding.

ii. Equipment/facilities with shed shall have structural steel superstructure with permanently colour coated metal sheeting at roof and side open. However, kerb wall shall be provided all around the plinth/ floor area above the Finished Floor Level (FFL). For other buildings brick wall cladding on exterior face shall be provided.

iii. Unless specified, the wall cladding for buildings shall be with minimum one brick thick on exterior face. However, brick wall for buildings adjacent to transformers shall be minimum 345mm thick.

5.02.11.01.01 Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion, etc.

5.02.11.01.02 The load and load combinations and design criteria shall be as specified elsewhere in the specification.

5.02.11.01.03 All liquid retaining structures shall be designed for following load conditions.

Underground structures:

a. Water filled inside up to design level and no earth outside.

b. Earth pressure with surcharge of 2.0 T/m2 and ground water table up to FGL outside and no water inside.

c. Stability against uplift shall be checked for completed structure and under construction stage with no water inside and ground water table up to FGL, with a minimum factor of safety of 1.20 against uplift. Installation of pressure relief valves shall not be permitted in the base slab of any liquid retaining / conveying structure.

d. The structure shall also be checked for normal working condition with water filled inside up to design level and earth pressure outside with no effect of surcharge and ground water table.

For design of over - ground liquid retaining structures appropriate load cases shall be considered.

5.02.11.01.04 All liquid retaining and conveying structures shall be designed as per IS 3370 (Part 2).

In the wall of liquid retaining structures with cylindrical shape such as clarifiers, vertical reinforcement shall be checked assuming the walls were fully fixed at the base, and the horizontal reinforcement shall be provided to resist horizontal (hoop) tension assuming hinged condition at the junction of the base slab & wall.

Wherever sandwich slabs are provided in liquid retaining structures to take care of stability against uplift, only well graded sand shall be used as fill material. The sand compaction shall be done with plate / disc compactors in such a manner that the bottom slab is not structurally damaged.

Clear free board of at least 300 mm above design (total) water level shall be provided in all liquid retaining / conveying structures.

Coefficient of active earth pressure shall be considered for design of free-standing retaining walls and coefficient of earth pressure at rest shall be considered for design of top propped retaining walls.

The minimum grade of concrete for all RCC structures shall be M30.The minimum concrete clear cover to reinforcement bars in all RCC structures shall be as per IS:456(2000) and IS:3370(Part 2) for water retaining structures. Durability of concrete shall conform to severe exposure conditions as per Table-3 of IS 456 except noted specifically otherwise.

5.02.11.01.05 Factor of safety against overturning and sliding

The structure shall be checked for minimum factor of safety of 1.5 against overturning conditions (ratio of stabilizing moment to overturning moment) and 1.4 against sliding conditions as per IS: 456.

5.02.11.01.06 For detailing of Reinforcement IS 5525, IS 13920, IS 4326 and SP 34 shall be followed.

Two layers of reinforcement (on both faces) shall be provided for RCC sections having thickness of 150 mm and above.

Minimum diameter of main and distribution Reinforcement bars in different structural elements shall be as follows:

Sl. No.	Structural Element	Main Reinforcement	Distribution Reinforcement / Stirrups/ ties/ Anchor Bars
a)	Foundation	12 mm	12 mm
b)	Beams	12 mm	8 mm
c)	Columns	12 mm	8mm

Spacing of reinforcement bars in walls and slabs of liquid retaining / conveying structures shall not be more than 200 mm.

Suitable shrinkage reinforcement shall be provided at top face of foundations. Minimum shrinkage reinforcement shall be 10 mm dia. @ 200mm c / c.

	Minimum Reinforcement in all elements of liquid retaining / conveying structures shall be 0.24 % of cross sectional area.
	Minimum tensile Reinforcement in each direction for all foundation slabs / rafts shall be 0.2% of cross sectional area.
5.02.11.01.07	Minimum thickness of foundation slab / raft and base slab of all liquid retaining tanks / pits shall not be less than 250 mm.
	Minimum thickness of all other elements of RCC liquid retaining / conveying structures (except effluent drains, launders and aerator waste slab) shall be 200mm. Effluent drains (depth more than 500mm), aerator waste slab and launders shall have minimum element thickness of 150mm.
5.02.11.01.08	All Insert plates (except edge protection angles) provided in liquid retaining structures shall be 12 mm thick GI with lugs not less than 12 mm diameter rods or 6 mm flats.
	Edge protection angles shall be provided as specified elsewhere.
5.02.11.01.09	All water retaining structures shall be tested for water tightness as per provisions of IS: 3370 and IS: 6494.
5.02.11.01.10	2.0m wide walkway with M25 grade concrete paving over an under bed specified elsewhere shall be provided connecting all structures, buildings and facilities. The top of walkway shall be minimum 200mm above FGL Reinforcement of the RCC paving shall consist of minimum 8mm diameter bars @ 200 mm c / c in both directions at the centre of the slab.
5.02.11.02	**Coating on RCC water retaining structures (other than drinking water)**
	Epoxy phenolic coating as per details specified below shall be applied on internal surfaces of the RCC water retaining structures and external surfaces of RCC Neutralisation-pit which is in contact with earth:
	a) All concrete surfaces shall be provided with two component transparent polyamide cured epoxy sealer coating (having solid by volume minimum 40% ±2%) of minimum 50 micron DFT. Surface to be coated shall be absolutely dry, clean and dust free.
	b) Sealer coat shall be followed with the application of epoxy phenolic coating (solid by volume minimum 63%) of minimum 400 micron DFT. This coat shall be applied after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.
5.02.11.03	**Coating on RCC water retaining structures (drinking water)**
	Internal surfaces of RCC water retaining structures shall be provided with minimum 400 micron Food grade epoxy coating complying to FDA Title 21, Part 175.300. Surface to be coated shall be absolutely dry, clean and dust free.
5.02.11.04	**Architectural Concepts and Finishing Schedule**
	Architectural concepts and finishing schedule shall be as specified elsewhere in architectural specification.
5.02.11.05	**Acid / Alkali Resistant Treatment:**
	Acid / alkali resistant lining treatment shall be provided in different areas as follows:
	Neutralization Pit: The walls shall be provided with one coat of bitumen primer, followed by 18 mm thick bitumastic layer, 115 mm thick Acid Resistant (A.R.) bricks, 6 mm thick under bed of potassium silicate mortar, pointing the joints of bricks with acid / alkali resistant epoxy / furane mortar upto a depth of 20 mm and bitumastic end sealing. Suitable pilasters shall be provided

with A.R. bricks at regular intervals depending upon the height of lining, as per the specification.

The floor of neutralization pit shall be provided with acid / alkali resistant lining treatment as given in the above para, except that the 115 mm thick A.R. bricks layer shall be replaced by 75 mm thick A.R. tile layer and pilasters shall be omitted.

The ceiling of neutralization pit shall be provided with one coat of epoxy primer followed by 2 coats of epoxy paint (150 micron).

Acid / Alkali storage area / projections above the floor, pedestals projecting from the floor / saddles. The floor shall be provided with one coat of bitumen primer followed by 12 mm thick bitumastic layer, 20 mm thick A.R. tiles, 6 mm thick under - bed by potassium silicate mortar, 6mm thick pointing of joints of tiles with acid / alkali resistant epoxy / furane mortar up to a depth of 20 mm and bitumastic end sealing. Dado of 1.0M high with above treatment shall also be provided if applicable in case of walls nearby.

The floor shall be provided with acid / alkali resistant lining treatment as given in the above para except that the 75 mm thick A.R. tile layer shall be replaced by 12 mm thick A.R. tile layer.

Basket of Alum Solution Preparation tank: 5mm thick epoxy lining over a coat of epoxy primer.

Curved surfaces of saddles shall have minimum 12 MM thick bitumastic layer to support the vessel / tanks.

Effluent Drains: Acid Resistant lining treatment indicated for the storage area shall be provided on the bed as well as walls of the drains with 38 MM AR tiles. The underside of the pre-cast slab cover shall be applied with one coat of epoxy primer and two coats of epoxy coating, total DFT 150 microns.

Lime tank: Two coats of bitumen paint conforming to IS: 9862, with total DFT 150 microns.

Guarantee

The Contractor shall give a guarantee for satisfactory functioning of the lining for a period of 36 months from the date of completion of the work or date of handing over the site to the Engineer, whichever is later.

The Contractor shall replace / rectify defects is any, observed in the lining to the satisfaction of the Engineer without any extra cost during this period.

5.02.11.06 **Foundation of Over Ground Steel Circular Water Storage Tanks**

General Requirements

The tank foundation shall be as per IS 803 and as specified in relevant clause of foundation chapter.

Sub Grade Preparation

The surface of natural soil shall be thoroughly compacted by rolling or other means, as directed by Engineer, to obtain 95% of max. laboratory dry density for the soil, as per IS:2720 (Part-VII).

Anti Corrosive Layer

Anti-corrosive layer shall consist of screened coarse sand, mixed with 80/100 bitumen or equivalent 8% to 10% by volume.

Bitumen shall be heated to a temperature 175^0C to 190^0 C, with 3% kerosene, if required. Sand shall be thoroughly mixed with it in a mixing drum to obtain uniform mixture and shall be laid over the compacted surface, laid in line, grade and levels and as directed by the Engineer. Bitumen shall not be heated beyond the temperature limits given above.

The premix carpet shall be laid in two layers of 3 cm and 2 cm respectively. After compacting and laying the first layer of 3cm, a tack coat of hot bitumen at the rate of 1 Kg. per Sq.m. shall be uniformly applied to the surface, by means of Sprayer and the Second layer of 2cm thick shall be laid, tamped and compacted to the satisfaction of the Engineer.

Sand shall be spread on the final surface at the rate of 0.5 Cu. m per 100Sq.m.

5.02.11.07 **Premix**

Materials

Sand

Sand shall be clean, dry, coarse, hard angular, free from coatings of clay, dust and mix of vegetable and organic matters and shall conform to IS 383 (Grade -III).

Stone Chippings

Stone chippings shall be hard black trap or granite or locally available stone and shall conform to IS 383. The grading shall be of normally 12mm down size and 6mm down size, in the ratio of 3:2 respectively.

Bitumen

Bitumen required for the work shall be 80/100 grade or its equivalent quality.

Laying

Areas on which the premix is to be laid shall be thoroughly cleaned of all dust and loose materials. On the cleaned surface, a tack coat at the rate of 1.0 Kg. per Sq.M. of hot Bitumen shall be uniformly applied by Sprayers. The applied Binder shall be evenly brushed.

The Binder bitumen 80/100 shall be heated to the temperature of about 190^0 C with 3% kerosene, if required and mixed with stone chippings of size, as mentioned above, at the rate of 400 KG, with Six (6) Cu. M. of stone chips, for 100 Sq.M. of surface. The total mixed quantity, as mentioned above, is the quantity required for the total 50mm thick for 100 Sq. m. of area. Mixing shall continue until the aggregate is well coated.

5.03.00 CHIMNEY

5.03.01 Salient Features

Configuration and height of chimney(s) shall be as specified in mechanical portion of technical specification. There shall be one flue (liner) for each unit.

The chimney shell (windshield) shall be constructed using slip form shuttering. Internal platforms of steel structure shall be provided for enabling access to various elevations of the chimney and to provide support to the flue liners. Spacing of internal platforms shall not exceed 45.0 M. The platform beams shall be supported on concrete shell using suitable load bearing arrangement in the recesses provided for the purpose. The platform beams getting supported in the chimney shell shall have complete bearing support within the thickness of shell at that location and shall in no case be supported completely/partially on corbels/ brackets from the shell. "Through openings" in shell if provided to facilitate erection of platform beams shall be closed with cast-in-situ RCC closure wall on the external face of the shell. Necessary dowel bars shall be provided in the shell during construction for this purpose. Openings in the concrete shell for flue duct entry, access door & truck entry door at ground level, air ventilation etc shall be provided. Hand railing shall be provided all around internal staircase & around the ventilation voids in the internal platform using min. 32 mm nominal bore MS pipes of medium class conforming to IS:1161. Spacing of railing posts shall not be more than 1500 mm centre to centre with a minimum height of 1200 mm. The handrail shall have three rows of horizontal

members between the railing posts including the top member. Kick plate of min. size 100x6 thick shall be provided in the hand railing.

The flue duct outside the chimney shall be suitably connected to the vertical flue liner inside the chimney as per EPRI Wet Stack Design Guidelines. Expansion Joint shall be provided at the interface between the flue liner and the absorber outlet duct as per design.

The expansion joint in the chimney flue liner shall be suitable for flue gas parameters & operating conditions as specified in Mechanical Portion of the specification. (Amendment No 02, D-1-5)

~~The expansion joint in the flue liner shall comprise of non-metallic material suitable for wet stack operations, shall be acid resistant to withstand acidic flue gas condensates arising out of flue gas parameters & operating conditions as specified elsewhere in the specification and shall also prevent dust accumulation. If required as per design or as per the recommendation of expansion joint manufacturer, the space between the expansion joint material and the liner shall be packed and sealed by providing a bolster made up of light weight compressible material suitable for wet stack operations and acid resistant to withstand acidic flue gas condensates arising out of flue gas parameters & operating conditions as specified elsewhere in the specification. The bolster shall be confined in texturized glass fabric having a final covering of stainless steel wire mesh. Design of expansion joint shall comply EPRI guidelines to avoid contact of condensate with expansion joint material and to ensure drainage of condensate.~~

Chimney roof shall be of RCC slab over a grid of structural steel beams and provided with rainwater drainage system. An internal structural steel staircase supported from chimney shell with chequered plate floor panels and pipe handrails, shall be upto the platform just below roof platform and an internal cage ladder for a small height, over last staircase landing to access the chimney roof through a roof access hatch.

The other components of the chimney include liner test ports (for continuous pollution monitoring), liner hatches, grade level slab of RCC with metallic hardener floor finish, acid resistant treatment on roof slab, a large electrically operated grill type roll-up door and personnel access metallic door at grade level, roof drain basin, rain water down comer pipe (150 mm diameter galvanized pipe), connection to plant drains, louvers with bird screens for ventilation and all other openings in the wind shield, all finishing works, electrical power distribution boards, lighting panels, power & control cabling and wiring systems, stair and platforms lighting, socket outlet, lightning protection and grounding system, aviation obstruction lighting with photoelectric controller etc, communication system, a rack and pinion elevator and other items, though not specifically mentioned but reasonably implied and necessary to complete the job in all respects.

Aviation Warning Lights (AWL) shall be mounted on door panel of required size (open able from interior of chimney shell) fixed to openings in the chimney shell at locations and levels specified elsewhere. Suitable provision for approach to the AWL shall be provided at the platform level. AWL shall be located at about 1-1.5 metre above the top of platform to enable easy handling for maintenance.

The size of roll-up door shall be determined based on minimum requirement for ventilation and transportation & erection of flue segments.

5.03.02 Design Concept

Design and construction of various components and systems of the chimney shall be in accordance with relevant Indian Standard and where provisions are not covered in Indian Standard, reference shall be made to ACI, BS, CICIND and other international standards.

In case of any conflict between this document and the Indian and International Standards, the stipulations of this document shall prevail.

Imposed loading for design of all chimney components shall not be less than 5 kN/ Sq.m. An additional 25% of liner load shall be taken as impact loading for liner erection in addition to the liner load.

The min. thickness of web for plate girders shall be kept as 12 mm.

Seismic forces on the chimney system shall be determined based on site specific seismic information provided elsewhere in this document.

Wind forces on the chimney system shall be determined based on site specific wind design criteria provided elsewhere in this document.

The chimney and its components shall be designed to resist the most onerous forces resulting from all the possible combinations of the various loadings.

5.03.03 Wind Shield

The wind shield shall be designed for vertical loading, cross wind loading, seismic loading, circumferential wind loading, thermal gradients etc. The load calculation and load combinations shall be as detailed in IS 4998. The wind shield shall be analysed for cases with and without flue liner loads.

Forces/stresses in the wind shield due to eccentricity effects of local loadings, insolations effects, rotation of chimney foundations, construction tolerances and moments of second order shall also be considered.

Seismic response of the chimney shall be computed by the response spectrum method. Dynamic modulus of Elasticity shall be considered for calculating natural frequencies of the chimney. At least, the first five modes of vibrations shall be used for this analysis.

The across wind analysis of the chimney shall be carried out as per the provisions of IS 4998. Across wind loads shall be combined with co-existing along wind loads.

The effect of the openings/cut-outs in the chimney shell shall be duly considered in the design of the windshield. The minimum thickness of shell shall not be less than 500mm.

The minimum vertical reinforcement shall be 0.3% of the concrete area. The maximum spacing of the reinforcement bars shall not be more than 250 mm on each face. The minimum circumferential reinforcement shall be 0.2% of the concrete area. The maximum spacing of the reinforcement bars shall not be more than 200 mm on each face. The circumferential reinforcement in the top 3 meters of the windshield shall be twice that required from design forces. The clear cover to reinforcement shall be 50 mm.

There shall be a continuous ring of concrete shell without any opening for a height of atleast 5m below the soffit of flue duct openings.

There shall not be any reverse (outward) slope in the inside face of chimney shell. Where there is a sudden change in slope/ profile of the shell, the circumferential reinforcement shall be increased to twice the requirement as per the design in a circumferential band extending atleast 3m above and below such slope/profile change level.

The diameter of the reinforcing bar for the main vertical reinforcement of shell shall not be less than 25mm for a shell height up to the top level of flue duct opening.

Shell thickness between any two 10m reference levels shall not vary more than 150mm.

The minimum thickness of shell/closure wall at beam support recess/ opening locations shall be 100mm.

Grade of concrete for chimney shell, and other super structure shall be minimum M30. Only OPC cement shall be used for Chimney shell and other super structure.

The final design shall be checked & verified by 'Wind Tunnel Test' and shall be conducted at a reputed institution. Dynamic interference effects due to additional chimney(s)/NDCTS's and other tall structures located upto distance of 20 times diameter at 2/3rd height of subject

chimney in the area or in the future expansion stage of the project, as envisaged by the owner at the time testing, shall be determined along with the other topographical features of the local area through model test.

5.03.04 Flue Liners

The flue gas parameters & various operating conditions for selection of flue liner material, material specification for flue liner and the criteria of flue gas exit velocity for sizing the flue liner shall be as specified elsewhere in the specification.

For flue liner with base metal as mild steel, the thickness of the base metal shall be determined from structural considerations. The thickness of any clad metal/coating/block lining etc. provided on the base metal shall not be considered for computing the structural strength of flue liner. The minimum thickness of the mild steel base metal shall, however, not be less than that specified elsewhere in the specification.

Two manholes placed diametrically opposite shall also be provided in each flue at all internal platform levels.

The supporting/restraining arrangements of the liners should be such that expansion of the liners longitudinally or circumferentially is not restrained.

5.03.05 Internal Platforms

The platforms shall be designed for dead, imposed (live), erection work and other possible loadings and temperatures effects. These platforms shall provide support and lateral restraint to the steel liners and provide access for inspections and maintenance. Forces imposed on the floors due to lateral restraint of flues shall be enhanced aptly for impact effects. These platforms shall also be designed suitably for the liner erection works. The platform shall be made up of chequered floor panels supported on grid of structural steel beams. All beams shall have bolted connections. The maximum permissible deflection in main steel girders supporting flue liner shall be span/1000.

5.03.06 Internal Staircase

The staircase shall have a clear passage way width of not less than 800 mm and a clear headroom of not less than 2100 mm. The riser height shall not be more than 175 mm and tread width shall not be less than 225 mm.

5.03.07 Foundation

The chimney foundation shall be designed as per limit state method as per IS 4998 for the most critical combination of forces and moments, resulting from all possible combinations of the various loadings from the chimney system during all stages of constructions. The effect of water table shall be considered and the foundation shall be checked for overturning for minimum and maximum vertical loads. There should be no uplift under any portion of the foundation/piles for any loading condition. Since chimney is a wind sensitive structure no allowance shall be made in the load carrying capacity of the bearing strata / piles under any load case/combination with wind. The foundation diameter to depth ratio shall not exceed 12. The diameter of the reinforcing bar for the main radial and tangential reinforcement for the foundation shall not be less than 25mm. The spacing of radial steel at the outer edge of the foundation shall not be more than 250mm. Grade of concrete for foundation shall be minimum M 30.

5.03.08 **Thermal insulation (Applicable in case of Titanium / C-276 Flue Liner)**

The insulation shall be semi-rigid, resin bonded type, in the form of slabs and shall conform to IS: 8183. Blanket type insulation shall not be used. The density of insulation shall not be less than 64 kg/cu.m for resin bonded glass wool insulation and 100 kg/cu.m for resin bonded rock wool. The coefficient of thermal conductivity of insulation shall not be more than 0.52mW/cm/^{o}C at a mean temperature of 100^{o}C.

The insulation thickness shall not be less than 100 mm, in any case, and shall be provided in two layers with the second layer of insulation covering the joints of the first layer. The insulation shall be wrapped on the outer-most surface with galvanised wire mesh using MS galvanised pins and speed washer.

5.03.09 **Chimney Painting**

(i) All exposed steel surfaces (including exterior surface of mild steel flue liner in case the design does not envisage provision of thermal insulation on the exterior surface of flue liner) shall be painted as specified in corrosion protection clause of this specification.

(ii) All steel parts embedded in concrete including bolts, nuts, washers, pipe sleeves and insert plate shall be galvanized as per IS:4736. The minimum weight for galvanizing shall be 610 g/sq.m and shall comply with relevant IS Codes.

(iii) The inside surface of chimney shell above roof, horizontal surface of shell at top, underside of concrete roof slab, etc shall be painted with epoxy phenolic coating system having total 220 microns DFT.

a) All concrete surfaces shall be provided with two component transparent polyamide cured epoxy sealer coating (having solid by volume minimum 40% ±2%) of minimum 50 micron DFT to be applied over cleaned surface in multiple coats. Surface to be coated shall be absolutely dry, clean and dust free.

b) Sealer coat shall be followed with the application of Intermediate coat of epoxy phenolic coating (solid by volume minimum 63%) of minimum 100 micron DFT. This coat shall be applied after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.

c) Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT. This coat shall be applied after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer.

(iv) The entire external surface of chimney shell shall be painted with epoxy phenolic coating as specified in (iii) above. The finish coat shall be in alternate bands of 'signal red' and 'bright white' colour.

5.03.10 **Rack and Pinion Elevator**

A rack and pinion elevator, with a load carrying capacity of 400 kg (min) (passenger cum goods), cabin floor size of 1100 mm x 1000 mm (min.) and an operating speed of 40 m/min. (approx.), shall be provided for travel from the grade level to the top of the chimney. A landing platform shall be provided at all access/ platform levels. The elevator shall be of a proven and approved make. Enclosure shall be fabricated from tubular steel and expanded metal or wire mesh, 2.1 m high (Approx.).

A Safety device comprising of an over speed governor in constant mesh with the rack by means of a flame hardened steel pinion shall be provided to protect the cab against over speed during the cab downward motion and the same shall actuate the brake mechanism and stop the down ward motion gradually. The lift shall be installed using anchor fasteners. The electrical requirement of the system shall conform to the main electrical specification. Drive motor shall be of S3 duty class with CDF of 25% and maximum number of 120 starts per hour in 55 degree Celsius ambient temperature. The motor shall be provided with internal 220V AC single phase space heaters or an alternate heating system. The elevator shall be supplied, installed, painted, tested, commissioned etc. complete with all mandatory spares (as specified in Part-F of this specification) and operation maintenance manual.

5.04.00 **VOID**

5.05.00 **ASH HANDLING SYSTEM**

5.05.01 The civil works for Ash handling system shall comprise of bottom ash and fly ash handling system, which includes Ash slurry pump house and their related sumps/tanks, Ash water pump house, HCSD Pump house, Ash water recirculation pump house, Bottom Ash (BA) slurry transportation pump pit and their related sumps/tanks Slurry trench (In case of SCC system), Clarifier system for Ash water, Transport/instrument Air Compressor house, Conveying air compressor house, Switchgear /Control/RIO rooms, AHP Control room building, Ash silo, supporting structures and foundations for Bottom ash hopper, Buffer hoppers, Dewatering bins, bottom ash overflow tank, Settling tanks and Surge tanks, Seal water tank, Silo Utility Building complex including development of silo area (i.e. paving, fencing/boundary-wall, access roads, office block and watchman cabin), miscellaneous equipment foundations, trenches, pipe racks, pedestals/thrust blocks for ash slurry/fly ash pipe supports including bridges/ culverts for road/rail/drain/nallah as required. For the ballast-less rail track under silo area complex a 4.0m wide area (2.0 m either side of centre line of railway track) shall be left unpaved along the rail track in complete silo area complex same shall be constructed by railway siding agency. RCC peripheral drains, crossing rail track shall be covered with permanent RCC slab (minimum 150 mm thk.) & construction of these RCC drains such that it will not create any hindrance in construction of rail track. Top of paving level in balance silo area complex shall be governed by the top level of rail track in silo area complex. Steel gates of minimum 6.0m width for entry & exit of railway wagons in silo area complex shall be provided in boundary wall/ fencing of silo area complex. For the hindrance free movement of railway rake on the rail track under Silo following shall be provided however necessary approval shall be taken from the railway authority by successful bidder.

*Horizontal clearance: A minimum clearance of 3.5m shall be maintained between centre line of the Railway track to face of the crossing structure.
*Vertical clearance: A minimum vertical clearance of 8.5m shall be maintained between Rail top level and bottom of structure.

5.05.02 ~~Transport air compressor houses, Conveying air compressor houses, Ash slurry Pump House,HCSD Pump house shall have steel shed building with side sheeting and Silo utility building, AWRS Pump house shall have RCC framed structure, with RCC columns and profiled metal deck sheet roofing (filled with RCC) supported on steel purlins & truss / girders. Other buildings like MCC /switchgear rooms, control room, etc. shall have RCC framed structure with cast-in-situ RCC roof slabs. All RCC buildings shall have brick cladding. Crane girders or monorails shall be provided as per requirement and the same shall be of structural steel construction.~~

5.05.03 The documents and drawings as listed below are to be submitted for the approval of the Employer unless specified otherwise. The list given below is not exhaustive but indicative only.

Transport air compressor houses, Conveying air compressor houses, Ash slurry Pump House, HCSD Pump house, Silo utility buildings and other buildings like MCC /switchgear rooms, control room, etc. shall have RCC framed structure with cast-in-situ RCC roof slabs. All RCC buildings shall have brick cladding. Crane girders or monorails shall be provided as per requirement and the same shall be of structural steel construction. (Amendment No 03, D-2-18)

a) Project design intent document giving the basis of design, which shall cover all the design philosophy aspects, parameters, assumptions, references, loading cases, load combinations, analysis and design of all buildings, structures, facilities etc. shall be furnished for approval, before commencement of detailed engineering.

b) Structural analysis, design calculations and drawings of substructures and super structures for all buildings/structures, facilities like pump houses/shed, compressor houses, sumps / tanks, channels, pipe support structures, culverts/ bridges, pedestals, thrust blocks transformer yards, etc. shall be submitted for approval of the owner.

c) The design and drawings for the equipment and their supporting structures like bottom ash hopper, buffer hopper/collector tanks, surge tank/settling tank, silos/bins, etc. associated with Ash Handling System, shall be submitted to the Owner for information only. However, the structural design criteria and basis of design as mentioned at (a) above, for these structures also shall be approved by the Owner.

d) Top of RCC pedestal of foundation for bottom ash hopper, fly ash silo, other columns etc. shall be 300 mm above paving level or surrounding finished ground level (FGL).

5.05.04 The finished ground level (FGL) of Ash Water Recirculation (AWR) pump house complex shall be minimum 1.5m above High flood level (HFL) and Finished floor level (FFL) shall be 500mm above FGL. However, in order to facilitate approach/connection to the existing road with AWR pump house complex, if required FGL may be fixed at higher level than 1.5 m above HFL. AWR System shall include Ash water recirculation pump house complex along with related sumps/tanks, MCC/Switchgear building, maintenance room, control room, transformer yard, miscellaneous equipment foundations, trenches inside roads/RCC paving and area drainage etc. The peripheral drain inside the complex of suitable capacity & slope shall be suitably connected to the natural drain available outside the complex. The AWRPH complex shall be confined with boundary wall and a security gate. The complex shall be suitably connected to the nearest road. Since the complex is situated outside the plant boundary, an Independent sewerage system including soak pit/ inspection chamber shall be provided. RCC channel to be constructed from existing outflow from lagoon to AWRS sump.

5.05.05 The Silo Area complex shall be fenced with chain linked fencing, if placed inside the plant boundary and shall be confined with boundary wall if placed outside plant boundary. Gates shall be provided for rails, truck movement and transformers. The boundary wall shall be of one brick thick of height 2.4 m with a 600 mm high galvanized concertina at top, such that total height is 3.0 m above formation level. The fencing shall be PVC coated G.I. Chain link of minimum 4 mm thickness (including PVC coating) of mesh size 75mm x 75 mm and of height 2.4 m above toe wall. The toe wall shall be 1 brick thick, minimum 200 mm high above paving/formation level and 300 mm below paving/formation level on 75 mm thick PCC (1:4:8) bedding. Entire area in the silo area complex shall be paved and have a peripheral RCC drain of adequate capacity & slopes covered with perforated precast RCC slabs of minimum 150 mm thickness with provision of openable galvanized steel grating covers of 1.0 m at every 4 m interval. The complex shall be provided with a sump for collection of ash water. In addition to the outer confinement, additional fencing with gates should be provided for all transformers in the complex. A watchman cabin with a minimum area of 5 Sq.m shall also be provided in this area.

5.05.06 Pipe supports shall be provided for ash slurry pipes, HCSD pipes, Ash water Recirculation pipe, dry fly ash(FA) pipes including RCC thrust blocks and any other supports required to complete the system. Over-ground pipes shall be supported on RCC pedestals except for FA pipes which shall be on elevated steel trestles. Unless noted otherwise, the top of concrete pedestals shall be minimum 500 mm above surrounding ground level/paving level. Pipes shall

Ash slurry shall not be discharged on slope of the raised dyke. Slurry to be discharged at a distance from heel of the raised dyke which shall be at least five times the height of the dyke. If slurry is discharged in starter dyke then it may be discharged on slope of the dyke by providing RCC stairway type energy dissipation channel on the inside slope of dyke. The inside width of stairway shall be minimum 2000mm, which shall be extended into ash dyke area by a minimum of 3metre beyond the heel of the dyke. The side walls of dissipation channel shall be 200mm thick and 1200mm height above base slab. The base slab shall be 200mm thick on 75mm thick PCC. Reinforcement at 8dia @200c/c on both faces both ways for base slab and walls shall be provided. For the stairway the riser shall be 500mm and tread shall be as per the dyke slope. The pedestals/thrust blocks to be provided for ash disposal pipes and AWRS pipes. The pedestals/culvert may be combined for ash disposal pipes and AWR pipes in the common corridor. (Amendment No 03, D-2-18)

	be suitably anchored with RCC pedestals to resist lateral and vertical movements as per system requirement. Pipe shall be routed through pedestals as per available space in pipe corridor
5.05.07	~~**VOID**~~
5.05.08	Where the pipes are crossing the road through RCC box culverts, the culvert top generally, shall not be more than 100 mm above the road top and a hump with slope of 1:35 shall be provided on the road. All other road crossings inside the plant area can be either underground or overhead road crossings with necessary headroom clearance. For any boundary wall crossings, pipe shall be laid through casing pipe / RCC culvert. After laying the pipe, the boundary wall shall be restored. For other water body crossings, such as local Nallah / canal, local water bodies, local drains etc. suitable structural arrangement with 800 mm wide walkway shall be provided. Bidder to take all statutory clearance from concerned authorities for crossing his pipe/trestles over road / rail / culverts / nallah etc. at his own cost and initiative, without any commercial implication to the owner. For any other additional works, bidder have to make their own assessment too of the quantity/ number of culverts, existing pipe pedestal crossings, nallah crossings etc., based on their site visit before quoting
5.05.09	All ash handling system pipe crossings with Railway Lines including MGR lines shall be laid by method accepted by concerned railway authorities for existing rail lines & by cast in situ RCC box culvert for future envisaged rail lines. The railway track crossings are to be designed in accordance with railway Standard/RDSO guidelines and all necessary approvals from the concerned Railway authorities shall be obtained by the Bidder, without any financial implications to the owner.
5.05.10	**VOID**
5.05.11	All liquid retaining structure shall be designed as specified elsewhere in the specification.
5.05.12	VOID
5.05.13	VOID
5.05.14	All pump houses and other substructures shall be checked for stability as per the following guidelines: a) Stability of structure against sliding during construction as well as operating conditions for various combinations of applied characteristic loads. In case where dead load provides the restoring moment, only 0.9 times the characteristic dead load shall be considered. Factor of safety against sliding shall not be less than 1.4 under most adverse combination of applied characteristic loads. b) Stability of structure as a whole against overturning. It shall be ensured that the resisting moment shall be not less than the F.O.S. times the maximum overturning moment. Factor of safety against overturning shall not be less than 1.2 due to characteristic dead load and shall not be less than 1.4 due to characteristic imposed load. c) Stability of structure against uplift due to the ground water table at finished ground levels during construction and after construction stages. Minimum factor of safety of 1.2 against uplift shall be ensured considering 0.9 times dead weight, empty condition inside and ignoring the superimposed loadings. Inclined wedge action shall be limited to 15 degree with vertical plane. Provision of pressure relief valve / flap valves etc. shall not be permitted to counter the uplift. Also FOS against uplift, to be taken as 1.0 considering the dead weight of structure and soil resting on side projections, if any, in the vertical plane. Inclined wedge action of soil shall not be considered in this case.

5.05.15 **Architectural Features of Ash Handling System Buildings**

a. Building shall have Aluminium and Steel doors/ windows/ rolling shutters / ventilators.

b. Safety norms shall be followed as applicable. The buildings shall be provided for Pump houses, Switch Gear Room, Control Room etc. as per ash handling system requirements.

c. External finish shall be of premium acrylic smooth exterior paint with silicon additives over texture coat.

d. All the air conditioned rooms shall be provided with hermetically sealed double glazing in windows and false ceiling.

e. Encased staircase shall be provided for double storeyed buildings and cage ladder shall be provided for roof access in single storeyed building.

f. Each building shall have one toilet block with drinking water facility.

5.06.00 FGD SYSTEM

5.06.01 The civil works for FGD system shall comprise of civil, structural and architectural works below and above ground level of FGD control room building, slurry re-circulating pumps & oxidation blowers building, tank foundations, absorber tower foundation, MCC building, gypsum dewatering building, transformer foundation, equipment foundations, pipe & cable gallery/ trestles, drainage, sanitation, water supply (from terminal points to various buildings/facilities) and all other civil, structural and architectural works associated with the complete FGD system specified elsewhere in this specification. Bidder may also refer terminal points & exclusions in this regard.

5.06.02 **Buildings for FGD System**

FGD System may comprise of various buildings based on the functional requirement viz. MCC/Control room building, Gypsum dewatering building, re-circulating pumps & oxidation blowers building, Gypsum storage shed etc.

5.06.02.01 **Control building, M. C. C. Buildings**

These shall be steel/RCC framed building with RCC roof and floor. For steel framed building roof /floor shall comprise of RCC slab over profiled metal deck sheets (to be used as permanent shuttering only) over structural beams. Cladding shall be of brickwork/concrete block work with plastering on both sides. Roof shall be provided with roof water proofing treatment, as specified elsewhere in the Technical specification. Suitable arrangement shall be provided so as to prevent ingress of water into the cable trenches inside the building from cable entry locations.

All air conditioned areas, shall be provided with false ceiling system (details specified elsewhere) with under deck insulation.

5.06.02.02 VOID

5.06.02.03 **Gypsum Dewatering Building**

This shall be steel framed building with R. C. C. roof and floor. For steel building roof /floors shall comprise of RCC slab over profiled metal deck sheets (to be used as permanent shuttering only over structural beams). Cladding shall be of single skin metal sheeting or brickwork/concrete block work with plastering on both sides. Roof shall be provided with roof water proofing treatment, as specified elsewhere in the Technical specification.

5.06.03 **Booster Fan foundations**:

Fan, Mill foundations shall be RCC block foundation directly resting on virgin soil/ pile below Ground level. The vertical faces of this block foundation shall be isolated from adjacent footings by providing minimum 100mm thick polystyrene board of type-1 conforming to IS: 4671 with density 20 kg/cum sandwiched between the vertical face of block foundation and 230 thick brick wall all round.

ii) **Design Concept:**

a) For the foundations of Fans, etc. detailed static and dynamic analysis shall be done.

b) Wherever block foundation is adopted by the bidder for FAN foundations, suitable provisions to be ensured by the bidder in their General Arrangement and design to prevent transmission of vibration from these machine foundations to other nearby structures / foundations.

The bidder or his consultant should have adequate prior experience in design of machine foundations and the machines should be in successful operation for at least one year prior to the date of submission of bid.

5.06.04 Pipe and cable gallery/ trestles shall be as per details given in clause no. 5.02.08.

5.06.05 **RCC Floors, Paving & Grade Slab details**

Passages shall be provided inside the FGD area connecting to the outer periphery road to have access to the various facilities/buildings. These passage areas shall be provided with heavy duty paving for movement of heavy vehicles. The top surface of the passages shall be finished with 50 mm thick metallic hardener topping. Heavy duty paving shall also be provided for the areas in the equipment lay down area, unloading & maintenance area, storage area with 50 mm thick metallic hardener topping.

Lightly loaded areas such where no heavy traffic movement is envisaged shall be provided with Normal Duty paving. However, corridors below pipe/cable trestle gallery where no traffic movement is envisaged and in the area over the buried fire water pipes shall be provided with interlocking concrete blocks of minimum M35 grade and minimum 80 mm thickness underlain by 20mm thick layer of sand followed by 200mm thick 63 mm and down aggregate with interstices filled with selected moorum/ non-expansive soil.

All facility/buildings shall be provided with 750 mm wide plinth protection all around. It consists of 50 mm thick P.C.C. M-20 grade with 12 mm maximum size aggregate over 200 mm thick stone soling using 40 mm nominal size rammed, consolidated and grouted with fine sand.

An area of minimum 7.5m width all around the tank foundations and other facilities/buildings shall be paved. This paving shall be beyond the extent of plinth protection. Further, heavy duty paving shall be provided for passages connecting the outer periphery road to have access to the various facilities/buildings.

Wherever multiple FGD facilities are located in a cluster in the areas proposed for FGD, the entire extent of the cluster shall be provided with area paving maintaining minimum 7.5 m width around the facility buildings. Paving shall be extended up to nearest road for easy access to FGD facilities. Any functional requirement of paving for FGD facility not specifically mentioned in this document is also in scope of bidder.

GRADE SLAB OF BUILDINGS AT GROUND FLOOR

In buildings, the grade slab shall consist of 150mm thick RCC M25 grade base slab over an under bed as specified below. The under bed for ground floor slab shall consist of 75mm thick 1:4:8 PCC on stone soling of 200mm compacted thick with 63 mm and down aggregate with

interstices filled with well graded selected sand/ moorum/ non-expansive soil on compacted and dressed sub - grade. Reinforcement for the slab shall consist of minimum 8mm dia. bars @ 200 mm c/c at top & bottom of the slab in both directions. However, at unloading & maintenance area, gypsum storage shed stone soiling of minimum 400mm thick and grade slab with minimum 10mm dia bars @ 200 mm c/c at top and bottom in both directions shall be provided.

Further, top surface of grade slabs shall be finished with 50mm thick metallic hardener topping.

5.06.08 Bidder shall provide permanent access to all facilities/structures from the nearby existing roads of the Owner.

Roads shall be of concrete as per IRC standards, with minimum thickness of pavement (PQC) as 250mm (in M 35 grade) and DLC of 150 thick (in M 10 grade). Double lane road (width 12m having 7.5m wide pavement & 2.25m wide shoulders on both sides) shall be provided.

5.07.00 SEWERAGE SYSTEM:

Complete sewerage system including Sewage Treatment Plant for facilities within the plant is in bidder's scope. Bidder shall provide 'De-centralized Sewage Treatment' units. The capacity of the Decentralized Sewage Treatment' units should be as per the design requirements, subject to minimum combined capacity of 75 Cum/day.

Design of Sewage treatment plant shall be as per CPHEEO manual. Primary, Secondary and Tertiary treatment to be provided. Treated sewage water shall be used for horticulture purpose as per quality requirement of CPHEEO manual.

Cement concrete pipes of class NP-3 as per IS 458 shall be used below ground level for sewage disposal in all areas other than main plant area. However, for pressure pipes and in main plant areas, and under roads spun Cast Iron pipes conforming to IS 1536 of required class shall be used. RCC manholes with CI cover shall be provided at every 30m along the length, at connection points, and at every change of alignment, gradient or diameter of a sewer pipeline. This shall be as per IS 4111.

Sewage pump stations shall be provided as per IS 4111.

Bidder shall have to provide complete arrangement for sewage disposal up to the sewage treatment plant including pumping facilities.

5.08.00 Plant Storm Water Drainage System

as stipulated in/mentioned in 'Area drainage study report'. (Amendment No 03, D-2-30)

Complete storm water drainage system of Plant area is in bidder's scope. Storm water drain shall be designed taking into account the finished ground levels of the plant & surrounding area, drainage pattern, intensity of rainfall, etc with a return period of 50 years. These values shall be based on minimum rainfall intensity of 75mm/hr. All RCC drains shall be either RCC Cast-in-Situ or RCC Pre-cast drains. The minimum grade of concrete shall be M25 for RCC Cast-In-Situ drains and M30 for RCC Pre-cast drains. The maximum velocity for RCC open drains shall be limited to 1.8 metre per second. However, minimum velocity of 0.6 metre per second for self - cleansing shall be ensured. Bed slope not milder than 1 in 1000 shall be provided. The inside drain dimension at any point should not be less than 0 .45m (height) x 0.75m (breadth).

The runoff coefficient for paved and unpaved area shall be taken as 0.9 and 0.6 respectively. (Amendment No 03, D-2-30)

Open RCC rectangular section, unless required otherwise due to functioned requirement, shall be provided for all drains. The thickness of side walls and bottom slab of RCC drains shall be minimum 150mm or as per design considerations whichever is higher for drains upto depth of 1m from formation level. For depth of drain more than 1m from formation level, the thickness of side walls and bottom slab of RCC drains shall be minimum 200mm or as per design considerations whichever is higher.

The drains shall be provided on both sides of the double lane roads and single lane roads. The drains shall be provided on one side of the patrol roads along boundary wall. These shall be designed to drain the road surface as well as all the free and covered areas, etc. Box culverts shall be provided at all rail, road and other crossings.

Layout of drain shall be as per layout given in tender drawing "Layout of drain'.

Complete drainage upto outfall point to be completed to avoid flooding in the respective area.

5.08.01 WATCH TOWERS

Watch towers shall be RCC construction with all-weather enclosure at 6m height. watch towers shall be provided at 600 m interval along the boundary as well as at corner turning points of the plant boundary. watch towers shall be provided with MS STAIRCASE

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5.08.02 GATE COMPLEX

The Gate Complex shall comprise two (2) mild steel vehicle entry gates of minimum 8.0m width and height 3.0m and shall be electrically operated. Minimum one room for security personnel shall be located at each end of the gates.
Two (2) separate mild steel pedestrian gates minimum 3.0m high and 3.0m wide shall be provided at each end.
Gate Complex shall include Security Personnel building. The Security Personnel Building shall be a two (2) storied RCC super structure with office complex in ground floor & first floor. The building shall be constructed with 250mm thick brick wall with provisions for doors, windows & ventilators. The first floor shall also have a viewing gallery. The floor area and architectural details shall be as per the Arch spec. mentioned hereafter in this Specification.
Design Concept:
The Security Personnel building shall be designed as moment resisting sway frame in both orthogonal directions and shall be designed as per IS: 456, IS: 1893 and IS: 13920 (for seismic ductility requirement) and as per design criteria mentioned hereafter in this specification.
Architectural Features
The Security Personnel Building shall be 2-storied building. It shall be of RCC Frame structure & brick
masonry. The floor area of this building shall be minimum 700 sq m
The Gate Complex shall have sufficient no: of guards rooms to regulate movement of men and material and overall security, using latest modern technology like turnstile type/ boom type access control with magnetic cards and close circuit TV sets, computerized time and security office, etc shall be made. For any other gate provided for entry or exit, provision for a suitable small security hut/shed shall be made.
Space provision for Security Personnel personal staff, time office including time machine, reception, lounge, Arms store, Detention Room, Conference room, Toilets and pantry shall be provided as per functional requirement including toilets for Ladies, Gents, physically handicapped.
The provision for covered parking shall be made for 20 nos. Cars (23 sq.m./car including driveway) and 20 nos. Scooters (5 sq.m./Scooter).
In addition to above, provision for space for open parking for 5 trucks, &20 cycles shall be made.
External finishing shall be of Premium Acrylic Smooth Paint with silicone additives over Texture Coat & Aluminium Composite Panel combination.

5.08.03 PRE-CAST BOUNDARY WALL

A pre-cast boundary wall all around the land acquisition line as shown in the General layout Plan for plant area shall be provided. The total height of boundary wall shall be 3600mm above formation level (natural ground level in case formation level is less than natural ground level). Upto height of 3000mm it shall be constructed with precast reinforced cement concrete panels / cast in situ RCC panels and over that for 600mm concertina coil with maximum loop spacing of 125mm shall be provided with Y-shaped MS angle. The RCC precast/cast in situ reinforced concrete columns shall be provided at spacing not more than 2500mm centre to centre.
The RCC precast/cast in situ reinforced concrete columns and footing shall be minimum 1500mm below finished formation level with suitable foundation designed for horizontal and vertical loads. The precast reinforced concrete panels/ cast in situ RCC panels shall be at least 600m below formation level. The RCC precast concrete columns/ cast in situ RCC panels of minimum size 300mmX350mm shall be provided with two grooves of minimum size 115mmX50mm, so as to receive Precast Concrete RCC panels spanning from column to column with minimum width of 600mm and minimum thickness of 100mm as filler wall. The grade of concrete for all precast/cast in situ work shall be of M30 grade conforming to IS 456.
The boundary wall shall be designed as per relevant IS codes and as per standard practices. The same shall be submitted to Owner for approval at the time of detailed engineering, The architecture of boundary wall shall be finalized in consultation with Owner. The precast/ cast in situ reinforced cement concrete coping with minimum projections of 150mm on each side shall be provided at the top of the precast reinforced cement concrete panels / cast in situ RCC panels with suitable provision for MS angle Post for concertina throughout the boundary wall. Opening for gates/drains and for other crossing shall be suitably provided as per the requirement.

All exposed concrete surfaces of all precast members/ cast in situ RCC members have high quality shuttering finish with tolerance of +/- 5mm. Plinth protection of 150mm thickness PCC (M20) shall be provided on both side of boundary wall extending upto 300mm from centre line of boundary wall. High quality shuttering to be approved by Owner.

5.09.00 TRANSFORMER FOUNDATION

Foundations of transformers shall be designed for seismic and wind loads in addition to other applicable loads. Solid RCC block foundation shall be provided for the main transformer block. Alternatively, transformer shall be supported on a RCC foundation comprising of common raft for rail supporting walls up to rail-cum-road along with pedestals for jacking pad, roller lock etc. Tie beams connecting roller lock pedestals at rail level shall also be provided. Common raft/solid RCC block shall be supported on soil or pile based on requirement specified elsewhere in the specification.

Oil soak pit / oil water separation pit for transformer shall be provided as envisaged elsewhere in the specification.
The oil soak pit shall be provided for each transformer and shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store one-third (1/3) of the oil volume of transformer/reactor considering only 40% of the volume as available voids between gravel filling. The oil soak pit shall also be provided with a sump at the corner to allow drainage of water/oil from the soak pit. Oil soak pits sump of individual transformers shall be connected to common oil retention /oil water separation pit through hume pipes and manholes.
Separate common oil retention pit/oil water separation pit shall be provided for a group of transformers in transformer yard area of each generation unit of plant.
The Oil-water Separation pit shall be designed for an effective capacity of complete oil of one transformer having highest volume of oil along with 10 minutes of firewater. For calculating effective capacity of oil-water separation pit, effective depth excluding 200 mm freeboard

All roads shall be of rigid pavements unless otherwise specified. Rigid pavements shall be constructed with either conventional cement concrete or with Geopolymer concrete. Concrete road/ pavement or rigid pavement, mentioned in specification, shall mean road /pavement constructed with either Cement Concrete (CC) or Geopolymer Concrete. All concrete roads shall be unreinforced jointed plain concrete pavement having dowels in transverse joints and tie bars at longitudinal joints. (Amendment No 02, D-2-1)

below invert level of inlet pipe shall be considered. Plan area and depth of oil-water separation pit shall be decided based on above consideration.
Oil-water Separation pit shall be provided with five separate chambers interconnected by pipes.
First chamber shall be for collecting oil-water mix from transformers' soak pits in case of fire. After entering into first chamber, oil being the lighter in density floats above the water. The water from lower elevation flows in to subsequent chambers interconnected through galvanized MS pipes. The accumulated oil in the first chamber to be pumped out for subsequent usage or disposal. Water collected in the last chamber to be pumped out for subsequent disposal after treatment. Invert level of inlet Hume pipes (of NP-3 grade and adequate capacity), carrying oil and water from transformers soak pits, shall be designed for gravity flow. Freeboard of 200 mm shall be provided below the invert level of inlet pipes. Invert levels of interconnecting pipes of subsequent chambers shall be decided accordingly.
Arrangement for moving the transformer into place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer/reactor foundations.
RCC Firewall shall also be provided between the transformers wherever required.
300 mm thick PCC M20 encasement all around the Pylon supports inside soak pit for firefighting system shall be provided up to top of gravel filling. However, the supply and erection of Pylon supports with anchor fasteners for HVW spray system are not under the scope of this package. Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

5.10.00 Roads

All roads shall be of rigid pavements unless otherwise specified. Rigid pavements shall be constructed with Geopolymer concrete. Concrete road/pavement or rigid pavement, mentioned in specification, shall mean road /pavement constructed with Geopolymer Concrete. All concrete roads shall be unreinforced jointed plain concrete pavement having dowels in transverse joints and tie bars at longitudinal joints.

A 40mm bitumen mastic wearing course over concrete pavement shall be provided with industrial bitumen of grade 85/25 conforming to IS : 702, prepared by using mastic cooker and laid to required level and slope, including providing antiskid surface with bitumen fine grained hard stone chipping of approved size at the rate of 0.005 precoated cum per 10 sqm and at approximate spacing of 10 cm centre to centre in both directions, pressed into surface protruding 1 mm to 4 mm over mastic surface, including cleaning the surface, removal of debris etc. all complete. (Considering bitumen using 10.2% as per MORTH specification).
This 40mm bitumen mastic wearing course shall be laid after completion of construction activities i.e at the time of handover.

All the road shall again be repaired/made good as per IRC : SP :83 after completion of construction activities i.e at the time of handover.

All service and utility lines like fire water line, sewerage line, electric cables line etc. crossing the road shall be taken through NP3 class RCC Hume pipe. Hume pipe shall be laid before road work so that the road shall not be damaged.

Turning Circle radius adequate for 16 Wheel Truck shall be provided at all relevant points including approach (Entry/Exit) and access road for Truck movement at loading/unloading/weighment facilities of Limestone, Gypsum, Ash, Biomass for efficient and safe movement of truck.
Construction of road work shall be as per priorities given in Tender drawing 'Layout of Road Drawing'.

For road to be constructed with Conventional Cement Concrete or Geopolymer Concrete (Amendment No 02, D-2-2)

5.10.01 ~~For road to be constructed with Geopolymer concrete~~

The design of rigid pavement shall be carried out as per IRC: 58. The effects of design wheel load, maximum tyre inflation pressures, tyre contact area for the vehicle, traffic loads, environmental factors such as temperature changes in the pavement, other factors, like impact, load repetitions, etc., are to be taken. The design traffic load shall be a minimum value of 4 million standard axles. The road shall be designed for 30 years of life and considering a minimum traffic growth rate of 1 per cent per annum. The concrete pavement for roads shall be minimum 250 mm thick slab.

The road construction including its shoulders, base, sub base and concrete pavement shall be as per MORTH. The road base shall be with minimum 150 mm thick dry lean concrete over granular sub base. Dry lean concrete shall be laid by a mechanical paver and compacted by vibratory rollers. Concrete pavement of the road shall be done with fully mechanized paver fitted with electronic sensors for construction techniques. Laying /placing of Concrete DLC and PQC manually with hand-guided means or by semi-mechanized methods may be permitted around BTG area provided acceptance criteria as per MORT&H specification is achieved. Dry lean concrete shall be minimum M10 grade and concrete pavement slab shall be minimum M35 grade concrete pavement shall be provided with 125 micron polythene sheet below it. Concrete pavement shall also be provided with contraction and expansion joint with MS dowel bars and as per Ministry of Road Transport and Highways (MORTH) specification.

The finished top (crest) of all roads shall be 350 mm above the surrounding finished ground level.

All culverts and RCC bridges at crossings of all roads / rail tracks / facilities with drains / nallahs / channels / roads / rail tracks / pipes / other facilities, etc. are to be designed and constructed.

Unless otherwise specified, all roads (excluding access roads to all buildings / facilities / structures, patrol road along boundary wall and road inside the switchyard) shall be double lane roads.

5.10.00.02 Geo-polymer concrete road shall be constructed over soil sub-grade/embankment. Road section shall comprise of Granular Sub base over soil sub-grade, Dry Lean Concrete of M10 Grade (DLC) base and Pavement Quality Concrete of M35 grade (PQC) top layer. Thickness of different layers of pavement section shall be as per design. However, minimum thickness shall be 150 mm for DLC and 250 mm for PQC. Provisions of Clause 5.10.00.01 in respect of design, construction and other requirement shall also be applicable for Geopolymer concrete road. In addition, specific information pertaining to ~~geopolymer concrete is provided in Chapter D-1-8.~~

Conventional Cement Concrete or Geo-polymer concrete road is provided in Chapter D-1-8. (Amendment No 02, D-2-3)

5.10.01 **Double Lane Roads**

The double lane roads shall be (12 metre wide) with 7.5 metre wide concrete pavement and 2.25 metre wide raised shoulders on both sides of the roads as given in tender drawing “Details of road” .

5.10.02 **Single Lane Roads**

All access roads to all buildings / facilities / structures, road approaches / connections, access roads to liquid fuel storage areas and other equipment areas where access is necessary from inspection, operation and maintenance point of view and all roads inside the switchyard shall be single lane roads as given in tender drawing “Details of road”.

5.10.03 **PATROL ROADS**

All patrol roads along the boundary wall shall be single lane roads with 3.75 metre wide concrete pavement and 1 metre wide shoulders on one side of the road. as given in tender drawing "Details of road".

5.10.04 **INTERMIDIATE ROAD**

The Intermediate lane roads shall be (8metre wide) with 5.5 metre wide concrete pavement and 1.25 metre wide raised shoulders on both sides of the roads as given in tender drawing "Details of road"

deleted. (Amendment No 02, D-2-4)

*~~Concrete roads mentioned anywhere in the specification shall be read as Geo polymer concrete road~~.

5.11.00 Hydrogen Generation Plant Building

This building shall be RCC Frame structure with brick masonry.

This building falls under hazardous building category. Hydrogen generation plant shall be fenced with provision of gate as per clause 8.05.00 all around the single lane road surrounding the building to prevent unauthorized ingress or egress.

5.12.00 Fuel Oil Handling system

The civil works are to be provided for following fuel oil handling system areas as mentioned below:

a. Fuel Oil pressurizing pump house.

b. Foundation and dyke wall and all associated works for LDO tanks.

c. Pedestals and foundations to support the interconnecting piping between LDO tanks to the pressurizing pumps as well as piping from tanker unloading area to the Unloading pump house and further on to the LDO tank.

d. Oil water separator pit.

5.12.01 **Fuel Oil Pressurising Pump House**

Salient Features:

This building shall be a single storeyed framed superstructure with RCC columns, structural steel roof truss (with rafter and tie level plan bracings), purlins and roof slab. The roof slab shall comprise minimum 40 mm thick (above the crest of metal deck sheet) RCC slab supported on profiled metal deck sheet connected through shear anchor studs. Waterproofing of Roof slab shall be done as per architectural specifications. The building shall be completely covered with one brick thick wall with provisions for fire proofdoors, windows, rolling shutters. The basement RCC slab and RCC wall shall be designed as for uplift and external surcharge load as per the design criteria specified elsewhere. All pump foundations shall be designed for both static and dynamic loading. The building shall have separate enclosures for the control room and the switchgear room. All rainwater down comers shall be concealed with brick wall. The minimum floor area of this building shall be as per the equipment layout plan of the bidder/ EPC contractor.

Design Concept:

The grade of concrete shall be M 25 for all columns, beams, footing and slabs. The building shall be designed as per IS: 456, IS 800, IS 1893, IS 13920 (for ductility detailing).

5.12.02 **Fuel Oil Storage Tank Foundations**

The Fuel Oil Storage Tank foundations shall be either RCC raft or RCC Ring Beam system with compacted infill. The RCC raft /RCC ring beam shall be supported on virgin soil or pile foundation depending on the load bearing capacity of the soil. The tank bottom base plate shall

be supported on flexible compacted fill comprising 75mm thick Bitumen aggregate mix on top and compacted sand/ soil fill below, compacted in layers of 200mm to minimum 85% relative density as per IS:2720. The bitumen-aggregate mix shall consist of compact crushed stone, screenings, fine gravel, clean coarse sand(river sand) mixed in hot asphalt (8 to 10 percent by volume) and rolled or compacted. In the GA & detailing of foundation RCC ring wall/ beam it should be ensured that no bearing stress from tank superstructure is transmitted to the concrete surface. The top of flexible compact fill and top of RCC Circular wall shall be atleast 325mm above the surrounding ground surface for effective drainage.

The finished tank grade (Top surface of flexible compact fill) shall be crowned from its outer periphery to its centre at a slope of 1 in 100.

The Tank foundations shall be inside a RCC dyke wall enclosure. The entire area outside the tank foundations and within the surrounding RCC dyke walls shall be paved with concrete. The thickness of concrete paving shall be minimum 100mm.The single layer reinforcement in paving slab shall be min 10 Tor@200c/c. The area paving RCC slab shall be supported on 230mm thick Rubble soling with the internal voids filled with coarse sand. The height of the RCC dyke wall shall be evaluated based on the depth of Oil spillage for full oil volume of one storage Tank in addition to a free board of 300mm. Structural steel cross over ladder shall be provided (min 2 numbers) for each RCC wall dyke enclosure. Operating platforms wherever required as per functional requirement shall be provided.

5.12.03 **VOID**

5.12.04 **VOID**

5.12.05 **Oil Water Separator Pit**

The Oil-Water Separator RCC structure (pit) shall be designed as an underground structure. The sizing of the separator shall be based on the total surface run-off from the Fuel Oil Handling area and Hydraulic design for the oil separation. Surcharge load and ground water table up to ground surface shall be considered in addition to other functional loads for structural design of RCC wall for the separator pit.

Drainage trenches with proper bed slopes towards the oil-water separator pit shall be provided around the tank foundation. The entire area outside tank foundation shall have slope towards the drain trenches

Foundation for trestles and pedestal foundations, for supporting the pipes, shall be provided wherever required, at appropriate spacing. At pipe bends, necessary thrust resisting arrangement shall be provided.

The entire fuel oil handling area shall be fenced all around with metal fencing with provision of gates at key locations as per clause 8.05.00.

Seismic design shall be carried out for the Fuel Oil Storage Tank foundation, Fuel Oil Unloading Pump House & the Oil water separator.

5.12.06 **Architectural Features of Fuel Oil Handling Buildings**

Spaces for Pump Rooms, MCC Rooms, Control Rooms etc. shall be provided as per functional requirement. One Toilet block with drinking water facility shall be provided in each building.

External finishing shall be of Premium Acrylic Smooth Paint with Silicone additives over Texture Coat.

5.13.00 AREA PAVING

RCC paving of minimum 150 mm thick with M25 grade concrete, over an under bed as specified herein shall be provided for areas mentioned below. RCC paving shall be designed as rigid reinforced concrete pavement for the crane/ vehicular/ equipment movement loads which the paving has to bear. The under bed for paving shall consist of preparation and consolidation of sub-grade to the required level, laying of stone soling of 200mm compacted thickness for normal duty paving and 400mm compacted thickness for heavy duty paving with 63 mm and down aggregate with interstices filled with selected moorum/ non-expansive soil followed by 75 mm thick 1:4:8 PCC (1 part cement, 4 parts sand and 8 parts stone aggregate) with 40 mm nominal size aggregate. For normal duty paving, reinforcement of the RCC paving shall consist of minimum 8mm diameter bars @ 200 mm c / c in both directions at the centre of the slab. For heavy duty paving/ passage, reinforcement of the RCC paving shall consist of minimum 10mm diameter bars @ 200 mm c / c in both directions at the centre of the slab.

Paving areas shall be provided with the metallic hardener floor finish as specified elsewhere in the specification.

Passages shall be provided inside the main plant block connecting to the outer periphery road to have access to the various facilities/buildings. These passage areas shall be provided with heavy duty paving for movement of heavy vehicles. The top surface of the passages shall be finished with 50 mm thick metallic hardener topping. Heavy duty paving shall also be provided for the areas in the complete Mill bunker building and handling areas for PA/FD/ID fans with 50 mm thick metallic hardener topping.

Ground floor area in the boiler shall be provided with normal duty paving and shall be finished with 50 mm thick metallic hardener topping.

Ground floor area in the ESP envelope shall be provided with normal duty paving with neat cement punning. Wherever paving is envisaged to be provided, RCC paving shall be provided. However, corridors below trestle where no traffic movement is envisaged and in the area over the buried fire water pipes shall be provided with interlocking concrete blocks of minimum M35 grade and minimum 80 mm thickness underlain by 20mm thick layer of sand followed by 200mm thick 63 mm and down aggregate with interstices filled with selected moorum/ non-expansive soil.

All other areas inside the Main plant block shall be provided with normal duty paving without metallic hardener topping.

Suitable open RCC drains shall be provided to dispose off storm water drain. Separate open RCC drains shall be provided to dispose off floor wash and plant effluents into RCC sump pits. Separate RCC sump pits shall be provided for different types of effluents. The paving shall be provided with slope of 1:500 to dispose the surface water/wash water to the nearest drain. All drains/pits shall be provided with Heavy duty electro forged GI grating cover.

Sewer lines (Cast Iron), interconnected by sewer manholes (RCC) at regular intervals (not exceeding 30-meter centre to centre) shall be provided to dispose off sewage from main plant block.

For the purpose of area paving, Main plant block is defined as the entire area enclosed between peripheral roads encompassing the Transformer yard area, Main Plant Building area, Service Building area, Boiler area, ESP area, Chimney area & FGD area.

5.13.01 **Ground Floor Slab of Buildings**

In all buildings including main plant building, the ground floor slab shall consist of minimum 150mm thick RCC M25 grade base slab over an under bed as specified below. The under bed for ground floor slab shall consist of 75mm thick 1:4:8 PCC on stone soling of 200mm compacted thick with 63 mm and down aggregate with interstices filled with well graded selected sand/ moorum/ non-expansive soil on compacted and dressed sub - grade. Reinforcement for the slab shall consist of minimum 8mm diameter bars @ 200 mm c/c at top & bottom of the slab in both directions. However, at passages, unloading & maintenance bays, stone soiling of minimum 400mm thick and minimum 10mm diameter bars @ 200 mm c/c at top and bottom in both directions shall be provided.

Further, top surface of ground floor slabs shall be finished with 50mm thick metallic hardener topping.

5.13.02 **Civil Works for Fire Detection & Protection System in Ground Floor/ Paving**

Fire water pipes shall be provided with either RCC trench/buried underground/on pedastal.

Fire water trenches shall be open RCC type trench with removable RCC cover. RCC valve pit alongside trenches and RCC fire trenches crossing drains shall also be provided as per requirement.

Interlocking concrete block paving shall be provided over the buried fire water pipes as specified elsewhere in the specification.

At road/ drain crossings, NP3 class hume pipe encased in RCC shall be provided as per requirement at a depth of minimum 1m from FGL for routing of fire water pipes.

In case of rail crossings, NP4 class hume pipe encased in RCC shall be used instead of NP3 class hume pipe.

Each of the outdoor deluge valve and accessories shall be provided with housing comprising of Brick wall and RCC roof.

5.14.00 VOID

5.15.00 VOID

5.16.00 VOID

5.17.00 NATURAL DRAUGHT COOLING TOWER (NDCT)

The civil works for cooling towers are related mainly to following areas, but not limited to:

The design and construction of reinforced concrete double curvature hyperbolic shell, raker columns, ring beams, foundations including piling work (if applicable, vertical/ raker piles), cold water basin with partition walls, hot water ducts, drain sumps, external drain chamber with associated pipe work, cold water discharge channels for each cooling towers (as specified elsewhere) along with trash rack & stop-log gate and its lifting arrangement, hoists and monorails, primary and secondary hot water distribution troughs, fill support systems including columns & beams, testing of cold water basin for water tightness, external stairs, ladders, platforms, walkways as specified or required for operation and maintenance, access doors, Two (2) numbers Pultruded FRP staircase for approach to hot water distribution level of each cooling tower. RCC Paved walkway of minimum 10 m clear width all around the periphery of each cooling tower, Doors and suitable permanent walkways for access into distribution system, drift eliminator and fill packs shall be provided for each cooling tower, Pultruded FRP handrails, steel fittings/fixtures/inserts including fabrication, galvanizing and erection of associated steel work, providing protective measures in concrete and steel materials against effects of chemicals on the completed structure etc. all complete as per specifications, drawings and directions of Engineer. Wind tunnel model test for Natural Draught Cooling Tower

shall be carried out by the bidder as per technical specifications. Any other works not mentioned herein, but sufficiently implied and are necessary for completion and proper functioning of the cooling tower.

5.17.01 **GENERAL DESIGN CRITERIA**

5.17.01.01 Loading

The following loads shall be considered for the design of cooling towers:

a) Dead Loads
b) Wind loads
c) Earthquake forces
d) Loads due to temperature and shrinkage effects. Temperature effects due to solar radiation shall also be considered.
e) Construction load.
f) Foundation settlement etc.
g) Any other load likely to come on cooling tower.

A. Dead Load

All other dead loads shall be assessed in accordance with relevant codal provision. Dead load shall include the self-weight of structure, weight of fill material, weight due to algae growth & salt deposit, weight due to plugging/chocking of fills, weight of falling water, weight of hot water pipe, weight of water in hot water channel and distribution system including the self weight of channel and distribution system, weight of drift eliminators, etc.

Secondary stresses, if any, due to permanent fixtures on the shell shall also be considered.

B. **Wind Pressure**

The wind pressure on the towers shall be assessed on theoretical basis as well as with the help of Model tests in a wind tunnel of turbulent boundary layer.

All the theoretical methods outlined hereunder for estimating wind loads on cooling tower shell shall be valid only if the towers spaced at clear distance of greater than 0.5 times the base diameter at the finished graded ground level. The theoretical method outlined herein forms the basis only for assessing lowest limit of wind forces and shell structure interaction.

For conducting Model tests, bidders should survey the whole terrain and make their own assessment of likely critical wind forces & wind-structure interaction. It is pertinent to note that at the project the general topography of the area is uneven with adjacent existing/proposed plant structures of comparable height, and other natural topographical features are present in the vicinity of the plant area. Such model tests shall also include all adjacent topographical features, buildings and other structures which are likely to influence the wind load pattern on the tower significantly including all tall structures/NDCTs/chimneys of earlier stages of project (If applicable). The model test shall be carried out in a well reputed institute/testing laboratory after obtaining prior approval from the owner. The testing agency selected by the bidder shall have requisite experience and should have successfully carried out tests in the past for atleast one

cooling tower of similar capacity. The model tests shall be duly witnessed and approved by the Engineer. The model test results shall be made available before final approval of the design.

The complete cooling tower shall be designed for all possible wind directions and on the basis of worst load conditions as obtained from Model test and theoretical methods. Minimum multiplying factor of 1.43 shall be considered in wind pressure design. Wind pressure distribution shall be determined by aero-elastic model testing in atmospheric boundary layer wind tunnel offering appropriate aerodynamic similitude. Such models shall include all adjacent topographical features, buildings and other structures which are likely to influence the wind load pattern on the tower significantly. If pressures obtained from wind tunnel tests are higher than the pressures obtained from theoretical method, the pressures obtained from wind tunnel tests shall be followed in the design.

The Bidder is required to furnish the results of the wind tunnel model tests prior to the initiation of design of NDCT foundation.

Under the theoretical method, the total peak wind pressure and total & minimum wind pressure coefficient distribution for the tower shell shall be obtained from the IS: 11504. This design net pressure coefficient (p) and the distribution along the circumference of tower shall be used at all heights of the tower. The above design net pressure coefficient (p) includes the effect of internal suction.

In order to compute the quasi-static design wind pressure at a given height along the circumference of the tower, the design net pressure coefficient (p) shall be multiplied by the wind pressure acting at that height [P(z)]. For details, reference shall be made to "Criteria for Wind Resistant Design of Structures and Equipments" placed under Annexure-D of this sub-section.

The wind pressure at a given height [P(z)] shall be computed as per the stipulations of IS:875 (PART 3). The bidder shall also compute the wind pressure (pz) along the wind direction by Gust Factor (GF) or Gust effective factor method (GEF). Method for estimating the wind load on the tower and other elements, shall be based on IS-875 (part-3). While calculating the gust factor, the term `b' shall be taken as the diameter of the throat in Fig. 10 of IS:875 (Part-3).

Dynamic effects on the tower due to wind action shall also be investigated to ascertain the wind induced oscillation such as ovalling and excitation along and across the wind direction. Bidder shall carry out detailed analysis for the tower and consider the worst combination of static and dynamic effects.

Design of the tower shall satisfy quasi-static method & GEF method. In case the bidder proposes to adopt aerodynamic rough surface such as provision of meridional ribs in the cooling tower shell, the pressure coefficients as given in the VGB-BTR KUHLTUMRE GERMAN SPECIFICATIONS (latest) (structural design of cooling towers) shall be permitted. The provisions of BTR may be adopted for choosing the value of circumferential wind pressure coefficient (p1) only. The wind pressure coefficient (p1), as obtained from BTR after accounting for internal suction, shall be multiplied by a factor 1.43 to arrive at the net design pressure coefficient (p). The bidder shall furnish authorized English Translation of VGB-BTR KUHLTURME GERMAN SPECIFICATIONS (latest) for the review of the owner. All other stipulations as specified in these specifications shall be met with.

Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant references where the same has been successfully implemented.

The wind load as specified in clause 5.17.01.01 above shall be the minimum loading to be considered for analysis and design. The bidder shall also carry out the entire analysis & design on the basis of BS 4485 (latest) for smooth shell surface or BTR (latest) in case of ribbed shell surface. The design of entire tower including foundation shall be checked as per BS 4485/BTR as the case may be.

The final design shall be based on the worst case situation i.e. each element including foundation of the tower shall be designed on the basis of highest loading/ stresses computed as per above. However, the basis of wind speed shall be as per clause given Cl. 5.17.01.01 above. The loading/stresses obtained by model studies shall govern in case they show high values than the theoretical design values obtained as above.

C. Earthquake Forces

Earthquake forces shall be as per the site specific seismic study result enclosed as Annexure-E of this sub-section. The seismic analysis shall be carried out in accordance with IS: 1893 by modal analysis for the hyperbolic cooling towers or any other method as approved by the owner. The earthquake analysis of the shell and its support columns including the foundations shall be carried out by response spectrum method. For the fill supporting structures (RCC frames) response spectrum method is permitted. The modulus of elasticity for concrete shall be obtained from IS:456. All the analysis shall be carried out as per the theory of elasticity.

Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant references where the same has been successfully implemented.

D. Loads due to temperature effects

Stresses due to temperature effects:

The cooling tower shell shall be designed for stress due to axi-symmetric temperature distribution corresponding to external ambient temperature variation from 3 °C to 50 °C. However, the detailed analysis of actual thermal gradient by considering temperatures inside the tower and external ambient temperatures shall be carried out furnishing detailed references and justification for the same.

The shell shall also be checked for thermal stresses arising due to partial operation of the tower in case the operational philosophy so demands. The analysis for the stresses resulting from non-axisymmetric temperature loading shall be carried out. In such non-symmetric temperature loading, the calculation shall be based upon the operating specification. Besides, the shell shall be designed for one sided solar radiation effect also. Nevertheless an effective temperature difference of at least 25°C across the shell thickness constant over the height and following a sine functions along half the circumference shall be considered.

Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant references where the same has been successfully implemented.

E. Constructional Loadings

The method of construction and the type of formwork to be used shall be decided by the bidder in advance and should be enclosed in the bids submitted. Construction loadings that may occur during execution of work shall be considered in the design of the cooling tower structure. Factors causing temporary loading may include the following depending upon the method of construction.

i. Barrowing of concrete

ii. Scaffolding and formwork

iii. Loads produced by anchoring devices of climbing scaffolds.

iv. Hoist fixings

v. Storage of materials on scaffolding

vi. Temporary access

vii. Tower Crane fixings

viii. Works temporarily omitted for access purposes.

Computations shall be provided to verify the stability of the shell at various levels of construction to ensure that a satisfactory margin of safety always exists during shell construction.

F. Any other load such as foundation settlement

All loads likely to act on cooling tower but not specified herein shall also be considered for the design of cooling tower structures.

In case different degrees of subsoil stiffness exist, effect of the same shall be taken into account. In such a case, for computing settlements, load distributing capacity of the shell may be considered. Differential settlement between adjacent sections of foundation shall be considered under most unfavorable load combination.

5.17.01.02 Load Combinations

Following minimum load combinations shall be considered for the design of cooling towers structures:

a) DL + WL + SL

b) DL + EL

c) DL + TL

d) DL + WL + TL + SL

e) DL + EL+ TL + SL

f) 1.0 DL + 1.5 WL

Where DL = Dead Load,

WL = Wind load,

SL = Settlement Load.

EL = Seismic Load,

TL = Thermal Load,

In addition to above, construction loads shall be duly accounted for. Under TL various types of thermal loads, as described above, shall be considered separately. Besides above load combination, other load combinations as per relevant IS codes shall also be followed.

5.17.01.02 Tower Design Consideration

5.17.01.02.01 General

a) The complete cooling tower, including the shell, columns, ring beam and foundation, shall be structurally analyzed using a proven finite element modeling technique or an approved alternative method including validation of software used for analysis. For elastic analysis, concrete may be assumed to be uncracked, homogenous and isotropic. The design geometric profile, thickness variation and support conditions of shell shall be considered in the structural analysis.

b) Regardless of analysis method adopted, the equilibrium checks of internal forces and external loads should be performed.

c) Analysis based on a recognized bending theory of the elastic shells shall be adopted for the design of the tower and supporting structures.

d) Geometric imperfections, if exceed the permissible limit, then the analysis of shell shall take into account of such imperfections and resubmitted for owner's approval.

e) Boundary conditions shall be realistic and based on actual configuration.

f) The magnitude of the calculated displacements should be within limits of the applied theory.

g) A detailed dynamic analysis shall be carried out for the complete tower for seismic forces by response spectrum method.

h) Cooling tower shall also be designed for cross wind oscillations (Wind induced vibration) if the fundamental natural frequency of the tower is less than or equal to 1 Hz. Frequency calculation for free vibration analysis shall also be furnished by bidder during detailed engineering.

5.17.01.02.02 Size and Shape

The base diameter, air intake opening height, tower height and throat diameter shall be determined by thermal design consideration by the bidder and submitted to Owner for approval.

As the range of possible hyperbolic shell shapes is infinite, the same shall generally conform to the following major proportions which have been extensively adopted in cooling tower constructions.

H/D=1.2 to 1.55

Where H is the total tower height above basin sill level

Hb/H = 0.75 to 0.85

Hb is the vertical distance from the throat to basin sill level and `D' is the base diameter at basin sill level. However, other proven profiles may be permitted subject to approval from the owner. Bidders shall submit along with the offer complete details of the profile, in case the profile is not within the limits stated above, and the names of the sites where such shell profiles have been successfully constructed. Notwithstanding what is stated above, the owner reserves the right to accept /reject the shell profile.

5.17.01.02.03 Tower Shell Boundary conditions

A. Shell Analysis and Design

The following boundary conditions shall be assumed for the design of cooling tower shell:

a. At upper Edge

The top edge of the shell shall be gradually thickened to form a ring beam to guard against possible instability of the top of the shell due to high velocity wind gusts. Top edge shall be considered as a free edge in the analysis.

The thickness transition from shell to upper ring beam shall be smooth.

b. At Lower Edge

The lower edge of the shell shall be thickened to form a lower ring beam. The thickness transition from shell to lower ring beam shall be smooth and shall be considered as an integral part of the shell. The lower boundary of the shell shall be considered as elastically supported by discrete columns.

The influence of both support structure flexibility and foundation settlement shall be considered in the analysis and design of cooling tower shell. The shell analysis should include following information at every 10^{o} plan angle and at not more than 0.05 of the shell height interval:

i. Meridional and circumferential direct stress resultants and the tangential shear stress resultants.

ii. Meridional and circumferential bending moments.

iii. Displacements normal to the shell mid-surface.

B. Buckling of Tower shells

Critical dynamic pressure (wind pressure) at buckling shall be calculated as per the provision of IS 11504(latest)

The shell buckling shall be checked using the design dynamic wind pressure and other relevant loads acting on the tower. The factor of safety against buckling shall be not less than 5 for the completed tower as well as whilst under construction.

Besides above, a buckling analysis with wind forces should be made using the theoretical tower geometry and boundary conditions, including the influence of dead weight, by the method of buckling stress state (BSS) approach in accordance with the provisions of VGB.

The buckling safety factor shall be at least 5.0 for load combinations of dead load + wind load.

When imperfections in the shell geometry are larger than specified tolerances, the analysis should be rechecked to account for such imperfections and ensure that the desired buckling capacity remains.

C. Openings in shells:

Opening through the shells should be avoided as far as possible. They should be of smallest required dimensions and shall be shaped such that stress concentration is minimized at the boundary of the opening. Should thickening of the edges be necessary, it shall be smoothly tempered back to the shell thickness.

Openings shall be provided with additional edge reinforcement of a minimum cross sectional area at each edge equal to 75% of the reinforcement intercepted by the openings in the direction parallel to the edges. In addition, diagonal reinforcement shall be provided at each comer as close as possible. The total cross-sectional area in cm^2 of this reinforcement shall be 0.5 d, at each comer where 'd' is the shell thickness in cm.

No horizontal thrust due to the inlet piping shall be transmitted to the shell.

D. Minimum Thickness of Shell (for smooth shell towers without Meridional ribs):

The minimum thickness of the NDCT shell shall not be less than **350 mm**.

E. Minimum Reinforcement in Shell, Spacing and Placement:

The Minimum reinforcement to be provided shall be as follows:

Top one third portion of shell	0.4% of concrete cross - sectional area along circumferential direction and 0.35 % of concrete cross sectional area along meridional direction.
Remaining two-third portion	0.35% of concrete cross-sectional area in both of shell meridional and circumferential directions.

Minimum bar diameter shall be 8 mm in transverse direction and 10 mm in meridional direction.

Spacing of reinforcing bars should not exceed 200 mm in circumferential direction and 250 mm in meridional direction.

The two layers of reinforcing meshes shall be adequately joined by s-hook over the total shell surface. Atleast two S-hooks in each square metre area of shell surface shall be provided. The hooks shall be of minimum 6 mm diameter bars.

The clear concrete cover to all reinforcement including links shall be 45 mm minimum which shall be ensured by suitable means and frequent quality checks. No leftovers in form of wooden pieces, plastics or any other foreign objects shall be left in concrete. All leftovers holes of scaffoldings/ shuttering or other wise shall be suitably plugged with rich cement-sand pressure grout (minimum one grade higher than concrete) and coated with epoxy paint on either surface. No binding wires wooden pieces, shuttering pieces, cement bags should be left in the concrete.

The relevant provisions of IS:2210 - "Criteria for the design of reinforced concrete shell structures and folded plates" and IS:2204 "Code of practice for construction of reinforced concrete shell roof shall also be deemed to be applicable. All other design criteria for the cooling tower shell which are not specified above shall be in accordance with BS:4485 Part 4 and BTR.

F. Provision of meridional ribs in Cooling Tower Shell

Meridional ribs in the cooling tower shell may be provided subject to the following conditions :

a) Minimum thickness of shell excluding ribs shall not be less than **350 mm**.

b) Co-efficients for pressure distribution around the cooling tower circumference including suction may be taken as per VGB-BTR KUCHLTURMEN GERMAN SPECIFICATIONS (latest) : All other factors including load intensification factors shall be as specified else where in these specifications.

c) Shell buckling and strength shall be checked as per clause-b above without considering the effect of ribs.

d) All other stipulations as specified in these specification shall be met with.

e) Bidder shall furnish an authorized English translation of the VGB-BTR KUHLTURME GERMAN SPECIFICATIONS (Latest).

5.17.01.02.04 Raker Columns

Inclination of the column shall closely match the meridional slope at the shell so that the load transfer to foundation takes place through predominantly axial force in columns. Raker columns shall be designed for the most critical forces transferred to an individual raker column from super-structure considering various load combination as under **Load Combinations**. For selecting effective length of the raker columns, following restraints shall be considered:

a) In case columns restrained at both the ends, the effective length shall be 0.8 and 0.6 times the length of the column radially and tangentially respectively.

b) In case columns are restrained at one end only, the effective length of columns shall be 0.9 and 0.7 time the length of columns radially and tangentially respectively.

c) The columns shall be designed based on working stress method except for the forces from DL+1.5 WL which shall be designed as per limit state of strength method of IS:456.

5.17.02 **Pre-stressed Concrete Members**

Design, construction and workmanship of Pre-stressed concrete, members shall be in accordance with IS:1343. Steel wire for pre-stressing shall conform to IS:1785 (Part I) or IS:6003.

Particular attention shall be paid to achieve an effective bond of the wires in pre-tensioned concrete units. For this purpose, indented wire shall be used. Wires shall be corrosion resistant for specified duty conditions.

5.17.03 **(I)Design Criteria for Structures (Other than Tower Shell foundation)**

Corresponding to load combination (a) to (e) of **Load Combinations** above,

a) The design of all liquid retaining/conveying structures of cooling tower like C.W. basin, sump, outlet channel, sludge drain, pits and pedestals for raker column shall be designed as per IS 3370 (Part 2) with limiting crack width to 0.1mm. These structures shall be designed for following conditions :-

1. Water filled inside upto the designed level and no earth outside.

2. Earth pressure plus 2.5 T / M^2 surcharge (Vertical and equivalent horizontal direction) plus ground water table at Finished Graded ground Level (FGL) outside and no water inside.

3. Hot water distribution channel/basin shall be designed as per IS 3370 (Part 2) with limiting crack width to 0.1mm, considering loads such as dead load, live loads, seismic/wind load, temperature loads, water load etc. for full and empty condition.

4. The pedestals for raker columns shall also be designed for the load transferred by raker columns in addition to the above conditions.

b) The design of all structures other than liquid retaining/conveying structures of cooling tower above Cold Water basin slab such as Raker Columns, Shell structure, fill/drift eliminator support columns, beams, walkways, slabs, partition wall, precast beams etc. shall designed as per IS: 3370 (Part 2) with limiting crack width to 0.2mm. Further, for limiting the crack width, the stress for the reinforcement steel shall be limited to 130 MPa (on all faces) as per clause 4.4.3.1 of IS: 3370 (Part 2) using the partial safety factor for serviceability condition as per clause 4.4.1.3.

c) Wherever, the foundation raft of fill/drift eliminator support structure of cooling tower is same as Cold Water basin slab, the foundation shall be designed as per IS 3370 (all faces) with limiting crack width to 0.1mm. However, if the fill/drift eliminator support structure foundation is not the same as the Cold Water basin slab and a separate foundation for the cooling tower is provided below the Cold Water basin slab due to founding level requirements, the Cold Water basin slab (both faces, including beams at Cold Water basin slab level) shall be designed as structural slab as per IS 3370 (all faces) with limiting crack width to 0.1mm and the structures below Cold Water basin slab shall be designed as per IS:456. However, the size of the fill/drift eliminator support column below Cold Water basin slab upto foundation shall be maintained same as the size of the columns just above Cold Water

basin slab. Under the action of horizontal forces transferred at foundation/ pile levels, the passive earth pressure generated from soil surrounding the piles/ foundation shall not be accounted for in arriving the numbers of piles for the tower shell.

d) The design of staircase, pipe trestle foundation, and peripheral water drain shall be designed as per IS: 456 (2000).

e) For uplift due to ground water table the Cold Water basin shall be checked against uplift for basin empty condition with ground water table at FGL. Stability against uplift shall be ensured both for construction & operating stage with no water inside. The provision of flap valve / pressure release valves is not permitted. The factor of safety against uplift shall be as per IS: 3370.

f) Loads during construction, erection and maintenance stage shall also be considered.

g) Temperature fluctuations from operation shall be obtained from the design data. Hot water temperature inside and cold air temperature outside shall be considered.

h) Minimum thickness of basin slab shall be 300 mm with minimum reinforcement 0.35 % of gross sectional area in both the directions. Reinforcement shall be placed in two layers, top and bottom surface.

i) In the space underneath the basin floor slab a layer of at least 100 mm thick P.C.C. of grade M10 shall be provided.

j) Permissible stress for steel structures shall be as per IS:800.

For Load combination (F) 1.0 DL + 1.5 WL of **Load Combinations** above, design of elements shall be carried out as per IS: 3370 (Part 2).

5.17.04 **(II) Design Criteria for Tower Shell foundation.**

a) The design of the tower shell foundation below the pedestals for raker column shall be designed for worst load combination as per **Load Combinations** of this specification by IS:456. In case of load combination (F) DL + 1.5WL of **Load Combinations**, limit state method of design as per IS 456 shall be adopted.

b) Foundation shall be checked for safety against overturning, sliding and uplift for all load combinations specified at **Load Combinations**. While checking stability of the structure, favorably acting loads from water fill, soil cover beyond the edge of the foundation shall be neglected. High ground water level upto final graded ground level shall be considered to take into account buoyancy effect.

c) Generally net tension should be avoided in the foundations/piles for the shell support foundation unless specifically permitted by the Owner. For bored cast insitu piles, Raker piles are not allowed.

d) While accounting for over burden of the soil for checking the foundation against up-lift, dead weight of the soil directly above the pile cap or ring raft, as the case may be, shall only be considered, neglecting the weight of soil in the cone of up-lift above the foundation. Under the action of horizontal forces transferred at foundation/ pile levels, the passive earth pressure generated from soil surrounding the piles/ foundation shall not be accounted for in arriving the numbers of piles for the tower shell.

e) The foundation structure will be subjected to following loading and extreme load combination case shall be considered in design:

1. Most critical forces transferred from superstructure for the various load combinations.
2. Loading due to foundation settlement
3. Concentrated local loading from column nodes.
4. Thermally induced local loading where hot water ducts pass through the foundation structure without structural isolation.
5. Surcharge of 2.5 tonnes/sq. m.

C.W. basin surcharge load shall also be considered in addition to the other relevant loads for the design.

In the design of the cooling tower shell, column, pile caps, pedestals, ring beams etc. no increase in the strength with the age of the concrete shall be permitted.

5.17.01.02.07 **Water Distribution System**

The structural design of the water distribution system shall consider the worst combination of following loadings:

i. Self-weight, other imposed loads and live load.
ii. Hydraulic pressures during normal operations including pressure surges.
iii. Hydraulic pressure due to mal operation of the tower or supply pumps.

The water distribution system shall be provided with adequate pressure surge relief facilities to prevent pressure loading in excess of values used in the design. If such facilities are not provided, a further increase in loading shall be considered in the design.

The design of water distribution system and its supports shall be capable of accommodating all thermal stresses and movements due to changes in inlet water temperature and ambient temperature.

The possibility of vibrations being imposed on the distribution system shall be investigated in the design. Seismic loading on the water distribution system shall also be taken into account.

Strength check for worst loading including malfunctioning shall be carried out with stress limitations as per IS:3370. The construction shall be completely water tight without the used of fillets, sealing compounds etc. The method of construction shall be such so as to avoid excessive rise in temperature of concrete due to release of heat of hydration.

5.17.01.02.08 **Platforms, Walkways, Stairways, Staircases, Internal Grillage Etc.**

A minimum live load of 400 kg/sq.m shall be considered for the design of all platforms, Walkways, Staircases, etc. in addition to their own weight. Platforms shall be minimum 1.2 M wide and walkways shall have 1.5 M wide.

5.17.01.02.09 **Steel Structures**

These structures shall be designed, fabricated and erected as per IS:800 and other relevant Indian Standard codes for structural steel work. All steel structures shall be coated with anti-corrosive system.

5.17.01.02.10 **STOPLOG GATES AND TRASH RACK FOR COOLING TOWER**

STOPLOG GATES

The stoplog gate shall cover the clear opening of the cold water channel and effectively stop the water leakage. Clear size of the stoplog gates shall be equal to the clear opening size (freeboard of minimum 300mm over the maximum water level in stop log depth shall be ensured.). The capacity of the hoist (Min 2 ton capacity) shall be decided to match with provided size units of the stoplog gate. Structural design of stoplog gate shall conform to IS : 5620 and IS : 4622 (latest). Maximum water level for designing the stoplog gates shall be taken as maximum water level in the CT basin.

Stoplog gate and its lifting arrangement shall designed for a condition when basin is empty and water upto full level on the other side. Proper rubbers seal shall be provided in the stoplog to avoid any leakage of water. All gates shall be painted with sealed spray zinc coating conforming to BS:5493 (Table – 3, Part-8) for very long (20 or more) years of maintenance interval.

The design criteria and material specification for Stoplog gates and Trash racks shall be as specified for **Circulating Water Pump House**.

Leakage Tests of Stoplog Gates

Leakage tests shall be carried out with the stoplog gates lowered onto the sill. Before observation for leakage, the stoplog gate shall be raised and lowered about one meter several times in order to dislodge any debris that might have lodged in the side and bottom seals, The leakage shall then be measured and it should not be more than 5 Liters / Minute / Meter length of seal under maximum head.

5.17.01.02.11 **DELETED**

5.17.01.02.12 **FILL SUPPORT STRUCTURES**

The self weight of the fill pack support structure shall be based on the weight of the packing including weight of standing, running and dripping water in accordance with manufacturer's data.

Live load of 400 kg/sq.m on the walkways and platforms shall be considered. Hand railings shall be designed for horizontal load of 60 kg/m.

Wind deflector walls and any other structural elements shall be designed for a horizontal wind load of 80 kg/sqm. or as per manufacturer's recommendations, whichever is higher. Thermal loading shall be as per manufacturer's recommendations. Earth quake loading shall be considered based on criteria given for cooling tower. Response spectrum analysis shall be carried out.

The foundation shall be designed for the most critical forces transferred from CW basin & fill supporting structure including loadings introduced by constructional equipments and crane deployed for fill supporting structure or shell erection.

5.17.02.00 REQUIREMENTS FOR CONSTRUCTION MATERIAL

All concrete work for the cooling tower shall comply with the requirements given in technical specification for Cement Concrete (Plain & reinforced)

Structural concrete shall be of design mix complying with the relevant provisions of IS Codes or any International Code of Practice as approved by the owner.

Durability of the concrete shall confirm to severe exposure category as per table 3 of IS:456 except noted specifically otherwise. Minimum cement content of all RCC structures shall be 360 kg/Cu. M.

Column reinforcing bars shall be carefully anchored in the shell and foundation. The anchoring length shall not be less than 80 times the diameter of the bars.

All foundations structures shall be provided on all sides with a minimum reinforcement of 0.12 % of gross cross-sectional area distributed over top and bottom faces.

5.17.02.01 in The minimum grade of concrete for structural component s of cooling towers shall be as follows accordance with IS:456 :

a.	Entire tower shell, columns and ring Beams, Precast pre- stressed elements	:	M-35
b.	Basin, Basin wall, fill supporting structure, Tower foundation and all other RCC member	:	M-30
c.	PCC encasement	:	M-20
d.	Mud Mat PCC	:	M-10
e.	Piles	:	M-25

5.17.02.02 Coarse and fine aggregates shall be specially selected to ensure that they are not susceptible to alkali/chloride attack or prone to disintegration at high temperatures. The maximum size of coarse aggregate shall not be larger than 1/8th narrowest dimension between reinforcement bars nor more than 20 mm.

5.17.02.03 Washing and screening of coarse and fine aggregates to remove fines, dirt or other deleterious materials shall be carried out by approved means if desired by the Engineer-in-Charge.

5.17.02.04 The water cement ratio by weight shall be as given in IS:456 for severe exposure conditions including free moisture in the aggregates, and slump should be suitably decided to provide good quality concrete work.

5.17.02.04 REQUIREMENTS FOR STAGING AND FORMS

5.17.03.01 Automatic Climbform scaffolding system or Jumpforms shall be used for tower shell construction. Slipform with proven record for similar towers may used subject to specific approval of Owner. The design and detailed construction of the form work and the scaffolding system shall be based on the relevant IS code/International Code. In absence of the same, DIN 4420/ACT 347 shall be followed. Realistic loads shall be considered for platforms with regard to the classification of scaffolding system used. For material transport, it shall be designed by accounting for all transportation loads.

The connection between individual scaffolding units shall be made in such a way that in case of collapse of one unit, the adjoining units are not affected.

Scaffolding system should have atleast two independent safety measures against collapse.

Concrete shall have sufficient strength to withstand the anchoring loads of scaffolding system. The concrete strength shall be continuously checked and documented during the climbing process of the scaffolding.

5.17.03.02 Bidder shall prepare at his own cost, detailed scheme, design calculations. detailed working drawings showing all details of form work, staging, scaffolding, member section, connection details and other arrangements for the concreting work and submit the same for approval within one (1) month from the award. Only on receipt of the approval by the Engineer the work shall be taken up. However approval of the same by Engineer in no way relieves the Bidder of his responsibility for the proper functioning and safe working of the scaffolding system.

5.17.03.03 Hoisting for Personnel

The arrangement and method of raising and lowering of personnel, concrete, reinforcement and other materials to various levels for the cooling tower shell shall also be detailed by contractor. Details of equipment and procedure shall be submitted for information to the Engineer by the Bidder.

5.17.03.04.01 For shuttering, following provisions shall be complied with:

a) Self-weight of (scaffold + platforms) + minimum superimposed load of 370 kg/m^2 on total working platform areas at various levels.

b) Self-weight of (scaffold + platforms) + minimum superimposed load of 50% of 370 kg/m^2 on total working platform area at various levels + earthquake loads.

c) Self-weight of (scaffold + platforms) + superimposed load of 370 kg/m^2 on total working platform areas at various levels + wind load.

For load combination (a) above, no increase in the permissible stresses shall be allowed. For load combinations (b) and (c) above increase of 33.3% in permissible stresses shall be permitted.

5.17.03.04.02 Design and execution of form work, stagings, shutterings and scaffolding shall conform to National Safety Council and all relevant IS Code provisions, i.e. IS 2750, IS:4014, IS:4923, IS:800 etc. In case the IS Codes do not cover the specific type of shuttering system, then any International Code of Practice, as approved by the Engineer, may be followed.

5.17.03.04.03 Notwithstanding the stipulations contained in various codes, safe slenderness ratio shall be determined as follows:

a) Vertical members: Effective length shall be taken equal to the maximum distance between consecutive horizontal runners in any plane.

b) Horizontal and diagonal member: Effective length shall be taken equal to center-to-center distance between two nodes

5.17.03.04.04 If the support from shell for scaffolds are to be taken, following provisions shall be adhered to:

a) Members connecting/joining scaffolds with shell shall act as propping supports. Use of pre-tensioned or pre-compressed members for propping action shall not be permitted under any circumstances. Connection of propping members with shell shall be designed to comply with the above stated requirements.

b) All prop supports shall be taken at nodal points of scaffolds only.

5.17.03.04.05	Splicing joints in vertical pipes shall be such that the joints shall be rigid and the entire cross section area of the pipe takes part in load transference.
5.17.03.04.06	Special inspection hoist shall be provided by the Contractor for regular inspection. The hoist should be so placed that the inspection, checking of scaffolding members, joints etc. are easily carried out. Regular check at every fortnight of the joints and other elements of scaffolds shall be carried out by the Contractor along with representatives of the Engineer. Detailed inspection record shall be maintained by the Contractor and same shall be produced to the Engineer wherever required.
5.17.03.04.07	For design of structural members, IS:800 shall be complied with.
5.17.03.04.08	Notwithstanding the approval from Engineer, the Contractor and his collaborator will be solely responsible for the safety, security, functioning proper functioning and the speed of the construction work.
5.17.03.04.09	The formwork for shell shall be capable of adjusting to shell profile and thickness accurately, and shall be rigidly braced to prevent deflection or movement during concreting.
5.17.03.04.10	Forms shall be designed to produce hardened concrete having the shape, lines and dimensions indicated on the drawings. Forms shall be constructed and maintained in proper position and accurate alignment. Accurate alignment shall include maintaining hyperbolic shape, round cross section, and plumbness of concrete shell.
5.17.03.04.11	Forms shall maintain vertical alignment of form seam marks. Forms for the exterior of the shell shall produce surfaces having a smooth uniform appearance.
5.17.03.04.12	Forms shall be specially designed and installed so as to prevent leakage of mortar, produce a smooth exterior surface, and permit removal without injury to the adjoining work.
5.17.03.04.13	The insides of the forms shall be coated with an approved non-staining parting agent that will not impair the blend coatings. The Contractor shall ensure that the parting agent is not applied to the reinforcement.
5.17.03.04.14	Forms shall not be removed until the concrete has adequately hardened and attained sufficient strength to maintain its shape with no spalling and to support safely its own weight together with any construction loads likely to be imposed.
5.17.03.04.15	All details of formwork staging, placing, tying etc.; shall be subject to the approval of the Engineer and the Contractor shall submit drawings, when required, showing details of procedure of construction. Contractor shall be responsible for the adequacy of the form work to withstand the pressure of freshly placed concrete or other loads imposed without, movement or deflection of the parts.
5.17.03.04.16	For concrete surfaces that are exposed to view and for all other concrete surfaces that are to be finished smooth, the lining of forms shall be of smooth non-absorbent lining material. All

	edges of panels shall be square and straight in both directions and all panels shall match perfectly in length, width and alignment as required.
5.17.03.04.17	Minimum time of form work shall be approved by the Engineer for RCC shell depending upon weather conditions, quality of cement, etc.
5.17.03.04.18	Outer ends of the permanently embedded portions of form ties shall be at least 25 mm recessed from the adjacent outer concrete faces.
5.17.03.04.19	All MS embedments in concrete shall have anti-corrosive treatment as per Tech. Spec.
5.17.03.04.20	All temporary construction facilities such as office, warehouse tool room storage shed, casting yard etc. required by the Contractor shall be constructed by the contractor within the area allocated by Engineer at no extra cost to the Owner.
5.17.04	**Setting out of the shell** Survey of absolute position of the shell shall be carried out using the following method: The shell shutters of known radius shall be accurately located through the peg at the base of the tower using a special optical plumb. The optical plumb shall be installed permanently inside of the tower by the bidder. The plumbing of the ring shall be checked at least once per day and shall not be left in the same position for more than four consecutive lifts. The tape used shall be fitted with a spring balance and constant pull of not less than 10 kg shall be applied while reading the tape. No taping shall be undertaken during high wind conditions.
5.17.04.01	Deployment of vertical laser-ray equipment for measuring the dimensions and controlling the shape of the tower at all elevations and plan angles shall be carried out. Measurements shall be taken by vertical laser-ray technique at different points along the circumference of the tower (number of such points shall be approved by the Engineer depending upon the formwork system used) for each lift before placing the concrete and again after concreting. Wherever required adjustments shall be made through spindling of the formwork. The intermediate points between two laser measuring points shall be chord measured i.e. the gauges are measured off a chord taut string. The measurements shall be taken of the inner form work. The outer formwork shall be aligned accordingly. All measuring points on the shell and the chord gauges shall be predetermined by the contractor and got approved by the Engineer. Depending on the number of laser measuring points, a corresponding number of radial lines on the concrete floor shall be provided and reference points shall be marked for the purpose of placing the laser device. The perpendicular shall be checked once in a week or earlier, as required by the Engineer, from outside points.
5.17.04.02	Tolerances for the cooling tower construction shall be in accordance with the following:

	i. Shell wall center line in horizontal plane measured radially at mid point on a 3m wide chord	+/- 15 mm
	ii. Shell wall centre line in meridional plane measured over a height of 1m	+/- 10 mm
	iii. Shell thickness	+ 10 mm or- 5 mm
	iv. Horizontal radius of shell at any section other than shell base	+/- 50 mm
	v. Horizontal radius at shell base	+/- 40 mm

5.17.04.03 **Checking of shell geometry**

Check for absolute positions may be carried out from ground stations arranged at not more than 10 degree plan angle apart. Readings of horizontal radius shall be taken at every 6 m height or weekly during construction period whichever is more frequent.

If the permissible dimensional tolerance are exceeded, the Engineer will instruct the contractor, in writing, to stop construction of the shell. The Contractor shall then examine the situation and submit a report to the Engineer who may require the contractor to demonstrate by calculations that the structural integrity of the shell will not be impaired as a result of the imperfections. The calculations shall be submitted to the Engineer, for approval, before construction will be permitted to proceed.

If in the opinion, of the engineer the calculations show that the integrity of the shell could be threatened, the Contractor will be required to submit to the Engineer detailed arrangement and supporting calculations to set right the shell geometry for approval, before construction will be permitted to Proceed.

The cost of carrying out the calculation, any remedial work required and idle time or any delays to the construction program as a result of dimensional tolerances being exceeded will be borne by the contractor.

Adjustment to the tower shell line on the basis of the survey results shall be made gradually, limiting the maximum change of direction from the existing vertical shell profile to be not more than an angular change of 10 mm measured over 1 m of height. Any such adjustment shall be made with full knowledge and consent of the Engineer.

5.17.04.04 The Contractor shall carry out an as-built-survey of each lift of the shell. The results of these checks will be recorded on a suitably developed drawing of the shell from which it will be possible to locate the survey check point. A copy of these results will be presented to the Engineer prior to commencing the next shell pour.

5.17.04.05 The Contractor's shell construction procedures shall include for providing the Engineer with the facilities and a reasonable time period as may be required to carry out an independent check of the completed works.

5.17.04.06 Suitable communication system such as telephone, wireless equipments, etc. shall be provided by the contractor so that the communications are possible at different elevations of the tower from the ground during construction.

5.17.05 **GENERAL REQUIREMENTS**

i. In case the basin slab is divided, the same shall be divided into two equal parts by a partition wall designed to withstand full hydrostatic pressure, with one side empty. The basin construction joints shall be made watertight by injection of chemical grout through nipples. The basin construction shall be tested for water tightness, in accordance with IS:3370 (Part-1). The cost of the test and any rectification and re-test if required is deemed to be included in the Contractor's quoted price. Any cost of filling and emptying of the basin and to rectify defects shall also be borne by the Contractor.

ii. PVC ribbed water stops with central bulb shall be used where expansion joints are envisaged. The minimum thickness of PVC ribbed water stops with central bulb will be 10 mm and minimum width 230 mm.

iii. The basin floor of each compartment shall be provided with a slope of not less than 1 in 120 towards a peripheral drain of minimum width 500mm and minimum depth of 500mm at the starting point running along the periphery of the cold water basin. Further, this drain shall be sloped 1 in 500 towards collecting sump as indicated elsewhere in the specification. From sump, the water will be drained by. C.I. drain pipe, embedded below the basin floor, into a drain chamber outside the tower basin or as per the arrangements described elsewhere in the tender document. Suitable operating platform with access ladders for operating the gate valve(s) shall be provided in the drain chamber.

iv. A 250 mm high sill shall separate the pond floor from the tower outlet.

v. Uniform surface on the top of basin floor shall be provided. In case undulated surface is observed, a top of layer of minimum 25 mm thick 1:3 mix mortar to be provided to achieve uniform surface.

vi. The level of top of basin wall shall be kept at least 300 mm higher than the top surface of paving outside the cooling tower.

5.17.05.01 A screed or concrete layer not less than 100 m a thick of concrete grade M10 conforming to IS:456 shall be provided below the cold water basin and other liquid retaining structures.

Lean concrete below other foundations and underground structures, unless noted otherwise, shall be of concrete grade M10 (with aggregate of nominal size 40 mm maximum) and shall be at least 75 mm thick.

Internal Concrete Surface of NDCT Shell shall be applied with protective coating as mentioned below:

5.17.05.03

(i) Internal Concrete Surface of Shell for top 20M:

	2 coats of High Performance Moisture Compatible Corrosion Resistant Coating System to achieve total DFT of min. 300 micron as per Annexure-G followed by finish coat of two pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT. (ii) Internal Concrete Surface of Shell from 20M below top of NDCT to 2M above Drift Eliminator platform level: 2 coats of High Performance Moisture Compatible Corrosion Resistant Coating System shall be applied to achieve total DFT of min. 300 micron as per Annexure-G. (iii) Internal Concrete Surface of Shell from 2M above Drift Eliminator platform level to bottom ring beam, all round raker columns, bottom ring beams (all round), internal columns, beams & walkway/platforms, CW basin floor/slab & inner walls and any other RCC/PCC components in contact with water: 2mm thick high build 100% solid elastomeric polyurethane coating over suitable primer as per ANNEXURE- G
5.17.05.04	Exterior surfaces of cooling tower shell shall be coated with one coat of High Performance Moisture Compatible Corrosion Resistant Coating System of minimum 150 micron as per Annexure-G followed by finish coat of two pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT.
5.17.05.05	Water proofing and plasticizer admixtures conforming to relevant IS Codes may be added as per manufacturer's instruction to the concrete subject to approval of the Owner. Water proofing and plasticizer admixtures conforming to relevant IS Codes may be added as per manufacturer's instruction to the concrete subject to approval of the Owner.
5.17.05.06	All mild steel parts of structures including embedments shall be hot dip galvanized. The minimum coating shall be 610 gm/sq.m and shall comply with relevant IS Codes. Galvanizing shall be checked and tested in accordance with IS:2629. All welding shall be done before galvanizing. Any site joints required to be carried out after galvanizing shall be either flanged or screwed joints. Nails, nuts, bolts and all components coming in direct contact with water shall be of stainless steel of AISI 304 or equivalent.
5.17.05.02	i. The tower shall be provided with two numbers external FRP Staircase, leading to a heavy duty door giving access to the distribution system. Staircase shall be minimum 1000 mm wide (clear), with landings of minimum width of 1000 mm at not more than 2500 mm height intervals unless approved otherwise. The steps shall have a rise of about 175 mm and tread of about 250 mm. Anti - skid nosing at each step shall be provided. ii. Minimum size of all doors shall be 2100 mm high (clear) and 1200 mm wide (clear). The door shall be of FRP material. The door shall be air tight when closed.

iii. The hand railing on both sides of the staircase shall be FRP and shall have rails spaced not more than 1200mm centers. The top hand rail shall be at 1000 mm above the steps. Safety kerbs/toe plate with 100 mm (minimum) width shall be provided along each edge.

iv. In case the hot water pipes of cooling tower are extended upto inner surface of shell, they shall be supported over the RCC brackets which are cast integral with the shell. Alternatively, these brackets and its fixing bolting arrangement shall be of stainless steel SS316L grade to ensure trouble free operation.

5.17.05.03 Walkways and platforms, atleast two in each orthogonal direction, shall be provided inside the tower at distribution pipe level. walkways shall be at least 1000mm wide with 50 mm (minimum) safety kerbs along each edge. These walkways and platforms shall provide safe and clear access to all sprayers and all distribution pipes. A FRP platform of 1500 mm clear width shall be provided around the tower periphery which will be a means of access to next walkways and all end valves. Access ways shall be clear of all obstructions such as distribution pipe support beams, drift eliminator support beams, etc. The walkways shall be provided with transverse slots or other opening which will permit the free passage of air and water.

FRP handrails shall be provided on all sides of over ground platforms and around hot water basin and cold water outlet.

5.17.05.04 Platforms of size 1.5m x 1.5m clear dimensions shall be provided on the cooling tower for maintenance of aviation warning lights at levels specified elsewhere. At least two (2) diametrically opposite galvanized MS caged ladders, 600 mm wide, made out of 6 mm x 10 mm flats for full height of the tower shall be provided. Additional cage ladders for access to aviation obstruction lights at intermediate levels shall be provided at required locations upto the required height. Galvanization shall be provided for all MS components of ladder & caging as per specifications. All fastening bolts and anchor fasteners shall also be of galvanized finish. The ladder shall have 20 mm dia rungs at 300 mm centers, with stays at every 2250 mm, connected to the concrete shell and galvanized M.S. caging consisting of 50 mm x 70 mm vertical cage flats on the exterior surface of each cooling tower. The caged ladder shall be provided with intermediate landing of 1000 x 1200 mm wide at every 4500 mm height interval and further, the ladder shall be staggered at each such landing by a horizontal distance of 600 mm to avoid continuous climb. Some of the landing levels shall be suitably adjusted to give access to aviation warning beacons for maintenance. Handrails as described above, shall be provided on all platforms and landings. The ladder leading to the top platform shall have approach form the ground via the FRP staircase.

5.17.05.05 Steel gratings, where required, shall be fabricated out of steel flats with minimum thickness of 6 mm. Thickness of fabricated grating shall be 40 mm with flats so arranged as to have a maximum opening of 25 mm or less. Treads for staircases, where needed, shall be of similar grating construction but provided with toe flats of 6 mm thick, and non-skid nosing in an approved manner extending upto 100 mm above the walkway surface.

5.17.05.06 The finished ground level shall be paved for 10.0 Meter width all-round the outer edge of the cold water basin. The paving shall consist of 150 thick RCC slab of M-25 grade. The minimum reinforcement shall be 10 mm dia spaced 150 mm centre to centre both ways top and bottom. The RCC slab shall be laid over 75 mm thick PCC and 500mm well compacted layer of crushed hard stone aggregates (63mm to 45mm) with interstices filled with sand. A RCC peripheral drain on outer periphery of paving around cooling tower basin shall be provided to collect the water loss due to wind gust and shall be connected to nearest main plant drain.

5.17.05.07 Mild Steel Hot Dip Galvanized (610gm/sq-m) fixtures shall be erected on top ring beam of shell to facilitate future maintenance of interior and exterior of shell. The entire assembly shall be checked for a minimum vertical load of 1500kg. The minimum thickness of plates for fixtures shall be 16mm.

5.18.00 CW SYSTEM, RAW WATER SYSTEM CIVIL WORKS

5.18.01 Circulating Water Pump House (CWPH), Raw Water Pump House (RWPH).

5.18.01.01 A circulating water pump house (CWPH) for housing circulating water pumps shall be provided. Separate bays shall be provided for each pump by providing intermediate dividing piers of RCC between the pumps.

a) The pump houses shall be provided with minimum two sets of stop-logs for each opening sizes along with electrically operated hoisting arrangements. Steel embedment's required for stop-logs shall be provided for all the bays.

b) All bays of pump houses shall be provided with a removable trash rack including electrically operated hoisting arrangements and cleaning arrangements. Moreover, one spare trash rack for each opening sizes shall also be supplied. Steel embedments required for trash-racks shall be provided for all the bays.

c) Stop-logs, trash-racks and hoists shall be supplied in accordance with the specifications covered elsewhere.

d) The steel structure shall be provided to carry EOT crane of the pump houses. The over ground portion of CWPH & RWPH including maintenance bay shall be framed structure of structural steel work with permanently colour coated metal sheeting at roof and side open at bottom. However, 4m high steel sheet side cladding shall be provided at the top under the roof for protection against rain. At the operating floor level, brick cladding of 0.9m height above the finished floor level, plastered on both sides shall be provided.
The pump house including its forebay shall be of RCC with M-30 grade of concrete conforming to IS 456. The pump house shall be structurally separated from forebay by providing an expansion joint. The pump house shall be provided with separate maintenance bayCivil works associated with Stage-II Raw Water Pump House and connection with existing intake canal with required modification with all necessary enabling works, other arrangement & precautions as per requirement shall be provided.

5.18.01.02 Each pump house shall be provided with a separate maintenance bay for maintenance of various equipment. Length of maintenance bay shall be adequate for one pump maintenance. Hand-rail with 32 NB (medium) pipes shall be provided around the operating floor on the forebay side in the stoplog and trash rack area.

5.18.01.03 **Sump model study for CWPH**

Sump model study for circulating water pump house shall be carried out as specified elsewhere in the specification.

5.18.01.04 **Design requirement for CWPH & RWPH**

Design of substructure shall be divided into two parts, namely,

(a) Stability analysis, and

(b) Structural analysis and design.

For the design of substructure, a surcharge load of 2.0 T / Sq.m shall be assumed at the finished ground level for nearby vehicular movement.

(a) Stability Analysis

The Pump House sub structure shall be analyzed and designed for following load combinations: -

1. **Under Operation Stages**

   Maximum load from super structure + equipment load + load from sub structure + no water in the pump chambers + earth pressure at rest from outside with surcharge and maximum ground water pressure.

2. **Condition (1) + earthquake/ wind**

3. **Under Construction Stages**

   No load from super structure and deck slab, load from sub structure with no water in the pump chambers, pump units not installed, earth pressure at rest from sides with surcharge and maximum ground water pressure.

4. **Condition (3) + earthquake**

Following stability checks will be made for the above load combinations:

i) Check for overturning

Factor of safety against overturning, i.e, the ratio of stabilizing moment to overturning moment shall be as per IS: 456.

For the above condition, uplift due to maximum Ground water table (GWT) acting on the base slab and side pressures on the walls due to earth and ground water shall be considered as destabilizing forces. In order to have no tension condition at tip of the base slab, resultant of all the forces acting on the pump house under different conditions of loading as listed above shall fall within middle one third of the base width provided. Maximum compressive stress at other end of the base slab shall be within the safe bearing capacity of soil / rock.

Under earthquake condition, resultant of all the forces including earthquake force shall fall within middle three fourth of the base width provided. An increase of 25% shall be allowed in the safe bearing capacity of soil when earthquake forces are considered.

ii) Check for Sliding

Factor of safety against sliding under static condition, i.e. ratio of horizontal frictional resistance to horizontal sliding force shall be as per IS:456. For this condition, earth pressure at rest and the maximum GWT pressure from sides shall be taken as de - stabilizing forces. Keys shall be provided, if found necessary, to increase the factor of safety against sliding.

To ensure an adequate factor of safety under earthquake condition, the factor of safety against sliding shall not be less than 1.2.

iii) Check for Uplift

Right from construction to operating stage, minimum factor of safety against uplift due to ground water shall be 1.2. Installation of pressure release valves shall not be permitted in the base slab (raft) of the pump houses to counter the uplift due to ground water.

(b) Structural Analysis

1) Base Slab

Base slab of the pump houses shall be designed as a raft foundation supported at locations of piers. Following load cases shall be considered:

i. Maximum water level in the sumps with maximum GWT.

ii. No water in the sumps and maximum GWT.

iii. Alternate bays of sumps filled with water with maximum GWT.

iv. Same as in (iii) above but with minimum water level.

2) Intermediate Piers

Intermediate piers shall be designed by working stress method as per IS: 456, with limiting crack width of 0.2mm for the worst combination of maximum water pressure on one side and no water in the adjacent sump. These shall be designed as RC walls fixed at base and supported (hinged) at top by the deck slab. Since a breast wall may be provided for stop logs and back wall is provided connecting all the piers at the rear end, additional restraints for the pier due to breast walls and back wall may also be accounted for.

Intermediate piers are also to be checked for the combined action of direct load due to superstructure and bending due to water pressure from one side.

3) End Piers

Design of end piers will be similar to the intermediate piers. The end piers shall be designed for the following conditions:

I. Soil pressure + maximum GWT + surcharge of 2 Ton / Sq.m. at FGL from outside or design surcharge load at floor level with no water in the sumps.

II. Only maximum water level in the sump.

End piers shall be designed by working stress method as per IS: 456, with limited crack width of 0.2mm on water face and the outside, i.e., earth side shall be designed as cracked section as per IS : 456. Since end piers are fixed at base and supported (hinged) at top by deck slab, there will be negligible yielding of the wall at top. This will give rise to earth pressure at rest and therefore an earth pressure at rest, Ko = (1 - Sin f) is considered where f =angle of internal friction of soil.

End piers shall also be checked for the combined action of direct load due to super structure and bending due to earth pressure with surcharge and ground water pressure.

4) Back Wall

Back walls shall be designed as fixed at bottom of the base slab and on two vertical sides by the piers and supported at top by the deck slab. Since back walls are also of the unyielding type, earth pressure at rest, Ko, shall be considered for design.

Back walls shall be designed by working stress method as per IS: 456, with crack width limited to 0.2 mm on water face and as cracked section on outer face as cracked section as per IS : 456.

Following load combinations shall be considered:

i. Soil pressure + maximum GWT + surcharge of 2 T / sq.m. at FGL from outside with no water inside the sump.

ii. Only maximum water level inside the sump.

5) Operating Floor Slab

Operating floor slab or deck slab shall be designed for loads of the pumps and other equipment, which may be placed on it. A live load of 1.5 ton / Sq.m. shall be considered on the deck slab. The deck / slab shall have monolithic construction with the piers and shall be designed as a continuous RC slab supported on piers. Design of bottom face shall be by working stress method as per IS: 456, with crack width limited to be 0.2 mm. Floor slab of maintenance bay may be designed as slabs on grade. A live load of 3 T / Sq. m. may be considered for the maintenance bay floor slab. Dynamic analysis shall be carried out to ensure proper separation of natural frequency of the structure and pump operating frequency

5.18.01.05 **C.W. Ducts**

CW ducts shall be concrete encased steel lined ducts. The concrete encasement shall be of minimum 500mm thick with square shape outside. Generally, M20 grade PCC encasement shall be provided. At locations of duct crossing road, rail in transformer yard or any other facility, RCC encasement of grade M25 shall be provided. Minimum two layers of reinforcement (On both faces) of 12 mm diameter bars @ 200 mm c/c shall be provided for RCC encasement of CW Duct. Top of CW duct encasement shall be minimum 1.5 m below finished ground level.

The minimum thickness of steel pipes shall be as follows including corrosion tolerance of 2 mm:

a.	For pipes above 1800 mm upto and including 2300 mm dia.	-	12 mm
b.	For pipes above 2300 mm upto and including 3200 mm dia.	-	14 mm
c.	For pipes above 3200 mm upto and including 3750 mm dia.	-	16 mm
d.	For pipes above 3750 mm upto and including 4000 mm dia.	-	20 mm

However, for ducts running below rail line in transformer yard/road, minimum thickness of CW liner shall be 20 mm.

Suitable tap-offs shall be provided in the duct to connect CW blow down, ACW tapping etc. Based on the transient analysis, sufficient number of stub connection shall be provided in the duct to fix air release valves.

All duct installation & jointing shall be strictly in accordance with the stipulation given elsewhere in the specification for structural steel work. All the joints of liners shall be butt welded joints. The circular deformation of liner shall be less than 1% of diameter of liner while handling, transportation, erection & construction. If required, temporary bracings may be provided, during handling, transportation & concreting to reduce the deformation.

The completed duct shall be tested for water tightness, for the pressure equal to twice the working pressure or 1.5 times the design pressure whichever is higher and shall be generally water tight to Engineer's satisfaction. The testing pressure shall be held for minimum period of 30 minutes without any signs of leakage or failure of weld. Any in flow / leakage of water from the duct shall be sealed / repaired at Contractor's cost. However, tests in part of length of duct may be permitted with prior approval only.

Wherever required anchor / thrust blocks shall be provided with RCC M25 grade concrete. Suitable RCC chambers shall be provided with precast covers to install flow measurement devices and valves in the duct.

Manholes of minimum 1000mm clear opening shall be provided in each CW duct at a spacing of 200M (approx.) to facilitate maintenance / dewatering of CW ducts. At least one manhole shall be provided at the deepest point for both intake & discharge duct.

Following shall be considered for design of C.W. ducts:

a. Maximum design water pressure

b. Surge or water hammer pressure of 5.0 Kg / Sq.cm.

c. Expected vacuum conditions as arrived from transient analysis

d. Soil overburden

e. Surcharge Pressure of 2T/Sq.m

f. The effect of concrete encasement shall not be considered in the design of CW duct

Painting as per Cl. 6.04.03 shall be carried out on machined faces, flanges and external exposed surfaces of CW ducts. For external surfaces of CW ducts encased in concrete, painting shall be as specified in Cl. 6.04.02(a).

5.18.01.06 **CW Channel, Connecting Channels to Side Stream Filtration (SSF) System & Raw water intake channel**

The channel shall be of RCC section with vertical wall projecting minimum 300mm above finished ground level. Hand rails with 32 NB (medium) pipe shall be provided on both walls of the channel where height of channel wall is less than 1200 mm above finished ground level.

The channel shall be designed to carry the required discharge with minimum water level in cooling tower basin and considering minimum value of rugosity coefficient (n) of 0.018 for concrete surface. However, the maximum velocity in channel shall be restricted to 1.8m/sec.

The channel shall be designed by working stress method with crack width limited to 0.2 mm on water face and as cracked section on outer face as per IS: 456 considering (i) no water inside the channel, with earth pressure of soil upto FGL, ground water table upto FGL and surcharge load of 2.0 ton / Sq.m from outside, and (ii) with water inside the channel upto maximum level in the forebay / channel and no earth pressure, ground water pressure and surcharge load from outside. Right from construction to operating stage, minimum factor of safety against uplift due to ground water shall be 1.2.The channel shall be checked against uplift due to 50% of the total water head considering ground water table upto FGL. In addition pressure relief valves with under drainage arrangement in the channel shall be provided to prevent uplift of the channel as per relevant IS Codes. Minimum wall thickness shall be 250 mm.

Forebay Structure

Forebay consists of retaining wall and forebay slab. The walls shall be analysed as a retaining wall for stability against overturning and sliding, similar to end piers of the pump house.

Pressure relief valves and under drainage arrangements shall be provided below the forebay slab to prevent uplift of the forebay slab. Size and spacing of pressure relief valves shall be designed by the Bidder to take care of the uplift due to ground water table. However, centre to centre spacing of PRV shall not exceed 5000mm.The forebay slab shall be minimum 250 mm thick. The forebay slab shall be structurally separated from the retaining walls and water stops

shall be provided at the junction of slab and retaining wall.

Minimum thickness of retaining wall at top shall be 250 mm. Hand rails with 32NB (medium) pipe shall be provided on both walls of the forebay.

5.18.01.07 **VOID**.

5.18.01.08 **Stop-logs and Trash Racks for CWPH, RWPH**

5.18.01.08.01 **Stop-log gates**

Clear size of the stop logs shall be equal to the clear opening size of water inlet opening below breast wall. Number of segments of the stop log shall be decided to match the capacity of the electrically operated monorail hoist provided to handle it. Structural design of stop log shall conform to IS: 5620 and IS: 4622. Maximum water level for designing the stop logs shall be taken as maximum water level of the forebay. Top and bottom unit of stop log gates shall be designed for their respective water head, whereas the remaining interchangeable units shall be designed for the water head corresponding to the lower most interchangeable unit. The stop logs shall be operated under balanced water head and they are not to be designed for operating under flowing water. Filling valves shall be provided in the stop logs to balance the water pressure before lifting the stop log. These stop logs are used only during maintenance / inspection of pumps. The stop logs shall be operated by means of an electrically operated hoist. Suitable lifting beam shall be provided to operate the stop logs.

5.18.01.08.02 **Trash Racks**

Bar screen trash rack is to be provided at inlet of the sump of the pump house in order to prevent ingress of timber & other floating particles which could damage the Pumps.

Each bay of pump sump shall be provided with Type - 1 trash rack (removable section rack), conforming to IS: 11388. Centre to centre spacing of trash rack bars shall be 100mm (max). The trash racks shall be provided with number of interchangeable segments, to facilitate easier handling by means of a lifting beam and electrically operated hoist. Trash rack bars shall be designed for a differential water head of 2.0m. and other structural members shall be designed for a differential water head of 1.0m. Minimum thickness of trash rack bars shall be 10mm. Suitable size of horizontal members and end members shall be provided as per design requirements, for efficient operation of trash rack.

All trash racks should be capable of being lowered in the associated stop log groove to enable drawal of clean water while a particular trash rack is raised for cleaning purpose.

Suitable arrangement for storing all the stop logs and stand by trash rack shall be provided by the Bidder, to keep them in good working condition.

5.18.01.08.03 **Lifting Beams**

Separate lifting beams (automatic) shall be designed & fabricated with guide shoes, hooks, links and counter weights etc. complete for automatic operation to engage and disengage the stop logs and trash racks in the required position.

5.18.01.08.04 **Leakage Tests of Stop logs**

Leakage tests shall be carried out with the stop logs lowered onto the sill. Before observation for leakage, the stop log shall be raised and lowered about one meter several times in order to dislodge any debris that might have lodged in the side and bottom seals, The leakage shall then be measured and it should not be more than 5 litres / minute / meter of length of seal under maximum head.

5.18.01.08.05 **Material Specifications of Stop logs & Trash racks**

All material used in the fabrication of stop log or trash rack shall be of high grade, free from defects and imperfections and shall be of the highest standard commercial quality suitable for the intended use. Radiographic examination or magnetic particle testing or other comparable tests shall be carried out for determining the soundness of steel castings and shall be conducted by the Bidder, if asked for by the Employer.

5.18.01.08.06 **Materials for the various components of Stop logs**

Sl. No.	Component Parts	Recommended materials	Reference
1.	Stop log Leaf	Structural steel	IS 2062
2.	Stop log Frames, 1st stage embedded parts and structural steel members	Structural steel	IS 2062
3.	2nd stage embedment	Stainless steel	SS316L or IS:1570 (part-5)
4.	Wheels (the hardness of wheel track surface shall be kept 50 points higher than that of wheel tread)	Cast steel	IS : 1030
5.	Wheel axles, wheel track	Corrosion resistant steel.	IS 1570
6.	Seals	Rubber	IS 11855
7.	Bearings	SKF or equivalent	04Cr19Ni
8.	Seal seats	Stainless steel	SS316L or IS 1570 (part-5)
9.	Lifting pin	Stainless steel	SS316L or IS 1570 (part-5)
10.	Guide	Corrosion resistant steel	IS 6603
11.	Guide shoe	Structural steel	IS 2062

5.18.01.08.07 Materials for various components of Trash Rack:

Sl. No.	Component Parts	Recommended	Reference Materials
1.	Trash rack and 1st stage embedded parts	Structural steel	IS 2062
2.	2nd stage embedment	Stainless steel	SS 316L or IS 1570 (Part–5)
3.	Slide Block	Structural steel with bronze padding	IS 2062 & IS 305
4.	Track base	Stainless steel	SS 316L or IS 1570 (Part–5)

5.	Track	Stainless steel	SS 316L or IS 1570 (Part–5)
6.	Guides	Corrosion resistant steel.	IS 6603

5.18.01.08.08 **Painting Specification for Structural Steel parts for Stoplog Gates and Trash Racks**

(i) All structural steel surfaces shall be cleaned by shot blasting.

(ii) All MS structural parts shall be galvanised to minimum coating of Sealed Zinc spray (250 Micron) as per BS 5493.

(iii) Over zinc coating one coat of zinc Phosphate Epoxy primer having minimum 30 micron DFT and three coats of coal tar Epoxy paint having minimum 75 micron DFT / coat shall be provided. Total DFT of epoxy paint including primer shall be minimum 250 microns.

5.18.01.09 **CONSTRUCTION REQUIREMENT AND ACCESS TO WORK AREAS**

Contractor shall notify to the Engineer before start of work well in advance about the method of construction for crossing road, pipeline, cable, railway, canals, utility lines and other existing obstacles.

Contractor shall not commence work on such crossings before having obtained approval from the authorities and land owners concerned to the satisfaction of the Engineer. The work at crossings shall meet at all times requirements and conditions of the permit issued by the authorities concerned. In the absence of any specific requirements by authorities, Bidder shall comply with Engineers' instructions.

Where the work areas come within the area of influence of high voltage electrical installations, contractor shall propose and provide adequate safety measures for all personnel working. He shall obtain necessary permission/permit from the concern authority. No work is allowed in such areas without Engineer's prior approval.

5.18.01.10 **Switch Gear / Control Room/ Remote IO room for CWPH and RWPH**

It shall be single storied building, framed RCC structure with beams, columns, floor and roof. It shall have non-load bearing brick wall cladding. It shall house the switch gear and MCC of respective Pump house & associated cable trenches. The architectural features shall be as specified elsewhere in the specification.

5.19.00 WATER TREATMENT PLANT-DM Plant, PT Plant, ETP and CW Chemical Treatment Civil Works, CSSP, etc .

5.19.01.00 Design Concepts for Buildings/ Shed

i. All buildings shall have framed super structure.

ii. Equipment/facilities with shed shall have structural steel superstructure with permanently colour coated metal sheeting at roof and side open. However, kerb wall shall be provided all around the plinth/ floor area above the Finished Floor Level (FFL). For other buildings brick wall cladding on exterior face shall be provided.

iii. Unless specified, the wall cladding for buildings shall be with minimum one brick thick on exterior face. However, brick wall for buildings adjacent to transformers shall be minimum 345mm thick.

5.19.01.02	Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion, etc.
5.19.01.03	The load and load combinations and design criteria shall be as specified elsewhere in the specification.
5.19.01.04	All liquid retaining structures shall be designed for following load conditions. Underground structures: a. Water filled inside up to design level and no earth outside. b. Earth pressure with surcharge of 2.0 T/m2 and ground water table up to FGL outside and no water inside. c. Stability against uplift shall be checked for completed structure and under construction stage with no water inside and ground water table up to FGL, with a minimum factor of safety of 1.20 against uplift. Installation of pressure relief valves shall not be permitted in the base slab of any liquid retaining / conveying structure. d. The structure shall also be checked for normal working condition with water filled inside up to design level and earth pressure outside with no effect of surcharge and ground water table. For design of over - ground liquid retaining structures appropriate load cases shall be considered.
5.19.01.05	All liquid retaining and conveying structures shall be designed as per IS 3370(Part2) with limiting crack width to 0.1mm.
5.19.01.06	In the wall of liquid retaining structures with cylindrical shape such as clarifiers, vertical reinforcement shall be checked assuming the walls were fully fixed at the base, and the horizontal reinforcement shall be provided to resist horizontal (hoop) tension assuming hinged condition at the junction of the base slab & wall.
5.19.01.07	Wherever sandwich slabs are provided in liquid retaining structures to take care of stability against uplift, only well graded sand of approved quality shall be used as fill material. The sand compaction shall be done with plate / disc compactors in such a manner that the bottom slab is not structurally damaged.
5.19.01.08	Clear free board of at least 300 mm above design (total) water level shall be provided in all liquid retaining / conveying structures.
5.19.01.09	Coefficient of active earth pressure shall be considered for design of free standing retaining walls and coefficient of earth pressure at rest shall be considered for design of top propped retaining walls.
5.19.01.10	The minimum grade of concrete for all RCC structures associated with DM plant, PT plant, ETP and CW chemical treatment and CSSP shall be of grade M30.The minimum concrete clear cover to reinforcement bars in all RCC structures shall be as per IS:456(2000) and IS:3370(Part 2) for water retaining structures. Durability of concrete shall conform to moderate exposure conditions as per Table-3 of IS 456 except noted specifically otherwise.
5.19.01.11	Factor of safety against overturning and sliding The structure shall be checked for minimum factor of safety of 1.5 against overturning conditions (ratio of stabilizing moment to overturning moment) and 1.4 against sliding conditions as per IS: 456.
5.19.01.12	For detailing of Reinforcement IS 5525, IS 13920, IS 4326 and SP 34 shall be followed.

5.19.01.13 Two layers of reinforcement (on both faces) shall be provided for RCC sections having thickness of 150 mm and above.

5.19.01.14 Minimum diameter of main and distribution Reinforcement bars in different structural elements shall be as follows:

Sl. No.	Structural Element	Main Reinforcement	Distribution Reinforcement / Stirrups/ ties/ Anchor Bars
a)	Foundation	12 mm	12 mm
b)	Beams	12 mm	8 mm
c)	Columns	12 mm	8mm

5.19.01.15 Spacing of reinforcement bars in walls and slabs of liquid retaining / conveying structures shall not be more than 200 mm.

5.19.01.16 Suitable shrinkage reinforcement shall be provided at top face of foundations. Minimum shrinkage reinforcement shall be 10 mm dia. @ 200mm c / c.

5.19.01.17 Minimum Reinforcement in all elements of liquid retaining / conveying structures shall be 0.24 % of cross sectional area distributed equally over top and bottom faces.

5.19.01.18 Minimum tensile Reinforcement in each direction for all foundation slabs / rafts shall be 0.2% of cross sectional area.

5.19.01.19 Minimum thickness of foundation slab / raft and base slab of all liquid retaining tanks / pits shall not be less than 250 mm.

5.19.01.20 Minimum thickness of all elements of RCC liquid retaining / conveying structures (except effluent drains, launders and aerator waste slab) shall be 200mm. Effluent drains (depth more than 500mm), aerator waste slab and launders shall have minimum element thickness of 150mm.

5.19.01.21 All Insert plates (except edge protection angles) provided in liquid retaining structures shall be 12 mm thick GI with lugs not less than 12 mm diameter. Edge protection angles shall be provided as specified elsewhere.

5.19.01.22 All water retaining structures shall be tested for water tightness as per provisions of IS: 3370 and IS: 6494.

5.19.01.23 2.0m wide walkway with concrete paving shall be provided connecting all structures, buildings and facilities. The top of walkway shall be minimum 200mm above FGL.

5.19.01.24 **Coating on RCC water retaining structures (other than drinking water):**

Epoxy phenolic coating as per details specified below shall be applied on internal surfaces of the RCC water retaining structures and external surfaces of RCC Neutralisation-pit which is in contact with earth:

a. All concrete surfaces shall be provided with two component transparent polyamide cured epoxy sealer coating (having solid by volume minimum 40% ±2%) of minimum 50 micron DFT. Surface to be coated shall be absolutely dry, clean and dust free.
b. Sealer coat shall be followed with the application of epoxy phenolic coating (solid by volume minimum 63%) of minimum 400 micron DFT. This coat shall be applied after

an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.

5.19.01.25 Coating on RCC water retaining structures (drinking water)

Internal surfaces of RCC water retaining structures shall be provided with minimum 400 micron food grade epoxy coating complying to FDA Title 21, Part 175.300. Surface to be coated shall be absolutely dry, clean and dust free.

5.19.02.00 Architectural Concepts and Finishing Schedule

Architectural concepts and finishing schedule shall be as specified elsewhere in architectural specification.

5.19.02.01 Acid / Alkali Resistant Treatment:

Acid / alkali resistant lining treatment shall be provided in different areas as follows:

Neutralization Pit: The walls shall be provided with one coat of bitumen primer, followed by 18 mm thick bitumastic layer, 115 mm thick A.R. bricks, 6 mm thick under bed of potassium silicate mortar, pointing the joints of bricks with acid / alkali resistant epoxy / furane mortar upto a depth of 20 mm and bitumastic end sealing. Suitable pilasters shall be provided with A.R. bricks at regular intervals depending upon the height of lining, as per the specification.

The floor of neutralization pit shall be provided with acid / alkali resistant lining treatment as given in the above para, except that the 115 mm thick A.R.bricks layer shall be replaced by 75 mm thick A.R. tile layer and pilasters shall be omitted.

The ceiling of neutralization pit shall be provided with one coat of epoxy primer followed by 2 coats of epoxy paint (150 micron).

Acid / Alkali storage area / projections above the floor, pedestals projecting from the floor / saddles. The floor shall be provided with one coat of bitumen primer followed by 12 mm thick bitumastic layer, 20 mm thick A.R. tiles, 6 mm thick under - bed by potassium silicate mortar, 6mm thick pointing of joints of tiles with acid / alkali resistant epoxy / furane mortar up to a depth of 20 mm and bitumastic end sealing. Dado of 1.0M high with above treatment shall also be provided if applicable in case of walls nearby.

Alum/Lime Storage area and first floor of Chemical House : One coat of bitumen primer followed by 12mm thick bitumastic layer, 20 mm thick A.R. tiles, 6 mm thick underbed of potassium silicate mortar, 6mm thick pointing of joints of tiles with acid /alkali resistant epoxy /furane mortar up to a depth of 20 mm and bitumastic end sealing.

Alum solution preparation tank: The wall shall be provided with one coat of bitumen primer followed by 12 mm thick bitumastic layer, 75 mm thick A.R. tiles, 6 mm thick underbed by potassium silicate mortar, pointing of joints of tiles with acid / alkali resistant epoxy / furane mortar upto a depth of 20 mm and bitumastic end sealing.

The floor shall be provided with acid / alkali resistant lining treatment as given in the above para except that the 75 mm thick A.R. tile layer shall be replaced by 12 mm thick A.R. tile layer.

Basket of Alum Solution Preparation tank: 5mm thick epoxy lining over a coat of epoxy primer.

Curved surfaces of saddles shall have minimum 12 MM thick bitumastic layer to support the vessel / tanks.

Effluent Drains: Acid Resistant lining treatment indicated for the storage area shall be provided on the bed as well as walls of the drains with 38 MM AR tiles. The underside of the pre-cast slab cover shall be applied with one coat of epoxy primer and two coats of epoxy coating, total DFT 150 microns.

Lime tank: Two coats of bitumen paint conforming to IS : 9862, with total DFT 150 microns.

Guarantee

The Contractor shall give a guarantee for satisfactory functioning of the lining for a period of 36 months from the date of completion of the work or date of handing over the site to the Engineer, whichever is later.

The Contractor shall replace / rectify defects is any, observed in the lining to the satisfaction of the Engineer without any extra cost during this period.

5.19.02.02 DM Tank Foundation

5.19.02.02.01 General Requirements

The tank foundation shall be as per IS:803 and as specified in relevant clause of foundation chapter.

5.19.02.02.02 Sub Grade Preparation

The surface of natural soil shall be thoroughly compacted by rolling or other means, as directed by Engineer, to obtain 95% of max. laboratory dry density for the soil, as per IS:2720 (Part-VII).

5.19.02.02.03 Anti Corrosive Layer

Anti-corrosive layer shall consist of dscreened coarse sand, mixed with 80/100 bitumen or equivalent 8% to 10% by volume.

Bitumen shall be heated to a temperature 175^0C to 190^0 C, with 3% kerosene, if required. Sand shall be thoroughly mixed with it in a mixing drum to obtain uniform mixture and shall be laid over the compacted surface, laid in line, grade and levels and as directed by the Engineer. Bitumen shall not be heated beyond the temperature limits given above.

The premix carpet shall be laid in two layers of 3 cm and 2 cm respectively. After compacting and laying the first layer of 3cm, a tack coat of hot bitumen at the rate of 1 Kg. per Sq.m. shall be uniformly applied to the surface, by means of Sprayer and the Second layer of 2cm thick shall be laid, tamped and compacted to the satisfaction of the Engineer.

Sand shall be spread on the final surface at the rate of 0.5 Cu. m per 100Sq.m.

5.19.02.02.04 Premix Materials

Sand

Sand shall be clean, dry, coarse, hard angular, free from coatings of clay, dust and mix of vegetable and organic matters and shall conform to IS 383 (Grade -III).

Stone Chippings

Stone chippings shall be hard black trap or granite or approved locally available stone and shall conform to IS 383. The grading shall be of normally 12mm down size and 6mm down size, in the ratio of 3:2 respectively.

Bitumen

Bitumen required for the work shall be 80/100 grade or its equivalent quality.

Laying

Areas on which the premix is to be laid shall be thoroughly cleaned of all dust and loose materials. On the cleaned surface, a tack coat at the rate of 1.0 Kg. per Sq.M. of hot Bitumen shall be uniformly applied by Sprayers. The applied Binder shall be evenly brushed.

The Binder bitumen 80/100 shall be heated to the temperature of about 190^0 C with 3% kerosene, if required and mixed with stone chippings of size, as mentioned above, at the rate of 400 KG, with Six (6) Cu. M. of stone chips, for 100 Sq.M. of surface. The total mixed quantity, as mentioned above, is the quantity required for the total 50mm thick for 100 Sq. m. of area. Mixing shall continue until the aggregate is well coated.

5.20.00 Switchyard Civil Works

5.20.01 Civil works for switchyard includes:

a. Towers, girders, lightning masts and equipment supporting structures including proto type assembly etc.,

b. Foundations and supporting pedestals for towers, lightning masts, equipment supporting structures etc.,

c. GIS building,Control room/Auxiliary building as required for switchyard, foundation for AC Kiosks etc.

d. Foundations for transformers and reactors including oil pit, stone filling, laying and fixing of rails for movement of Transformers / reactors, rail track, jacking pad and fire walls as required, arrangement for cabling etc. all complete

e. Earthing mat, single lane roads and R.C.C. drains in switchyard area including road/drain/trench crossings etc.,

f. All necessary embedments, inserts, supporting structures & supporting members as required etc.

g. Cable trenches in switchyard and inside GIS building/Control room/Auxiliary building including civil works for panel fixing etc.

5.20.02 Design Criteria

5.20.02.01 Gantry structure, which consists of open web towers connected by girders, shall be made of structural steel conforming to IS 2062 and duly galvanized conforming to IS: 2629 and IS 4759. All joints shall be bolted connections. All bolts for connections shall be of 16mm dia conforming to IS 12427 and of property class 5.6 as per IS 1367 (Part 3). Nuts shall conform to IS 1363 (Part 3) of property class 5. Foundation bolts shall conform to IS 5624 and property class shall be 4.6 as per IS 1367 (Part-3). Butt splice shall be used for splicing the main members and splice shall be located away from the node point. IS 802 “Code of practice for use of structural steel in overhead transmission line towers” shall be followed for design of structures. Height & type of towers shall be established based on electrical requirements. A provision of ± 30 degree angle of deviation of line in horizontal plane and ± 20 degree deviation in vertical plane is considered and the resulting worst combination of forces shall be considered for design. For all outgoing and incoming feeders, the conductor span shall be taken as 200m for design purpose.

The analysis of towers and gantries shall be carried out with combined model of critical configurations of towers and gantries using any established structural analysis software like STAAD Pro. etc.

5.20.02.02 Switchyard structures shall be designed for the worst combination following loads:

1) Dead loads (load of wires/conductors, insulator, electrical equipment and structural members),

2) Live loads,

3) Wind loads

a. Switchyard gantries, towers, equipment supporting structures and lightning mast shall

be designed as per IS 802. The wind load calculations shall be made as per IS: 802 except the parameters basic wind speed (Vb) and terrain category as stipulated in "Criteria for wind resistant design of structures and equipment".

b. All other structures shall be designed as per IS 456 / IS 800. The wind load calculations to be made as per IS: 875 shall be with the parameters as stipulated in "Criteria for wind resistant design of structures and equipment".

4) Seismic loads,

5) Loads due to deviation of conductor (gantries shall be checked for ± 30 deg. deviation in horizontal plane and ± 20 degree deviation in vertical plane),

6) Loads due to unbalanced tension in conductor/wire,

7) Torsional load due to unbalanced vertical and horizontal forces,

8) Erection loads,

9) Short circuit forces including snap in case of bundled conductors, etc.

Note:

i. The occurrence of earthquake and maximum wind pressure is unlikely to take place at the same time. The structure shall be designed for either of the two. However, temperature stresses can be ignored, as these towers are freestanding structure in open space.

ii. Short Circuit forces and Wind pressure shall be considered to act together for design of switchyard structures

iii. Direction of wind shall be assumed such as to produce maximum stresses in any member for the combination of wind load with conductor tensions. The wind acting perpendicular and parallel to bus conductor and shield wire shall be considered separately.

iv. The conductor tension shall be assumed as acting on only one side of the gantry for the analysis and design of switchyard gantries.

v. The distance between terminal and dead end gantry shall be taken as 200 meters.

5.20.02.03 **Factor of safety:**

The factor of safety for the design of members shall be considered as 2.0 for normal condition and broken wire condition, 1.5 for combined short circuit and broken wire condition. Foundation shall be designed for a factor of safety of 2.2 for normal and broken wire condition and 1.65 for combined short circuit and broken wire condition.

5.20.02.04 **Design consideration for switchyard equipment support:**

The supporting structure for B.P.I., LA, CVT & Isolator equipment's shall be comprised of GI (ERW) pipe of grade YST:210 or of higher grade conforming to IS: 1161 & shall be designed as per IS 806 "Code of Practice for use of steel tubes in general building construction".

Minimum diameter of the pipe type support for 765kV structure shall be 300NB, 400kV structure shall be 250NB, for 220kV & 132kV structures shall be 200NB and that for 66kV & 33kV shall be 150 NB.

The supporting structure for CT, CSE & Wave Trap equipment shall be comprised of lattice structural steel conforming to IS 2062 and shall be designed as per IS: 802.

Common raft foundation shall be provided for each pole of isolator.

5.20.02.05 **Special design consideration for lightning Mast:**

Diagonal wind condition shall be considered for lightning masts. Diagonal wind shall be taken as 1.2 times the wind calculated on Longitudinal/Transverse side. Lightning mast shall be provided with minimum two nos. of platforms as per requirement and an\ ladder for climbing purpose shall be provided up to platform at top level. Top of platform shall have grating, railing and toe guard plates. The minimum width of platform shall be 900mm. Live load of 300kg/m2 above platforms shall be considered for design of Lightning Mast.

5.20.02.06 **Design Criteria for structures not covered under Cl. 5.20.02.01 to Cl. 5.20.02.05**

The Switchyard Control Room building shall have RCC framed super structure with one brick thick wall cladding on exterior face. The Control room building shall consist of rooms/facilities/ equipment/ monorail as per system requirement. An open space of one meter width (minimum) shall be provided on the periphery of the panel rows and equipment to allow easy operator movement and access for maintenance purposes.

The design of RCC structures shall generally be carried out using limit state method of design as per IS 456. The minimum grade of concrete shall be of RCC M25 as per IS 456.

The GIS building shall be a Steel framed superstructure with permanently color coated metal sheeting on roof and all sides with 300mm overlap with brick cladding. However, brick cladding shall be provided up to a height of 900mm from Finished Floor Level (FFL). GIS building shall consist of rooms/facilities/equipment/EOT crane as per system requirement. Design of steel superstructure shall be carried out by IS:800 and other relevant IS standards

5.20.03 The architectural features including roof water proofing, rain water down comers and RCC parapet walls etc. shall be as specified elsewhere in the specifications.

5.20.04 The fabrication and erection of the switchyard works shall be carried out generally in accordance with IS 802 and IS 800. All materials shall be completely shop fabricated and galvanised.

5.20.05 All structural steel members including stub members, bolts, nuts, spring washers, etc., shall be hot dip galvanised after fabrication. Minimum section thickness should not be less than 4 mm. Weight of zinc coating shall be at least 0.610 kg/m2 and foundation bolts shall have heavier zinc coating at least 0.80 kg/m2.

5.20.06 **Cable Trenches**

Cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within switchyard shall project at least 300 mm above the finished formation level so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits. The precast covers shall not be more than 300mm in width and shall not be more than 65 kg. Lifting hooks shall be provided in the precast covers. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected. All cable trenches shall be provided with suitable insert plates for fixing support angles of cable trays. All internal cable trenches shall have minimum 6mm thick (o/p) chequered plate covers while external cable trenches shall have pre - cast RCC covers. However, the portion of the cable trench behind and sides of control panel / MCC shall be provided with suitable chequered plate covers as directed by the Engineer. Cable trenches inside switchyard, having depth more than 500mm, shall have wall thickness of minimum 150mm with two layer reinforcement.

5.20.07 **PCC Layer & Gravel Filling:**

PCC Layer and Gravel filling shall be provided as specified elsewhere in the specifications. Before laying of PCC layer, the subgrade shall be properly compacted and the top layer of the soil shall be treated for anti-weed considering the type of weeds found in the vicinity. The anti-

weed - soil sterilization details such as manufacturer's name, their specification, test certificate, etc. shall be furnished for Owner's approval. Any modification if required in the proposed anti-weed treatment chemical shall have to be done by the contractor at no extra cost to the Owner. The contractor shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall be commenced from the date of completion of work or date of handing over, whichever is later. Stone/gravel shall be chemically inert, hard, strong durable against weathering, of limited porosity and free from deleterious materials. It shall be properly graded and shall meet the requirements of IS: 383.

5.20.08 **Transformer/reactor foundations**

Foundations of transformers/reactors shall be designed for seismic and wind loads in addition to other applicable loads. Solid RCC block foundation shall be provided for the main transformer/reactor block. Alternatively, transformer shall be supported on a RCC foundation comprising of common raft for rail supporting walls up to rail-cum-road along with pedestals for jacking pad, roller lock etc. Tie beams connecting roller lock pedestals at rail level shall also be provided. Common raft/solid RCC block shall be supported on soil or pile based on requirement specified elsewhere in the specification. Oil soak pit / oil water separation pit for transformer/reactor shall be provided as envisaged elsewhere in the specification. The oil soak pit shall be provided for each transformer and shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store one-third (1/3) of the oil volume of transformer/reactor considering only 40% of the volume as available voids between gravel filling. The oil soak pit shall also be provided with a sump at the corner to allow drainage of water/oil from the soak pit. The Oil-water Separation pit shall be designed for an effective capacity of complete oil of one transformer having highest volume of oil along with 10 minutes of firewater. For calculating effective capacity of oil-water separation pit, effective depth excluding 200 mm freeboard below invert level of inlet pipe shall be considered. Plan area and depth of oil-water separation pit shall be decided based on above consideration. Oil-water Separation pit shall be provided with five separate chambers interconnected by pipes. First chamber shall be for collecting oil-water mix from transformers' soak pits in case of fire. After entering into first chamber, oil being the lighter in density floats above the water. The water from lower elevation flows in to subsequent chambers interconnected through galvanized MS pipes. The accumulated oil in the first chamber to be pumped out for subsequent usage or disposal. Water collected in the last chamber to be pumped out for subsequent disposal after treatment. Invert level of inlet Hume pipes (of NP-3 grade and adequate capacity), carrying oil and water from transformers soak pits, shall be designed for gravity flow. Freeboard of 200 mm shall be provided below the invert level of inlet pipes. Invert levels of interconnecting pipes of subsequent chambers shall be decided accordingly.

Arrangement for moving the transformer into place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer/reactor foundations.

RCC Firewall shall also be provided between the transformers wherever required.

300 mm thick PCC M20 encasement all around the Pylon supports inside soak pit for fire fighting system shall be provided up to top of Stone filling. Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

5.20.09 The switchyard roads, drains, fencing and gate shall be as specified elsewhere in the specification.

5.21.00 **FIRE WATER PUMP HOUSE, FIRE WATER BOOSTER PUMP HOUSE& FOAM SYSTEM**

Salient Features:

The scope of the Bidder shall be design and construction of Civil, Structural, Architectural,

Water Supply, Plumbing and Sanitary Works of, Fire Water Booster Pump House including supply of all materials.

The fire water Pump House shall be single storeyed and single bay RCC superstructure provision for a structural steel monorail. MCC /switchgear rooms, control room etc. shall have RCC framed structure with cast-in-situ RCC roof slabs with brick cladding. The building shall be fully covered with external brick wall with provision for doors, windows, rolling shutters and exhaust fans.

The Fire Water Booster Pump House shall be structural Steel Shed superstructure with provision for a structural steel monorail. Switchgear/MCC room, Battery room,Control room shall have RCC framed structure with cast-in-situ RCC roof slabs with brick cladding. The shed and building shall be fully covered with external brick wall with provision for doors, windows, rolling shutters and ventilation fans.

Steel shed with roof covering with provision for a structural steel monorail shall be provided for foam system including associated civil works for foam bladder tank foundations, grade slab, pipe pedestals etc. Control room shall have RCC framed structure with cast-in-situ RCC roof slabs with brick cladding. The shed and building shall be fully covered with external brick wall with provision for doors, windows, rolling shutters and exhaust fans. Fire water storage tank foundation shall be provided as detailed elsewhere.

Fire water pipes shall be provided with either RCC trench or buried underground as per requirement.

Fire water trenches shall be open RCC type trench with removable RCC cover.

Interlocking concrete block paving shall be provided over the buried fire water pipes as specified elsewhere in the specification.

At road/rail/ drain crossings of fire water pipes, the fire water pipes shall be provided with minimum 200mm thick PCC encasement all around the pipe.

5.22.00 **VOID**

5.23.00 **COAL, BIOMASS, LIMESTONE & GYPSUM HANDLING SYSTEM**

5.23.01 **Wagon Tipplers, Track hopper, Reclaim Hopper, Underground TP's & Tunnel**

Wagon tippler, Track hopper, Reclaim Hopper, Underground portion of TP's and Underground Tunnel shall be of RCC. Structural Shed shall be provided over track hopper and reclaim hopper.

The vertical and inclined portion of coal hopper and beams in reclaim hoppers shall be provided with 50 mm thick guniting (shotcreting). Details of shotcreting have been given elsewhere in this specification.

Expansion joints shall also be provided at locations wherever tunnel connects with track hopper, wagon tippler, Underground TP's, penthouse etc. 600mm wide water stop fabricated with 22G copper plate with bitumen board fillers and polysulphide sealing compound as specified elsewhere shall be used as expansion joint material. FPO (Flexible polyolefin Tap) based waterproofing membrane shall also be provided. Reinforcement detailing at the expansion joint shall be done in such a way that there is no obstruction to copper plate installation.

Floor shall be provided with cross slope not flatter than 1 in 50 towards side drains. Side drains shall be sloped towards sump where sump pumps as specified elsewhere, shall be provided.

The slope of side drains shall not be flatter than 1 in 400. Side drains and sump shall have removable type steel grating cover. Gratings shall be galvanized to grade 610 gm/m2.

Water proofing / Damp proofing of underground portion of Track hopper, reclaim hoppers, tunnels, underground (i. e. basement) portion of transfer houses shall be done by providing the following treatments:

1. Chemical injection grouting for inner faces (details as specified elsewhere).

2. HDPE membrane for the bottom raft and Hybrid Polyurea coating on earth side faces as per the following :

On the outer surface of walls, frames and roof slabs coming in contact with earth, Hybrid Polyurea in two layers as specified and as per manufacturer's specifications shall be provided directly on the concrete surface.

HDPE membrane shall be provide over the minimum 75 mm thick PCC (1 : 2 : 4 with 10 mm nominal size stone aggregates)for the raft as specified elsewhere.

Steel gratings of mesh size 350 mm x 320 mm for wagon tippler hopper/track hopper shall be provided. The grating shall be built of min. 200mm x 28mm thick flats in main direction and min. 100mm x 20mm thick in secondary direction. The hopper and gratings shall be designed for movement of front end loader/ bulldozer over them. Bull-dozer weight shall be considered as 35T. No painting/galvanization shall be provided in gratings. However, two coats of Red oxide Primer to be provided immediately after fabrication.

Earth pressure to be considered for design shall be due to earth pressure at rest (Ko) condition only. Earth pressure due to surcharge intensity of Railway Loads (where applicable) or Uniformly Distributed Load (U. D. L) of intensity 2 T / Sq. M. whichever is critical, shall be considered in the design.

A minimum safety factor of 1.2 against uplift of wagon tippler/track hopper, transfer points (underground or with basement) and tunnels, due to ground water shall be ensured during execution and after execution, considering dead weight of the structure to be 0.9 times only, ground water table at adjoining formation level and soil wedge angle of not more than 15 degrees.

Also, FOS against uplift, to be taken as 1.0, considering the dead wt. of structure and soil resting on side projections if any in the vertical plane. Inclined wedge action of soil shall not be considered in this case.

Wherever slope of tunnel exceeds 10^{o}, RCC steps shall be provided for the entire width of each walkway.

5.23.02 Overhead / Ground Conveyor Galleries and Trestles

Overhead conveyors for trough belt conveyor shall be located in a suitably enclosed gallery of structural steel. The overhead gallery shall consist of two vertical latticed girders having rigid jointed portal frame at both ends. Cross beams at floor level supporting conveyor stringer beams shall be made of single rolled steel beam or single channel section or plate girder. Horizontal bracings are to be provided at top & bottom plan of the gallery (latticed girders shall be braced together in plan at the top and bottom). Common end portal frame shall not be used for adjacent conveyor spans. Roof truss shall be provided at upper node

points of latticed girders to form an enclosure.

The maximum span of overhead gallery shall be limited to 25 meter unless higher span is required due to site conditions, which shall be subject to approval of the Engineer. The gallery should as far as possible be erected as a box section keeping all the vertical and horizontal bracing tied in proper position. The gallery should be checked for all erection stresses that are likely to develop during handling and erection and if required, temporary strengthening of gallery members during erection shall be made. Contractor can also use tubular steel sections for roof truss of conveyor galleries only. The tubular steel section shall be of circular/rectangular/square shape. The circular steel tube shall conform to IS:1161 and rectangular/square steel sections shall conform to IS:4923. The steel structures using tubular sections shall be designed as per limit state method as per IS 800:2007. The properties and fabrication of tubular sections shall be as per IS:806 – "Code of Practice for use of steel tubes in general building construction." and EN 1993-1-8:2005.

Seal plates under the conveyor galleries shall be provided in such a way that complete gallery bottom shall form a leak proof floor.

Grade slab with brick toe wall and plinth protection along with drains shall be provided throughout the length of the ground conveyors. Top of pedestal for ground conveyor portals shall be 300mm above FFL. Bottom of the base plate of the columns of the trestles in Main Plant Block Area shall be kept 1.2m below the finished floor level of ground floor of Main Power House.

For double stream conveyor gallery, two side and one central walkway of minimum width 800 mm and 1100 mm respectively shall be provided. The minimum width of two side walkways for single stream conveyor gallery shall be 800 mm and 1100 mm respectively. Both sides of central and side walkways shall be provided with pipe handrails all along the conveyor gallery. Hand railing should not be supported on conveyor supporting stringers. The walkways shall be chequered plate construction with anti - skid arrangement. The anti - skid arrangement will consist of welding of 10 mm square steel bars at a maximum spacing of 500 mm along the length of the gallery. Where the slope of walkway is more than 10^{o}, chequered plate steps with nosing and toe guard shall be provided. The floor of conveyor gallery all along the gallery length, shall be provided with minimum 12 gauge thick seal plates (suitably stiffened) and other drainage arrangements as specified elsewhere.

Trough belt conveyor gallery shall have permanently colour coated steel sheet covers on roof and both sides. However, in roof, a panel of minimum 1.5 m x 1.5 m area at about 6.0 m center alternatively on both slopes, shall be provided with translucent sheets of polycarbonate material for natural lighting. A continuous slit opening of 500 mm shall be provided on both sides just below the roof sheeting. Adequate provision of windows shall be kept on both sides of conveyor gallery as appended in Mechanical Section (Belt conveyor system). Windows shall be provided with wire mesh as specified elsewhere in this specification.

Cross - over with chequered plate platform and ladder for crossing over the conveyors shall be provided at approximately every 90m intervals of conveyor. Crossover shall preferably be located over four-legged rigid trestle location.

For railway tracks passing below overhead conveyor gallery and along conveyors, the railway clearances both underground as well as over ground shall have to be adhered to for design, execution and erection of foundations, trestles, galleries etc., so that movement of locomotives and wagons is not hampered in any way during execution and afterwards. However, at the location where the overhead conveyor gallery crosses road / rail line, minimum clearance of 8.5m above the road crest / rail top shall be provided.

For calculation of material load on moving conveyor, a multiplication factor 1.6 shall be used to take care of inertia force, casual over burden and impact factor etc.

Thus material load per unit length of each moving conveyor shall be

$$1.6 \times \frac{\text{Rated Capacity of Conveyor system}}{\text{Conveyor Belt Speed}} \times F$$

Where, F = 1100/800 for coal, 1700/1400 for lime,1000/600for Biomass& 1250/900 for gypsum

It should be noted that for structural design, unit weight of lime shall be considered as 1700 kg/cu. m, unit weight of gypsum shall be considered as 1250 kg/cu. m.

It should be noted that for structural design, unit weight of coal shall be assumed as 1100 kg/cu. m.

Conveyor Gallery structure shall be designed considering both conveyors operating simultaneously.

Conveyor gallery and supporting trestles located between transfer houses / buildings shall be arranged in any one of the following ways.

a) All gallery supporting trestles shall be four legged type only. One end of each gallery span shall be hinged to the supporting trestle and the other end shall be slide type. Slide type support shall be with PTFE bearings to allow both rotation & longitudinal movements.

OR

b) In between transfer houses / buildings, four legged trestles shall be placed at a maximum interval of 90 metres. The arrangement shall be such so as to ensure that force in the longitudinal direction (i. e. along the conveyor length) of conveyor gallery of length not more than 90 m is transferred to any four legged trestle. In the space between each successive four legged trestles, two legged trestles shall be provided at regular intervals. The end supports resting on the four-legged trestle can have either ends hinged or one hinge and the other on slide type depending on the arrangements. Slide type support shall be with PTFE bearings to allow both rotation & longitudinal movements.

End of conveyor gallery which will be supported over transfer house, shall be so detailed that only vertical reaction is transferred from conveyor gallery and no horizontal force in longitudinal direction is transferred from conveyor gallery to transfer house structure and vice - versa.

5.23.03 For trestles and trestle foundations for conveyor galleries located adjacent to existing structures, over ground and underground facilities, location and details of these trestles and foundations shall have to be decided such that there is no interference both underground as well as over ground with existing structures and facilities. Base plates of trestle columns shall be kept 300 mm above the finished ground level. Encasement of the pedestal shall be done up to the top of stiffener plate.

5.23.04 **Transfer Houses**

The over ground portion of all transfer houses shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding (from lowest working floor level till top) and RCC floors comprising of RCC slab over profiled metal deck sheets (to be used as permanent shuttering without considering any composite action effect of metal deck sheet) over structural beams. Shear anchor studs shall be provided through metal deck at regular interval on all top flange/flange plate of structural beams. However, the lower portion of side cladding, at ground, for a minimum height of 0.9 m above the finished floor level shall be one brick thick wall plastered on both side. In some areas like MCC floors etc., one brick thick wall cladding shall be provided. Brick wall cladding shall be supported on encased wall beams and suitably anchored to adjoining columns and beams. Vertical bracings shall be provided only on four sides along the periphery. Grade slab with brick cladding of 0.9 m height, plastered on both sides shall be provided for all transfer houses. Bottom of the base plate of the columns of the transfer houses in Main Plant Block Area shall be kept 1.2m below the finished floor level of ground floor of Main Power House.

Adequate steel doors and windows for proper natural lighting and ventilation shall be provided. In addition to steel windows, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting.

The roof of Transfer points shall be provided with pre-fabricated insulated metal sandwich panels. Pre-Fabricated Insulated Metal Sandwich Panel for Roofing shall be laid to specified slope. Composition of Insulated Metal Sandwich Panels shall be as described in relevant section of Technical Specification. Adequate slope shall be provided for quick drainage of rain water.

For Lime handling transfer house RCC floors comprising of RCC slab over profiled metal deck sheets (to be used as permanent shuttering without considering any composite action effect of metal deck sheet) over structural beams.

5.23.05 **Crusher Houses**

The crusher house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. However, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting. The lower portion of side cladding, at ground, for a height of minimum 0.9m above the finished floor level shall be of one brick

thick wall plastered on both faces. Floors shall be of RCC comprising of RCC slab over profiled metal deck sheets (to be used as permanent shuttering without considering any composite action effect of metal deck sheet) over structural beams. Shear anchor studs shall be provided through metal deck at regular interval on all top flange/flange plate of structural beams. Within this building, cubicles for resting room of operators shall be constructed with one brick thick brickwork having both sides plastered and roof slab. Adequate steel doors and windows for natural lighting and ventilation shall be provided. Vertical bracings shall be provided only on four sides along the periphery.

The roof of crusher house shall be provided with pre-fabricated insulated metal sandwich panels. Pre-Fabricated Insulated Metal Sandwich Panel for Roofing shall be laid to specified slope. Composition of Insulated Metal Sandwich Panels shall be as described in relevant section of Technical Specification. Adequate slope shall be provided for quick drainage of rain water.

If any equipment to be located on the roof of lime crusher house, roof shall comprise 150 mm thick RCC slab(measured over crest of the metal deck) over profiled metal deck sheets (to be used as permanent shuttering without considering any composite action effect of metal deck sheet) over structural beams.

Crushers shall be supported on RCC deck, which in turn will rest on suitable vibration isolation system consisting of springs and dampers. This RCC deck shall be isolated from the floor. However, the vibration isolation system consisting of springs and dampers may rest on main building framework. Detailed specification of vibration isolation system including the unbalanced force, frequency and amplitude criteria and other design requirements are appended elsewhere in this specification.

5.23.06 Stacker Reclaimer Foundation

Stacker – Reclaimer (S/R) foundation shall be in RCC and shall be designed as RCC framed structures (in longitudinal & transverse direction). Lateral tie beams between two rail supporting elements shall be provided at a regular interval of approx. 3.0 m center. Conveyor short posts shall be supported on RCC beams at grade level. The foundation shall be designed for the most critical combination of loads as furnished by the equipment supplier. RCC retaining wall on both sides of the S/R foundation shall be provided as shown in the Annexure-H.

The portion between the two rails and between rail and retaining wall on both sides shall be paved in concrete as per specification for grade slab of ground level specified elsewhere. However no metallic hardener finish over RCC slabs is to be provided. Drains shall be provided along the rails for drainage of rain / dust suppression / floor washing water. Drains shall be routed on both sides of the foundation along the rail as shown in Tender Drawing. Drains shall be connected to the network drainage system for finally discharge into coal settling tank. RCC drains shall be provided in Coal stockyard area with precast RCC covers.

5.23.07 Control building, M. C. C. Buildings

These shall be steel or RCC framed building with RCC roof and floor. For steel framed building roof/floor comprise of RCC slab over profiled metal deck sheets (to be used as permanent shuttering only) over structural beams. Shear anchor studs shall be provided through metal deck at regular interval on all top flange/flange plate of structural beams. Cladding shall be of brickwork/concrete block work with plastering on both sides. Bidder has also the option to supply and construct pre-engineered buildings. Roof shall be provided with roof water proofing treatment, as specified elsewhere in the Technical specification. Suitable arrangement shall be provided so as to prevent ingress of water into the cable trenches inside the building from cable entry locations.

All air - conditioned areas, shall be provided with the false ceiling system(details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

5.23.08 Pump Houses

These shall be framed structure of structural steel work with permanently colour coated profiled steel sheet roof, grade slab and RCC foundations etc. Roof shall be provided with troughed profile permanently colour coated sheet with slope of 1 in 5 for quick drainage of rain water. Brick wall cladding (1m height above FFL) shall be provided all around the periphery of pump houses

5.23.09 Pent House

These shall be of RCC framed structures with columns, beams, slabs and foundations etc. Cladding shall be of brickwork with plastering on both sides. Roof shall be provided with roof water proofing treatment as specified elsewhere. Adequate nos. of steel doors and windows shall be provided for natural lighting and ventilation.

5.23.10 Gypsum Storage Shed

The Gypsum storage shed shall be RCC framed structure with RCC wall (upto Tripper floor) and structural steel shed with permanently colour coated profiled steel sheet roof and side cladding (above Tripper floor). Roof shall be provided with troughed profile permanently colour coated sheet with slope of 1 in 5 for quick drainage of rain water. At grade level Heavy duty paving as detailed elsewhere in the specification shall be provided inside the shed.

Finished floor level of Gypsum storage shed shall be kept at least 500mm above the finished ground level. The building shall be provided with 750 mm wide plinth protection all around as detailed elsewhere in the specification.

5.23.11 Toilets

Toilet with potable water line facilities shall be provided in each of the following locations:

(A) Crusher House (Ground Floor) – (Gents Toilet – 1 No for each.)

(B) In CHP/LHP/GHP Control Room building – (Gents and Ladies Toilets-1 No. each)

(C) Wagon tippler control room (toilet block)

Each Gents toilet shall have brick enclosure, and the following fittings.

i)	Wall mounted glazed vitreous china European water closet with low flush having flow rate of 6.0 litres and 3.0 litres of water per flush, dual flush adopters for standard flushing for solid waste and a modified smaller flush for liquid waste flushing valves shall be provided.	1 no.
ii)	White glazed vitreous china flat back lipped urinal 390x375x610 mm (approx.) fitted with photovoltaic controls for flushing system and all requisite fittings.	1 no.
iii)	Wash Basin 450x550 mm (approx.) mounted over 18 mm thk granite beveled edge counter fitted with photovoltaic control system for water controls, bottle trap with two taps and all requisite items.	1 no.
iv)	Mirror 600x900x6mm thk. with beveled edges (Superior sheet glass) mounted with teak wood beading and minimum 12 mm thk. plywood backing.	1 no.
v)	C.P. Brass Towel Rod 600 x 20 mm	1 no.
vi)	Liquid Soap Container	1 no.
vii)	Washing Tap (CP Brass)	1 no.
viii)	Overhead Polyethylene water tank (min. 500 litres capacity)	1 no.
ix)	Suitable provision for installation of drinking water cooler.	1 no.
x)	Space for Janitor room	1 no.

Ladies toilet shall be similar to gent's toilet as detailed above, except item at s.no. ii and ix (urinal and provision for drinking water cooler). Package type STP shall be to be provided.

No other facilities shall be provided below toilet block except toilet. Toilet facilities shall be provided at control room floor level.

5.23.12.01 Staircases

All floors of transfer houses/crusher houses and roof/floors of all multistoried MCC/Control room buildings shall be accessible through staircase and mumty of staircase of mcc/control

room shall be accessible through cage ladder. Cage ladders (min. 450mm wide) shall be provided for access to roof of penthouses & MCC/control room (with only ground floor).

All stairs of over ground portion of transfer houses & crusher house shall be of steel (minimum 1200 mm wide) and maximum rise should not be more than180 mm and minimum tread width 275 mm. Stringers shall be of rolled steel channel (minimum ISMC 250) and tread shall be of electro forged steel gratings. Stairs shall be provided with 50 mm dia nominal bore medium duty M. S. pipe hand rail.

Handrails (for staircases, around openings, in walkways etc.) shall be of standard weight steel pipe of flush welded constructions, ground smooth using 50 mm nominal bore medium class pipe provided with double rail, top rail about 1.0 metre, minimum above platform level (upto height of 12m the height handrail shall be 1.0 m and above 12m height the height of handrail on staircase landing and around cutouts and openings shall be 1.2 m) and pipe posts spaced not more than 1.5 metres apart. Angle handrail post may be provided when specifically called for in drawings approved by Engineering. Toe guard of size 100mm x 6mm shall be provided along the railing for all steel platforms/landings and staircases.

Smooth uniform curves and bends shall be provided at stair returns and also where so ever required. Posts connected to curb plates shall have a neat closure at the bottom and a 6 mm thick plate neatly welded to posts for attachment to curb plate. All necessary fittings including inner dowels at splices, brackets, belts, bends, flanges and chains, where required 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. 30 mm. **(Amendment No 02, D-1-5)**

Treads and landing shall be suitable for the prescribed loading. The maximum width of openings in gratings shall not exceed ~~40 mm~~. The minimum size of main bars shall be 25 x 6 mm and cross bar shall be 6mm. The usual span of grating will not generally exceed 1.5 meters. Stair case gratings shall be galvanized to grade 610g/m^2. All gratings shall be electro forged types.

Outside stairs to transfer points shall be open type. However, sheeting shall be provided at the top.

Stairs of MCC/control room, wagon tipplers, track hopper, reclaim hopper and underground TP's shall be of RCC construction. The minimum width of stairs for MCC/Control room, wagon tippler/track hopper, reclaim hopper/underground TP's shall be 1200 mm. Maximum rise should not be more than 180 mm and minimum tread with 250 mm. Minimum 50 x 50 x 6 mm size angles with lugs shall be provided as edge protection for treads of stairs in wagon tippler/track hopper, reclaim hopper, underground TP's.

Numbers and arrangement (including enclosures etc.) of stair cases shall be such as to meet the fire safety requirement as per guide lines of statutory regulatory bodies. External fire escape staircase along with internal staircase shall be provided for crusher house and multi-storied MCC cum control room building. Minimum headroom in all staircases and all levels shall be 2200mm from floor finish level.

5.23.13 Trenches

All trenches for cables or any other underground facility as detailed out elsewhere shall be

of RCC Cable trenches shall be provided with pre - cast RCC covers / chequered plate cover. Cable trenches as well as pre - cast covers shall be provided with edge protection angles. Lifting hooks shall be provided for all pre - cast RCC covers. All embedments / block outs as required and specified elsewhere in these specifications shall be provided. Trench pre - cast cover weight shall not be more than 65 Kgs. At road crossings & entry locations, RCC trench covers designed for 10 T wheel load at centre shall be provided. Pre - cast covers shall be designed for central point load of 75 Kgs. RCC cable trenches shall be filled with sand after erection of cables, up to top level and covered with pre - cast RCC covers. For cable trenches outside buildings, top level shall be 200 mm above G.L and sand filling shall be overlaid with 50 thk. PCC.

Minimum 50 x 50 x 6 mm size angles with lugs shall be provided as edge protection all around cut outs / openings in floor slabs, edges of drains supporting grating/precast RCC covers, edges of RCC trenches supporting pre - cast covers, supported edges of pre - cast cover.

5.23.14 **Cable gallery/trestles**

Cable galleries/trestles shall be made of structural steel. The contractor can use either rolled sections or tubular steel sections. The tubular steel section shall be of circular/rectangular/square shape. The circular steel tube shall conform to IS:1161 and rectangular/square steel sections shall confirm to IS:4923. The steel structures using tubular sections shall be designed as per limit state method as per IS 800:2007. The properties and fabrication of tubular sections shall be as per IS:806 – "Code of Practice for use of steel tubes in general building construction." and EN 1993-1-8:2005. Glavanised gratings shall be provided for walkways as per approved electrical drawings. Ladders shall be provided for access from ground to cable galleries at maximum 100m intervals.

5.23.15 WIND BARRIER

Structural steel wind barrier needs to be provided all around the stock pile area. Its foundation and super structure need to be design considering 100% blockage condition of mesh. For the details of mesh, mechanical part of the specification shall be referred.

5.23.16 **Limestone and Biomass Storage Silo**

The supporting structure for silo shall be of structural steel. Enclosure with side metal cladding is to be provided above Limestone/biomass Storage Silos for limestone/biomass handling equipment. Side metal cladding is also to be provided for outgoing conveyors below limestone/biomass storage silos.
Stored Limestone/biomass load shall be treated as dead load for analysis and design of silo supporting structure.

5.23.17 **Drainage & Water Supply Works**

5.23.17.01 Drainage System: -

The drainage arrangements shall be so planned so as to ensure quick disposal of drainage water without stagnation and / or overflow. It is envisaged to clean the conveyor galleries, transfer points, crusher building, penthouse etc. with water periodically.

Minimum 4 nos. down comers shall be provided in each transfer house / crusher house. In case of conveyor galleries, the down comer shall be provided at every trestle location.

Drainage of the complete coal stock pile, area around stacker reclaimer rails etc. shall be discharged into the coal slurry settling pond.

For all coal Conveyors, each down comer shall lead the water / coal slurry to RCC pit (of 2 Cu.M capacity) to allow settling of coal. The water from the pit shall overflow into contractor's R.C.C drain, which will lead the discharge finally into coal slurry settling pond.

For Crusher House, pent house, transfer house each down comer shall lead the water / coal slurry into the peripheral drains which will lead the water / coal slurry to water / coal slurry to RCC pit (of 2 Cu.M capacity) to allow settling of coal. The water from the pit shall overflow into contractor's R.C.C drain, which will lead the discharge finally to the coal slurry settling pond.

For track hopper/ Wagon Tippler & transfer houses peripheral drains shall lead the water / coal slurry to a local RCC pit (of 2 Cu. M. capacity) near each facility to allow settling of coal. The water from the pit shall overflow into contractor's R.C.C drain, which will lead the discharge to a coal slurry settling pit.

In case of Control rooms and MCC buildings, Pump houses, etc water / coal slurry coming from down comers shall discharge into peripheral drains which will lead the water / coal slurry into contractor's RCC drain, which will lead the discharge finally into coal slurry settling pond.

Drainage of the complete biomass handling system facilities shall be discharged into coal settling pond after separation of biomass in biomass separation Pit. Drainage of the complete Lime handling system facilities shall be discharged into bottom ash slurry sump after separation of lime in lime separation Pit.

Contractor's scope shall also include construction of necessary culverts under the rail lines / roads as per railway / IRC standards and approval of Railway culverts from concern Railway authorities.

5.23.18 **Internal and external water supply, drainage etc.:-**

The scope for potable water supply includes all distribution systems, tanks, pipes, fittings etc. as required and as described here or elsewhere in these specifications.

The scope for service water supply and dust control water supply shall be as described elsewhere in these specifications.

For water supply, medium class galvanized mild steel pipes conforming to IS: 1239 shall be used.

The scope for drainage of surface water shall include design, layout and construction of drains for and from buildings and drains required for coal stockyard area, drainage up to main coal slurry settling tank including connection with the tank. Drainage system shall be designed for maximum intensity of rainfall as 75 mm/hr and 60 % runoff coefficient. Moreover, the drainage system shall also comply to detail mentioned in project information chapter. All buildings (including transfer houses, crusher house, MCC rooms, pump house etc.) shall be provided with open surface brick drains of minimum size of 300 mm width and

300 mm depth with removable steel gratings all around the periphery. All drains shall be of RCC construction. Minimum 850 mm Width and 450 mm depth RCC drain shall be provided around stockpile area. Minimum 850 mm Width RCC drain shall be provided around crusher house area and its succeeding drains. All open RCC drains carrying coal/limestone/biomass slurry except in the stockpile area shall have removable steel gratings designed for loads as specified under loading clause. Moreover, all open drains around periphery of the CHP/LHP/BHP/GHP buildings shall have removable steel gratings designed for loads as specified under loading clause. Minimum size of main bar of steel grating (Galvanized to 610 gm/m^2) shall be 40 mm x 5mm and cross bars 6mm. At all entry or road/rail crossing point's RCC box/pipe culvert shall be provided. The opening size of grating shall not be more than 90 mm x 35 mm. All drains as well as pre - cast covers shall be provided with edge protection angles and lifting hooks.

However, drains in coal stockyard area shall have pre cast RCC covers. RCC pre - cast cover weight shall not be more than 65 Kgs. RCC pre-cast covers near entry or at road crossings shall be designed for 10 T wheel load at centre. RCC pre - cast covers shall be designed for central point load of 75 Kgs.

The scope for foul water from toilets shall include layout and laying of sewers for sewerage system together with all fittings and fixtures and inclusive of ancillary works such as connections, manholes and inspection chambers within the building and from the building to the terminal point.

For rain water down comer and those to be used for conveying water / coal slurry generated from cleaning of walkways/floors, Galvanized MS pipes conforming to IS: 1239 (for 150 mm NB Medium grade pipes) with welded joints shall be provided for MCC buildings, penthouse, control rooms and Galvanized steel ERW pipes (273mm OD, 4mm thk) of steel grade Fe330 conforming to IS: 3589 with welded joints shall be provided for all TP's, Crusher house, and Conveyor galleries.

All rain water down comers shall be provided with roof drain heads and complete with shoes bends, junctions, sockets, adapters, brackets and finished with anti-corrosive painting over a coat or primer.

For design of building drainage system IS: 1742 shall be followed.

For sanitary / sewerage pipes above ground, sand cast iron pipes conforming to IS : 1729 with leak proof lead joints.

For underground drain pipes, minimum class NP - 2 pipes conforming to IS: 458. At road crossings, concrete pipes of class NP 3 conforming to IS: 458 and at rail crossing RCC box culvert to be provided.

For sewerage below ground stoneware pipes conforming to IS: 651 with concrete bedding and haunch.

5.23.19 **Roof Details**

Roof slabs for CHP, LHP, BHP and GHP buildings shall be minimum 150 mm thick (in case of metal decking thickness shall be measured from crest top) and shall have minimum 10 dia HYSD reinforcement bars placed at 200 mm center both ways at top and bottom.

1000 mm high and minimum 100 mm thick RCC parapet wall shall be provided over roofs of all buildings. However, for mummty, 600mm high parapet wall shall be provided. Parapet wall shall have suitable coping. External face of parapet wall of the buildings provided with metal cladding shall also be finished with metal cladding of design and colour as per approved architectural drawings.

Junction of roof and parapet shall be provided with 150 x 150 mm size concrete fillet.

Drain level shall be provided with 45 x 45 cm size khurras having minimum thickness of 30 mm of M-15 concrete over PVC sheet of 1 m x 1m x 400 micron and finished with 12 mm 1 : 3 cement : sand plaster.

Roofs of all M. C. C./control rooms, crusher house and TP (if applicable), penthouse etc., shall have roof water proofing treatment. Roof water proofing treatment shall be as mentioned elsewhere in specification.

Roof of pump house shall be provided with single skin troughed profile permanently colour coated sheet with slope of 1 in 5 for quick drainage of rain water.

5.23.20 Floors and Grade level details

5.23.20.1 VOID

5.23.20.2 The floor slabs shall be minimum 150 mm thick (in case of metal decking thickness shall be measured from creast top) and shall have minimum 10 dia HYSD reinforcement bars placed at 200 mm center both ways at top and bottom. The RCC slab shall be designed without considering any composite action effect of metal deck sheet (ie the structural strength of metal deck sheet shall not be considered for RCC slab design).

Floors of transfer points shall have cross slope of not flatter than 1: 80, towards the floor washing drainage outlets, for efficient drainage. For ground conveyor & crusher house slope shall be 1:100.

Chequered plates (used for floors, walkways etc.) shall be minimum 6 mm thick o/p or as indicated on drawings. The chequered plate pattern shall be approved by Employer / Engineer. Mild steel flats/angles of suitable size shall be welded to the bottom portion of chequered plates at a designed spacing to stiffen chequered plates to restrict deflection within span/200. Chequered plates shall be fixed by staggered welding of suitable size.

Toe guard of size 100 x 6 mm shall be provided at various openings provided in floors e.g. around stair case openings, chute openings and other similar cutouts. For conveyor walkways, angle runner to act as toe guard shall be provided.

All along the periphery of RCC floors (where no brick masonry walls are provided) 100 mm thick 300 mm high RCC wall and 900 mm high steel handrails all around over this RCC wall shall be provided.

The grade slab shall consist of 230 mm thick rubble soling (63 mm downgraded hard stone aggregate as per IRC specification, watering and compaction to minimum of 90% Standard Proctor density, including filling the interstices of stone aggregates with sand), over well compacted earth, overlaid by 75 mm thick P. C. C. M-7.5 and 100 mm thick RCC of grade M-25 with minimum 8 mm dia bars placed at 200 mm C / C in either direction respectively. There will be minimum 50 mm thick metallic hardener finish over the RCC slab.

All buildings (including Wagon Tippler and machinery hatches, truck hopper, penthouse, MCC rooms, pump houses, transfer houses and crusher house) and ground conveyors shall be provided with 750 mm wide plinth protection all around. It consists of 50 mm thick P.C.C. M-25 grade with 12 mm maximum size aggregate over 200 mm thick stone soling using 40 mm nominal size rammed, consolidated and grouted with fine sand.

An area of 5 m width all-round the water tanks near pump house, transfer houses and crusher house, Gypsum storage shed, truck tippler area, HGTU, VGTU, storage silo shall be paved. This paving will be in addition to plinth protection in case of building. The paving construction shall be as per specifications for the grade slab at ground level. However, 50 mm thick metallic hardener finish is not required to be provided in paved area.

Heavy duty paving shall be provided inside the building (Gypsum storage shed) if any vehicular movement is envisaged.

Finished Floor level of all buildings shall be kept at least 500 mm above the finished grade / formation level.

5.23.21 Brickwork and allied masonry works

Brickwork cladding for various structures shall be so provided that there is a clear gap of 40 mm between inside face of external brick wall and outside face of column flange. Structural steel wall beams supporting brickwork shall be provided at a maximum spacing of 3m and suitably encased with plaster or 1:2: 4 concrete as the case may be. In case of box type steel beam, encasement shall be done with cement sand plaster in specified thickness and proportions over G. I. wire netting of 0.9 mm thickness.

50 mm thick Damp proof course shall be provided at plinth level for all brick wall.

5.23.22 CONCRETE

Refer General Specification.

5.23.23 De-watering of Deep Excavations

For deep underground structures like wagon tippler, track hopper, truck hopper, reclaim hopper, tunnels and underground transfer houses, requiring open excavation with extensive de - watering, completely dry working conditions during excavation, shuttering, placement of reinforcement, concreting, water proofing of structures, backfilling and any other operation shall be maintained by suitable de - watering method of suitable capacity.

Suitable Earth Retaining structures shall also be provided if required to ensure the safety of existing structure/facilities.

5.23.24 Galvanizing

All burrs and irregular edges of the structural steel members to be galvanized shall be ground smooth before galvanizing.

Purity of Zinc to be used for galvanizing shall be 99.5 % as per IS : 209 (latest edition).

The weight of the zinc coating shall be at least 610 Gms. / m^2 unless noted otherwise.

5.23.25 Waterproofing Underground Structures

The following requirements are applicable to all underground structures such as Tunnels, Wagon tippler, Underground TP and Track hopper and any other structure wherever specified.

General Requirement for water proofing

Procurement of waterproofing material shall be from a single manufacturer, long-term engaged in manufacturing waterproofing. All components and elements, which are needed to make the structure watertight, shall be proven to work together. There shall be a single source of responsibility and performance of the products. The manufacturer shall confirm full and proven compatibility of the entire waterproofing system in writing. The waterproofing system provided shall be installed without damage and protected against construction operations. The waterproofing system shall be designed to be fully effective over the design life of the structure (30 years) and shall be designed to fulfil all requirements according to the specification. Particular attention shall be paid to the compatibility of interfaces and junctions with adjacent structure. The water-tightness standards to be applied to all underground, water retaining or water excluding structures shall be in accordance with free from all visible, leakage, seepage and damp patches. Dampness shall be defined as moist to touch with no visible film of water.

The material, application and protection requirements shall be as follows:-
Fully bonded membrane shall also confirm to the requirement of IS 16471-2017 “Protection of below ground structures against water from the ground – Guidelines” with following or Equivalent requirements.

5.23.25.1 HDPE membrane system : For Raft water proofing

The HDPE membrane should conform to the following parameters with shall be consider as minimum requirement.

(i) Minimum composite thickness of HDPE layer 1.5 mm
(ii) Resistance to hydrostatic head greater than 50m as per ASTM D 5385
(iii) Minimum peel adhesion to concrete greater than 880 N/m as per ASTM903
(iv) Minimum tensile strength 25 Mpa ASTM D412
(iv) Minimum Puncture resistance 1000N as per ASTM E154
(iv) Minimum Elongation 400% as per ASTM D412

Surface Preparation

1. The water proofing area should be protected with proper barricades.
2. The substrate must be free of loose aggregate, slush, mud, sharp protrusions and stagnated water.
3. Ground water level needs to be kept under the PCC level, continues dewatering to be done till completion of concreting
4. The surface does not need to be dry but standing water must be removed.

Method of Application

1. Final cleaning the surface
2. Place the fully bonded preformed HDPE membrane, 1.5 mm thick with HDPE film side facing onto the PCC substrate and sand finish facing towards the concrete pour.
3. Leave the plastic release liner in position until overlap procedure is completed.
4. Accurately position succeeding sheets to overlap the previous sheet 75 mm along the marked selvedge. Ensure the underside of the succeeding sheet is clean, dry, and free from contamination before attempting to overlap.
5. The HDPE membranes shall be welded/bonded together as per manufacture recommendation.
7. In case of any minor damages in the laid HDPE membrane, the area shall be marked and sealed with another patch of HDPE membrane with appropriate bonding.
8. On completion of quality inspection of membrane, reinforcement laying for raft slab shall be taken up and concrete casting for raft slab shall be done accordingly, the membrane gets bonded to the poured concrete.
9. Termination on vertical: Plywood shuttering: HDPE shall be taken up to a height of 300mm on the vertical inside the shuttering from PCC surface for future overlapping of Hybrid Polyurea Polyurethane coating.

5.23.25.2 Hybrid polyurea system : For wall and top slab water proofing

Material specification: Waterproof Coating (Vertical)-Providing and spray applying of two-component, rapid curing hybrid polyurea system- Polyurea for retaining walls and other sub structure walls at 1.5mm (Minimum) thick as per manufacturer specification.

The cured membrane (Hybrid Polyurea) shall have the following minimum properties
(i) Solids by Volume : 100%,
(ii) crack bridging 2 mm ASTM C1305
(iii) Puncture resistance more than 600 N ASTM E154;
(iv) Tensile strength ASTM D412 : more than 13 MPa
(v) Tear Resistance ASTM D624C : more than 50KN/m
(vi) Elongation ASTM D412 : more than 450%
(vii) Shore A ASTM D2240 : 80

Preparation and procedure:

1. The entire area shall be taken up for thorough surface preparation and mechanical removal of debris, laitance, protrusions, etc.
2. Removing PVC pipe from tie rod holes & exposed rod if any to be cut 15 mm inside from the surface.
3. All honeycombs, concrete defects and surface undulation must be treated as per standard procedure.
4. All concrete surface to be completely cured and surface to be given to receive waterproofing system as per Consultant's approval.

Method of Application

1. Final cleaning the surface by grinding the surface thoroughly.
2. Packing the tie rod hole with non-shrink grout.
3. Along the construction joint make a V groove of approx. 15mmx15mm. Pack the joint with cement mortar 1:4 admixed with integral water proofing compound.
4. Injection grouting (cementitious grouting) must be done at all construction joints, angle fillet areas at 0.75m C/C through the PVC nipples with 40PSI grout pump using cement slurry mixed with non-shrink admixture @225gms per bag of cement.
5. Ensuring that the surface moisture content to be less than 8%.

6. Laying double sided tape over the extended HDPE membrane on vertical surface to create adhesion for hybrid polyurea coating to bond.
7. Priming the surface with two component Solvent free epoxy primer applied using roller/brush with a total consumption of 200 gms /Sqm. Primer should be allowed to dry for a period of minimum 2-4 hours depending on the weather condition.
8. Using spray machine, applying two component Hybrid Polyurea Polyurethane coating in two layers with a total consumption of 1.6 kg/Sqm to achieve system thickness of an average 1.5 mm DFT.
9. Allow the membrane to cure completely for 24 hours as per the site and weather condition.
10. Fixing 8 mm dimple thick board over the entire membrane as a protection to the waterproofing keeping 75mm overlaps by spot bonding method using synthetic rubber adhesive.
11. Backfilling should be done at every 300 mm using soft soil and should be done carefully without harming the membrane. Backfilled soil will act as a working platform for further stages.

Other Conditions

Waterproofing materials shall be installed only by the manufacturer of the products or his approved applicator. Proper accessories such as anchor strips, pipe collars, outside and inside corners, steel laminated plates etc. shall be used for the correct and secure application of the waterproofing system.

Application of waterproofing system shall only commence upon completion of curing of the concrete. The Contractor shall ensure that surfaces to which waterproofing is to be applied shall be clean, dust free and dry and shall be prepared fully in accordance with the manufacture's recommendation. No laying shall be commenced until all rough edges and excrescencies have been removed from the surfaces to receive the membrane. Surface depressions shall be filled in accordance with consented-to procedures and the filling allowed to set. The surface to be waterproofed shall be thoroughly cleaned, dried and swept, and kept clean and dry at all stages until the work is complete.

All cracks on exposed surfaces of external structural members shall be effectively sealed before applying any waterproofing system. Inside rendering shall not be accepted as a method of making the joint watertight. Where external walls above the base slab are to be constructed in open cut, the membrane laid beneath the base slap shall extend 300mm beyond the limits of the structural slab in order that waterproofing to the wall may be lapped on to it. Blinding concrete beneath the membrane shall extend 300mm beyond the limits of the structural slab. Membrane from wall shall continue to roof slab with suitable arrangement to change the plane.

The Engineer may require the Contractor to carry out a trial application of the waterproofing materials for the proposed waterproofing system. No waterproofing works shall commence without the written consent of the Engineer.
Where membrane is used for waterproofing external walls, the membrane shall be protected against damage due to backfilling, compaction and ground settlement with dimple board. Providing & Fixing of 8 or 10 mm thick dimple board of compressive strength not less than 200kN/m2 with proper overlaps. The dimple board shall be fixed on the walls using suitable adhesive by spot bonding.

In case of partially underground structures, the water proofing layer shall be taken up to 300mm above the ground level and turned horizontally into a 20mm x 20mm chase cut into the wall face and sealed with a polysulphide compound.

5.23.25.3 Expansion joint

FPO (Flexible polyolefin Tap) based waterproofing membrane shall be provided in construction joints and expansion joint with specifically formulated single-ply of minimum width 200 mm, thickness 1mm membrane fixed at both ends of the external face of the expansion joint on the walls,roof using epoxy bonding adhesive and laid loosely at middle in the expansion joint. Waterproofing tape to be anchored using epoxy adhesive for a width of 75mm on either side of the joint and leaving 50mm in the centre for allowing necessary movements The waterproofing system shall be overlapped and covered with protection medium before back filling. The waterproofing tape shall have a Tensile Strength- 12.5.0 N/sqmm, Elongation at break- 400%, Water tightness, 60 kPa/24 Std (As per DIN EN 1928-A) and Water tightness, 400 kPa/72 Std (As per DIN EN 1928-B) above joint followed by another layer of epoxy adhesives complete as per specification.

In addition to FPO tap, copper strip shall be provided in expansion joint as specified in the specification.

Fillers and Sealant to Expansion Joints

All materials used to fill expansion joints shall be such that they will accept the calculated movements of the joints without extrusion and shall not shrink away from either surface of the joints. Consented-to backing strips and fillers shall be used in accordance with the manufacturer's recommendation. Where joints are required to be filled with consented-to polysulphide or polyurethane sealant, the material shall comply with BS 4254 or BS 5212. The appropriate sealant grades shall be used for horizontal and vertical joints, and the joints shall be thoroughly cleaned and primed with the appropriate primer before applying the sealant. The sealant shall be of a colour to match as nearly as possible the colour of the adjoining surfaces where it is to be permanently exposed. The sealing material shall be used and applied strictly in accordance with the manufacturer's instructions. The Contractor's attention is drawn to the undesirability of the sealant being smeared over the adjacent surfaces, and appropriate precautionary measures, including the use of masking tape, shall be taken to avoid this.

5.23.25.4 CHEMICAL INJECTION GROUTING

Minimum, 12 mm dia(NB) threaded nozzle of suitable length, shall be provided over the surface and along the construction joint line in a grid pattern at a spacing not exceeding 0.75 m c / c before concreting operation. Adequate precaution shall be taken to keep the nozzles plugged at both ends to prevent them from getting closed by concrete.

For fixing of any nozzle in set concrete suitable size hole shall be drilled, preferably by using repercussive hammer drill electrically operated, in grid pattern and grouting nozzle shall be fixed in these holes.

After the nozzles are fully set, neat cement slurry admixed with water soluble non - shrink polymer / monomer based chemical shall be injected through the net - work of nozzles with low pressure grout pumps at a pressure of about 2.0 Kgs. / cm2. Cement slurry shall be prepared by mixing cement with non-shrink polymer/monomer @ 500 gm/50 kg bag of cement and water, ensuring that Water: Cement ratio does not exceed 2 (by weight). Wetter the structure, lesser should be the water cement ratio. The property of the polymer/monomer should be such that when it is mixed with water @0.5% by weight of water, the viscosity of the resultant solution (water and polymer/monomer) should not be more than 1.2 centipoises. Plasticizing agent shall be added wherever required. The grouting shall be started at very low pressure and increased gradually to a required pressure. The grouting shall continue, till the hole refuses to take any further grout, even at an increased pressure. Applied pressure shall

not be more than the designed strength of the concrete. After completion of grouting operation, the nozzles shall be sealed properly to the satisfaction of the Engineer.

5.23.25.5 **Submissions, Method Statements, Working Drawings and other requirements.**

The contractor shall include details of his intended waterproofing methods in his design submissions for approval of the Engineer. Manufacturer's literature shall be provided to confirm the suitability of the proposed details. The Contractor shall produce and submit comprehensive Working Drawings showing all details and procedures for waterproofing of the Works. The proposed waterproofing material shall be suitably resistant to all chemicals with which they are likely to come in to contact.

5.23.25.6 **Warranty**

All waterproofing systems shall be warranted for a minimum period of ten (10) years from the date of Commercial operation Declaration (COD) of respective units. The warranties shall cover the whole of the waterproofing systems and shall be given jointly and severally by the Vendor.

5.23.27 **Miscellaneous**

5.23.27.1 Ordinary form work shall be used in roofs and floor slabs in transfer houses, footings, pedestals, cable trenches, pits etc., Plywood form work shall be used for all over ground exposed work like columns, beams, floors and ceilings in control room and M. C. C. buildings.

5.23.27.1 Monorail girders and fixtures shall be provided for monorails at the locations as required and as described elsewhere in these specifications or drawings. Monorail openings in the walls shall be provided with steel frame doors preferably sliding type or otherwise open able inside, access platforms and ladders.

5.23.27.1 Steel frame around openings in roof and on external walls for mounting of exhaust fans shall be provided.

Ready mix non - shrink cementitious grout of reputed manufacturer as approved by the Employer shall be used for grouting of block outs and foundation bolts, underpinning of base plates and machine bases. Crushing strength of grout shall be one grade higher than the foundation concrete. Minimum crushing strength shall be 30 N / mm^2 unless higher strength requirement is specified by the equipment supplier or the grout manufacturers.

The bottom of steel in case of cable / pipe galleries and trestles shall be generally 3m above the ground except for rail / road crossing where it shall be 8m above the rail top / road crest/ground. Further in bunker areas it shall be 8 m above the ground.

Polysulphide Sealing Compound shall be two-part polysulphide sealant and shall be from approved manufacturer, conforming to IS : 12118. Materials shall consist of polysulphide polymer and a curing agent. Gun grade material shall be used unless otherwise specified. The application of the sealant shall be strictly followed as per manufacturer’s guidelines.

5.23.28 **SHOTCRETING**

General Requirements

Generally, shotcreting shall be done in accordance with IS : 9012.

Reinforcement for shotcreting shall be as detailed below, unless specified otherwise.

(a.) Reinforcement in one direction consisting of 6 mm M. S. bars at 750 mm c / c shall be connected to the lugs for fastening of the wire fabric. This shall be used in case of 50 mm or above thick shotcreting.

(b.) Wire fabric conforming to IS : 1566 shall be used as reinforcement and shall consist of wire, 3 mm diameter, spaced 50 mm both ways and shall be electrically cross welded. Wire fabric shall be securely tied to 6 mm bars for 50 mm thickness. Adjacent sheet of wire fabric shall be lapped at least 100 mm and tied.

(c.) Clear cover to reinforcement mesh shall not be less than 15 mm.

Minimum thickness of shotcreting shall be 50 mm for abrasion resistant work and 25 mm for ordinary surface protection work.

Material

Generally, the materials shall be in accordance with aggregates specification given here under.

Fine aggregate shall consist of natural sand or crushed stone from a known source and shall be strong, hard, coarse, sharp, chemically inert, clean and free from any coating. It shall be free from clay, coal or coal residue, organic or any other impurities that may impair the strength or durability of the concrete and shall conform to IS : 383.

Fine aggregate (Sand) shall be well graded and particles shall range in size within the following limits. The Engineer, may approved the use of any other grading as per requirement or as per IS : 9012.

The fineness modulus shall be preferably between 2.5 and 3.3. Any other value can be used, with prior approval of the Engineer.

Application

After the placement of reinforcement and / or welded mesh and not more than six hours prior to the application of shotcrete, the surface shall be thoroughly cleaned of all loose materials and dirt. The Contractor shall properly prepare the surfaces, reinforcement and / or welded mesh to receive the shotcrete. Cleaned surfaces shall be wetted not more than hour prior to shotcreting.

The mix as placed on surface shall be one part cement to three parts approved sand by mass. Cement and sand shall be dry mixed; not water shall be added after mixing and before using in the gun. The quantity of water when added shall be only that which is sufficient to hydrate the cement. For average atmospheric conditions, the water cement ratio for shotcrete in place shall be between 0.35 and 0.5 by mass. Suitable admixture shall be used wherever required.

A uniform pressure of not less than 3 kg/cm2 at the nozzle shall be maintained. Necessary adjustments shall be made to ensure this pressure, taking into account the length of hose and height of the place to be shotcreted, above location of the machine.

The application shall proceed in an upward direction. Beams, stiffeners and intermediate walls, if any, shall be wrapped with wire fabric and completely covered with shotcreting. All rebound shall be removed from the area of application as the work progresses and such rebound material shall not be reused.

As soon as the freshly shotcreted surface shows the first dry patches, a fine spray of water shall be applied to keep too moist. After the surface has hardened, it shall be kept continuously moist for minimum seven days. If there is extreme heat, especially when accompanied by hot winds, the shotcreted surface, immediately upon completion, shall be covered with burlap or similar covering, which must be kept continuously moist for 14 days after shotcreting. The temperature of the lining shall not be permitted to exceed 38°C during placing and curing.

5.23.29 VIBRATION ISOLATION SYSTEM

These specifications are meant for the design, supply and erection of vibration isolation system for supporting coal/limestone crushers.

Supporting Arrangement

- The crushers shall be supported on vibration isolation system consisting of steel helical springs and viscous dampers. The supporting arrangement for each crusher shall consist of an RCC deck supported on steel helical spring units and viscous damper units which in turn shall be supported on girders. The girders shall be an integral part of the crusher house building.

The part of the structure consisting of the RCC deck, springs and viscous dampers shall hitherto be referred to as “spring supported foundation”. The part of the structure, which is below the spring shall hitherto be called “supporting structure”.

The Contractor should do the Engineering / design, supply and erection of vibration isolation system consisting of steel helical spring units and viscous dampers supporting the top deck which in turn would support the coal/limestone crushers. The vibrations isolation system supplied shall be of a proven make. The Contractor or his sub - contractor who designs and supplies the system should have designed, supplied and installed such systems for not less than five machines of speeds and unbalance forces comparable to the machine proposed by the vendor. The vibration isolation systems installed by the contractor or his sub - contractor in such machines should have been working satisfactorily for atleast five years

5.24.00 VOID

5.25.00 VOID

5.26.00 O&M STORE BUILDING

Salient Features:
The scope of work of the Bidder shall be design & construction of all Civil, Structural and Architectural, water supply, plumbing& sanitary works of the O&M store building including supply of all materials.
The Permanent store Building shall comprise the following:

a) Heavy Material Storage Hall

The Heavy Material storage Hall shall have a Single Bay framed superstructure with RCC/Structural steel columns and structural steel roof truss and purlins supporting pitched

roof. The roofing of the Heavy Material store shall be permanently colour coated insulated sandwiched metal sheet. An EOT crane shall be provided with chequered plate walkways at both ends inside the bay of the Heavy Storage Hall. The capacity of the EOT crane shall be 30MT. The clear height up to the bottom of roof truss of the Heavy material storage hall shall be finalized based on equipment/spare to be handled.

b) Light Material Storage Hall

The Light Material Storage Hall with 3 tier Rack system shall have a Single Bay framed superstructure with RCC/Structural steel columns and structural steel roof truss and purlins supporting pitched roof. The roofing of light material store shall be permanently colour coated insulated sandwiched metal sheet. The light material store shall be fully covered with external brick wall of 250mm thickness with provision for doors, windows, rolling shutters as per architectural concept.

c) General Light Material Storage Hall

The General Light Material Store shall be RCC structure with cast in situ RCC beams & slabs. The RCC building shall be two storied and all beam column joints shall be designed and detailed for adequate ductility.

d) Office Complex

Office complex of this store shall be a single storeyed RCC building.

Architectural Features

Total Foor area of the Permanent store building shall be 3000sqm.
The minimum clear floor area of Heavy material storage hall shall be approximately 20% of the total area of the Permanent store with bay width of 15m and clear floor height of 12.5m. Heavy material store shall have column free space for easy movement of materials. The Heavy Material storage hall shall be fully covered with external brick wall of 250mm thickness with provisions for doors, windows, rolling shutters as per architectural concept.

The minimum clear floor area of Light Material Storage Hall (with 3 tier storage) shall be approximately 33% of the total floor area of the Permanent Store. The height of the Light Material Storage Hall (with 3 tier rack system) from ground floor slab to bottom of roof truss shall be 10.0m. A part of light material store shall have facility for storing electronic equipment / instruments. Other Part of building shall have Light Material storage of two storyed with floor area of 600 sq.m. at each floor and clear height of 3.5 m. A part of this light material store shall have facility for storing electronic equipment / instruments. This particular area shall be air-conditioned for dust proof environment.

The General Light Material Store shall be two storied building, completely covered with 250mm thick brickwork, doors, windows & rolling shutters. The plan of the building shall be rectangular in shape with minimum floor area of approximately 20% of the total floor area of the Permanent Store.

The area of the office complex building shall be approximately 17% of the total floor area of the Permanent Store, with clear height of 4.0m. The external Wall shall be 250mm thick brick wall with provisions for doors and windows.

The central office shall be provided for management and monitoring the stored materials. Adequate space shall be kept for loading unloading of materials. Office shall space for

Supervisor/In-Charge room, general office cum record-documentation area, toilets, pantry, etc. shall be provided as per requirement.

All the above mentioned four buildings shall be interconnected by means of a covered passage 5.0m wide.

External finish shall be of Premium Acrylic Smooth Paint with Silicone additives over Texture Coat.

5.27.00 **VOID**

5.28.00 **VOID**

5.29.00 **VOID**

5.30.00 **VOID**

5.31.00 **VOID**

5.32.00 **VOID**

5.33.00 **Safety Control Room**

Safety control room shall be a single storyed RCC framed building of minimum area 60sqm to accommodate equipments and personals as mentioned in C&I chapter for 24X7 operation. Additionally, it shall have ladies and gents toilet, space for water cooler and Pantry.

5.34.00 **BIO TOILET**

Bio-Toilet shall be provided near all the Shed for Construction Workers and O&M Workers, CHP building outside the plant boundary. Besides these areas, any toilet block provided in area far from plant boundary shall be a Bio-toilet.
Bio-toilets shall be made for anaerobic bacterial decomposition of human waste. After decomposition and treatment of the human waste, the residual water from Bio-Toilet shall be: colorless, odorless , devoid of any solid particles and shall have pathogen inactivation by 99%. The water thus obtained shall require no further treatment / waste management and shall be used for irrigation purposes.
Bio toilet shall have all fixtures that shall include following fixtures besides the requirements stipulated by DRDO standards.

a) One number wall mounted colored (excluding premium colors) glazed vitreous China European water closet and flushing valve system, water faucet, toilet paper holder as per IS:2556

or

One number white glazed vitreous China Orissa pan (580 x 440 mm) and flushing valve system, toilet paper holder as per IS:2256

b) One number colour (excluding premium colors) glazed ceramic oval shaped wash basin 450x 550 mm (approx.) mounted over 20mm thick granite beveled edge counter fitted with photo-voltaic control system for water controls, bottle trap as per IS:2556. For common toilets, number of washbasins shall be as per requirement. However, for Pump Houses the same shall be provided without photo voltaic control system for water control.

c) For Male Toilets Urinal as per requirements, with all fittings with photovoltaic control flushing system as per IS: 2556.

d) One number looking mirror 600 x 900 x 6 mm, edge mounted with teak beading and minimum 12 mm thick plywood backing, one number stainless towel rail 600 x 20 mm, one number liquid soap dispenser

Bio toilet/Bio digester shall be comprised of four compartments and a soak pit. The size of the tank shall be as per the number of users. This four-compartment tank shall be constructed underground and shall be made of FRP with required strength as stipulated by DRDO norms. The bio-toilet constructed shall have S-trap and ball valve for ease of operation and maintenance. It shall have all necessary arrangement and fixture for future operation and maintenance as per manufacturer guidelines.

5.35.00 **VOID**

5.36.00 **SHED FOR CONSTRUCTION WORKERS AND O&M WORKERS**

RCC framed structure with truss roof provided with insulated sheeting catering to 20. No of workers each (approximately 29m x7.5m area) with common rest room, cooking area, Food serving kiosk, drinking water facility, toilet and bathing area along with covered verandah for easy approach to facilities. The rest room should be well ventilated. The rest rooms to be scattered as per work locations and suitably located in GLP. Minimum 6 nos of Workers Rest Room shall be constructed. Rest Room for O&M workers shall be constructed at the Start of Project construction work.

External finishes shall be Premium Acrylic Smooth Paint Premium smooth Exterior Paint with silicone additives over Texture Coat.

5.37.00 **VOID**

5.38.00 **OTHER BUILDINGS**

For all other buildings mentioned in the scope of work but requirement/details not furnished in this chapter, the Bidder shall develop the details of such buildings based on the functional and statutory requirements.

Any other facilities/structures that would be required, as per the system requirements covered under various sections/chapters of this specification but not covered here above.

SUB-SECTION-D-1-6

DESIGN CRITERIA

D-1-6 DESIGN CRITERIA

6.01.01 **General**

The design criteria given herein is applicable for all sub-structure, super-structure works/ buildings/ facilities and various other works included in the scope of the Bidder.

6.01.02 Structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, piping loads (static, friction and dynamic), earth pressure & surcharge loads, hydrostatic & hydrodynamic loads, wind loads, seismic loads and temperature loads. In addition, Erection loads, loads and forces developed due to differential settlement shall also be considered.

6.01.03

i) All the buildings shall have framed super structure. If the superstructure of building is a steel structure, the framed superstructure shall be moment resisting sway frame in the lateral direction and axially braced in the orthogonal direction. For columns having depth of 1000mm & above, the longitudinal bracings shall comprise a pair of members (spaced) with spacing equal to the column depth. Columns having depth less than 1000mm may have bracing in single plane and at the centerline of column. In both the cases (single bracing or pair of bracing) detailing shall be adequate to restrain the entire column cross-section including both the flanges. Only where axial bracing to one vertical plane is to be waived due to functional requirement, columns in that vertical plane may be allowed to undergo biaxial bending. Beam column joints shall be detailed as per seismic resistant joint with adequate ductility.

All 2-legged structural steel trestles shall be completely braced in the vertical plane. All 4-legged structural steel trestles shall be completely braced in all four vertical planes. In addition, specified horizontal planes shall be completely braced to provide stiffness against torsional sway.

If the superstructure is RCC structure, the superstructure shall be moment resisting sway frame in both orthogonal direction and all the members shall be designed for biaxial bending. Design of RCC structures shall be done as per IS 456. Detailing for ductility shall be followed as per guidelines of IS13920 to be effective against seismic load. Design of liquid retaining structures shall be done as per IS 3370.

ii) The Bunker building, transfer towers, conveyor galleries and trestles, crusher house, boiler, ESP Control Building, ESP supporting structures, including inlet and exhaust duct support structures, Compressor House, Pipe cable Gallery shall have structural steel framed super structure.

iii) All other buildings may have either RCC or structural steel framework.

iv) All buildings having RCC framing shall have masonry cladding of minimum one masonry unit thickness (not less than 225 mm.) on exterior face.

6.02.00 **Loading**

For consideration of loads on structures IS : 875 - 'Code of practice for structural safety of buildings' shall be followed. In addition to the dead load, live load, equipment load (including impact / vibration), Temperature loads etc. various loading conditions arising due to operation and maintenance of equipment shall be considered in the design.

6.02.01 **Dead loads**

Dead loads shall include the weight of structure complete with finishes, fixtures and partitions and shall be taken as per IS: 875 (Part-I)

6.02.02 **Imposed loads**

Imposed loads in different areas shall include live loads, erection, operation and maintenance

loads. Equipment loads (which constitute all loads of equipment to be supported on the building frame) are not included in the imposed loads furnished below and shall be considered in addition to imposed loads.

For consideration of imposed loads on structures, IS:875 (Part-2) "Code of practice for design loads (other than earthquake) for buildings and structures" shall be followed. The following minimum imposed loads as indicated for some of the important areas shall however be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered.

Sl.No.	Location		Imposed Loads (T/Sq.m.)
A)	Mill and Bunker Bay		
	i)	Ground floor	2.5
	ii)	Feeder floor	0.50
	iii)	Tripper floor	0.50
	iv)	Roof	0.15 (Where no equipment are located) 0.50 (Where equipment are located) 0.075 (For Inaccessible roof)
B)	Turbine Building		
	i)	Ground floor (general)	2.50
	ii)	Ground floor (heavy equipment storage area)	5.00
	iii)	Mezzanine floor	1.00
	iv)	Operating floor	
		a) Rotor Removal area	5.00
		b) Equipment lay-down area	3.50
		c) Other areas (corridors, etc.)	1.50
	v)	Gratings, chequered floors, walkways, platforms, stairs, etc.,	0.50
	vi)	Roof (Where no equipment is located)	0.15
C)	Deaerator and Heater Bay		
	i)	H.P/L.P. heater floor	1.00
	ii)	Deaerator floor	1.00
	iii)	Cable gallery	0.50

		(In addition to this, actual cable load shall be considered)	
	iv)	MCC, switchgear and Control building floors	1.00
	v)	Roof (Where no equipment are located)	0.15
		(Where equipment are located)	0.5
	vi)	A.H.U Room, Battery Room, Air Washer Room	1.0

D) Coal, Bio mass, Limestone and Gypsum handling structures

i)	Roofs	150 kg. / Sq. M. for accessible roofs and 75 kg. / Sq. M. for non - accessible roofs. In addition to this coal dust load (Dead load) of 150 Kg. / sq. m. on flat roofs & 25 kg. / sq. m. on inclined roofs shall also be considered.
ii)	Conveyor galleries	In addition to the live loads, loads due to cable trays, fire fighting / service water pipes shall also be considered @ 125 kg. / m (minimum) on each of the longitudinal girder. Roof-truss members are to be checked for supporting fire fighting pipes/ Service water pipes. Tentative locations and diameter for pipes are shown in Tender Drawing. In addition to this coal dust load (Dead load) of 50 kg. / sq. m. on walkway way shall also be considered.
iii)	Covers for trenches / channels/ drain	Covers for channels & trenches, shall be designed for a live load of 0.4T Sq. M. and loading as mentioned under clause in trenches, whichever is critical.
iv)	Sumps and tanks and other underground basement type structures/ drain	In addition to earth pressure with a surcharge of 2T / Sq. M. (or surcharge due to Railway loading whichever is critical for Railway load bearing structures etc.) and sub - soil water pressure etc. These are also to be designed for the following conditions : i) Water / liquid inside and no earth outside (applicable only to such structures which are liable to be filled up with water or any liquid). ii) Earth with surcharge outside and no water / liquid inside

iii) For underground (basement) structures protection against buoyancy during execution and after execution shall be ensured without superimposed loadings with minimum factor of safety of 1.2 against buoyancy.

v) Unit weight of bulk materials

a) For structural design
i) Lime stone 1700 kg. / Cu. M.
ii) Gypsum 1250 kg. / Cu. M.
iii) Coal 1100 kg. / Cu. M.
iv) Bio mass 1000 kg. / Cu. M.

For sizing calculation
v) Lime stone 1400 kg. / Cu. M.
vi) Gypsum 1100 kg. / Cu. M.
vii) Coal 800 kg. / Cu. M.
viii) Bio mass 600 kg. / Cu. M.

E) Boiler/ ESP Support Structures

i.	Operating Floors	1.00
ii.	Separator Floor	1.00
iii.	Elevator Machine Room	1.00
iv.	Maintenance Platforms	1.00
v.	Equipment Laydown Loads	As per Equipment supplier or 1.00 whichever is more.
vi.	Lift Structure	As per Equipment supplier with 100% impact factor

F) Pump Houses
Operating floor 1.50

G) Underground Structures such as Channels, Sumps, Underground Pump House, Tanks, Trenches, Reservoirs, C.W. ducts etc.

In addition to earth pressure and ground water pressure, the surcharge load of 2T/sq.m. shall also be considered for design of all underground structures.

H) Road Culverts/Bridges and its allied structures including RCC Pipe Crossings and Road Crossing of Trenches.

Design for class 'AA' loading (wheeled and tracked both) and checked for class 'A' loading as per IRC Standard.

I) Covers for Channels/trenches — 0.40 (General) or central point load of 75 kg whichever is higher
As per IRC Standard
(at road crossings
for vehicular traffic)

H)	Railway Supporting Structures, Rail Culverts		As per Railway 'Bridge Rules'
I)	Conveyor Galleries		In addition to the live loads, loads due to cable trays, firefighting / service water pipes shall also be considered @125kg/m (minimum) on each of the longitudinal girder. Roof-truss members are to be checked for supporting firefighting pipes/ Service water pipes.
J)	General (Unless Specified Otherwise)		
	i)	Stairs, Landings and Balconies	0.50
	ii)	Toilets	0.20
	iii)	Chequered plates, grating floors, etc.	0.50
	iv)	RCC floors (General)	0.50
	v)	a) Flat Roofs (where no equipment are located)	0.15
		b) Flat Roofs (where equipment are located)	0.50
		c) Inaccessible roof	0.075
	vi)	Inclined Roofs	As per IS : 875 (Part-II)
	vii)	Dust load on roof	0.050
	viii)	Walkways (General)	0.50
	ix)	Walkways of conveyor galleries, DM & PT	0.30
	x)	Floor of control room of switchyard control building	1.00
	xi)	Cable and pipe trestles	0.40 for walkway and in addition, friction loads as applicable
	xii)	Grating covers/ Precast RCC covers for drain, trench, sump pit in Ground floor/ paving of BTG area	2.50 As per IRC standard (at road crossings for vehicular traffic)

Notes:

a) If erection load is higher than the specified imposed loads on any floor or part thereof, then the erection loads are to be considered for the design.

b) Additional load for cable, piping/ducting, shall be considered as applicable. For any other structures, the loads specified for those structures elsewhere in the specification

CLAUSE NO.	TECHNICAL REQUIREMENTS
	shall be followed.
6.02.03	**Equipment, piping and associated loads** Equipment loads shall be considered over and above the imposed loads. Equipment loads shall be considered as given by equipment supplier.
6.02.04	**Crane load** For crane loads, an impact factor of 25% and lateral crane surge of 10% (of lifted weight + trolley weight) shall be considered in the analysis of frame according to the provisions of IS:875. The longitudinal crane surge shall be 5% of the static wheel load. Longitudinal surge and lateral surge shall not be considered to act simultaneously.
6.02.05	**Seismic load** For design of all structures, the site specific seismic design criteria as attached in Annexure-E shall be followed.
6.02.06	**Wind load** For design of all structures, the wind loads shall be taken as per the site specific wind data specified in Annexure–D of this specification.
6.02.07	**Temperature Load** For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation. Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns. ~~The maximum distance of the expansion joint shall be as per the provisions of IS 800 and IS 456 for steel and concrete structures respectively.~~
6.02.08	**Differential Settlement Loads** Structures shall be designed considering an additional load on account of differential settlement of 1 in 1000 between any two adjacent columns, subject to a maximum differential settlement of 8 mm in case of foundations resting on soils & 4mm in case of foundations resting on rock/ pile. These differential settlement loads shall be taken into consideration for design of footings & structures of Boiler & Mill Bunker, ESP supporting structure and Main Power House building. Further, in the analysis of differential settlement loads, adjacent columns interconnected with bracings are preferably to be provided with combined footing. In such cases, where rigid combined foundations are provided below braced columns, differential settlement between those columns needs not be considered. Moreover, when rigid raft is provided, the differential settlement amongst the columns supported on the rigid raft need not be considered. However, the differential settlement between the raft and the adjacent column footing of the same structure are to be considered. ~~In the structural analysis for differential loads, following approach may be considered: All the alternate columns in structure shall be applied downward displacement as described above and analyzed at a time. The resultant forces/ reactions shall be considered with reversible effects for design of structures and footings.~~
6.02.09	**Additional Loads** Following Minimum additional Loads shall be considered in the design of Steam generator structures, Mill & bunker buildings, Coal handling Transfer points and Trestles (in BTG island)

The maximum distance of the expansion joint shall be as per the provisions of IS 800 and IS 456 for steel and concrete structures respectively. In Limit state design, the partial safety factor for temperature load in load combinations shall be taken same as specified for dead load (DL) in Table 4 of IS 800: 2007 for steel structures and in Table 18 of IS 456 for concrete structures..
(Amendment No 01, D-1-04)

In the structural analysis for differential loads following approach be considered. All the alternate columns in structure shall be applied downward displacement as described above and analyzed at a time. The resultant forces/ reactions shall be considered with reversible effects for design of structures and footings. In Limit state design, the partial safety factor for differential settlement load in load combinations shall be taken same as specified for dead load (DL) in Table 4 of IS 800: 2007 for steel structures and in Table 18 of IS 456 for concrete structures.
(Amendment No 01, D-1-05)

and ESP structure.

(a) Cantilever Loads of not less than 2000 kg/m at a distance of 1200 mm from the external face of the columns, on both sides of the ESP, for Cable trays and Walkways.

(b) Cantilever Loads of not less than 500 kg / M at a distance of 1200 mm from the external face of the columns, on both sides of the Steam Generator, for Cable trays and Walkways.

(c) Cantilever Loads of not less than 2000 kg / M at a distance of 2500 mm from the external face of the Mill & Bunker Building columns, CHP transfer point columns/ VGTU columns & conveyor gallery trestles (on one side) for Cable trays and Walkways.

(d) Dry Fly Ash Piping Loads.

(e) Ash Water Piping Loads.

(f) Supply Air and Instrument Air Piping.

(g) Service Water Piping

(h) Loads associated with Coal Handling Plant equipment

(i) ~~Loads for Solar installations over roof to be taken not less than 1KN/sqm. Roof slab to be designed for local effect due to wind load at support location for installations~~

6.02.10
Loads for Solar installations over roofto be considered minimum 1KN/sqm or higher as specified by Solar Vendor. Roof slab to be designed for local effect due to Wind load at support location for installations.
(Amendment No 01, D-1-06)

6.03.00 **Civil Design Concepts**

6.03.01 Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion, etc.,

6.03.02 The different load combinations shall be taken as per IS: 875 (Part-5) and other relevant IS Codes.

a) Wind and seismic forces shall not be considered to act simultaneously.

b) For the design of main plant structures during seismic condition, the deaerator feed water tank shall be considered full upto operating level. However, for other load combinations, deaerator feed water tank in flooded condition shall be considered.

c) 'Lifted load' of crane shall not be considered during seismic condition.

d) In case two cranes are provided and tandem operation is not envisaged, the load shall be taken as one crane fully loaded and second crane without lifted load but standing idle adjacent to first crane all through the building length (lifted load near to A/B Row).

e) In case two cranes are provided and tandem operation is envisaged then the crane wheel loads shall be taken as both the cranes fully loaded to capacity and travelling side by side al through the building length.

f) Permissible stresses for different load combinations shall be taken as per relevant IS and IRS codes.

g) For the design of pipe/cable supporting structure, the soil weight shall be considered as backfilled up to grade level for the condition of pipe running full/cables in position.

h) Frictional forces between the pipes and supporting structure in longitudinal direction need not be considered along with seismic or wind forces.

i) Paving in crane corridor shall be designed for the maximum load due to movement of crane.

j) In TG bay at crane rail level, chequered plate walkway with handrails shall be provided for entire column sectional depth for full length of the building. Walkway width clearance from the face of the column to the edge of the crane shall be as specified elsewhere in the specification.

k) For checking against uplift / tension case, 90% of Dead Loads with no Imposed Loads

shall be considered along with other Loads.

l) The Structures shall be Designed for most unfavourable Combination of Dead Loads, Imposed Loads, Equipment Loads, Piping / Cables / Ducts Loads, Wind / Seismic Loads, Temperature Loads, Ash Loads, and other applicable Loads without exceeding the Permissible Stresses.
No reduction in equipment loads, piping loads, ash loads and loads due to other permanent facilities shall be considered for calculation of seismic weight of the building/structure and for load combinations thereof.

m) In all Loading Combinations, the Loads that have reduction effect on design condition shall not be taken into account in the Combination concerned.

n) VOID

o) In all Load Combinations, differential settlement loads (with reversible effects) are to be considered.

6.03.03 Design of steel structures shall be done as per provisions of IS:800: 2007 (Limit state design) and other relevant IS standards including National Building Code (2016). For design of coal/lime stone/biomass bins and loading hopper IS:9178 (part I to III) shall be followed.

6.03.04 Shop connections will be welded type and all field connections will be bolted. Field permanent bolts wherever provided will be high tensile bolts of property class 8.8(min) as per 1367 for all major connections. However, nominal connections in the field like purlins, stairs, wall beams will be done by means of M.S. black bolts of grade 4.6 conforming to IS-1367. The bolted joints will be designed for friction grip or bearing type. For friction grip type connections, bolts will be tightened to develop the required pretension during their installation.

For bolted Connection, IS 4000, IS: 3757, IS: 6623 and IS: 6649 shall be followed. IS 814, IS 816, IS: 1024, IS 4353 and IS: 9595 shall be followed for welding of structures.

6.03.05 All structures close to railway line shall have clearances conforming to Railway norms.

6.03.06 For calculation of coal/lime stone/biomass load on moving conveyor, a multiplication factor of 1.6 shall be used to take care of inertia force, casual over burden and impact factor, etc. Thus coal/lime stone/biomass load per unit length of each moving conveyor shall be

$$\frac{1.6 \times (\text{rated capacity of conveyor system})}{\text{Conveyor speed}} \times \frac{1100}{800}$$

6.03.07 a) Conveyor gallery structure and trestles shall be designed considering both conveyors operating simultaneously

b) Dynamic analysis of conveyor galleries and conveyor supporting system shall be carried out for spans greater than 25 m.

c) All structures close to railway line shall have clearances conforming to Railway norms.

6.03.08 **Coal, Biomass, Limestone and Gypsum handling structures:**

The loads for all railway load bearing structures e. g. track hopper, tunnel, culverts and under ground transfer houses etc. and the analysis and the design of these structures shall be made strictly in accordance with the provisions of Indian Railway Bridge rules (latest edition), and Indian Railway Codes of practice (latest edition) with all amendments up to the date of opening of bids. The axle load for analysis and design shall be considered as “DFC loading (32.5t axle load)” of Heavy mineral loading as per Indian railway standard. Coal heap of 1.2m height shall

be considered above hopper top for design of hopper and supporting elements of wagon tippler. The analysis, design and detailed drawing for tunnel, under ground transfer houses, culverts etc. coming directly below the railway track shall be got approved by the contractor from the concerned railway authorities before taking up construction. All necessary payment for the above work shall be made by the bidder to the railway authority.

The steel structures shall be designed and fabricated as per 'code of practice for use of structural steel in general building construction', IS : 800 and other relevant IS Standards. Minimum size of the angle section to be used as structural members shall be 50 X 50 X 6. Minimum weld size shall be 6 mm. The steel structures using tubular sections shall be designed as per limit state method as per IS 800:2007.The properties and fabrication of tubular sections shall be as per IS:806-"Code of Practice for use of steel tubes in general building construction". and EN 1993-1-8:2005.Minimum grade of steel & thickness of Tubular/Hollow sections shall be Yst 240 Mpa & 4.0mm respectively.Minimum thickness for rolled/ built up section shall be 6mm.

Slotted holes shall not be assumed to act as expansion joint for relieving of stresses and suitable bearings shall be provided at the supports.

All gallery supporting trestles shall be so proportioned that the transverse deflection of gallery due to wind / seismic load should not exceed trestle height / 1000 as stipulated in IS: 11592. Peak wind speed method shall be considered for checking the transverse deflection. Longitudinal deflection for all conveyor trestles (along the conveyor direction) shall be Height/500 for peak wind speed.

Vertical & horizontal deflection of conveyor gallery shall be restricted to span/500.

The crusher and transfer house structures shall be so designed that transverse deflection at places where conveyor galleries meet, should be equal to the respective transverse deflection of conveyor supporting trestles. Impact load due to VGTU over RCC/steel structure shall be avoided.

For transfer house and crusher houses monorail loads of two floors having highest capacity of monorails shall be considered in addition to other gravity loads along with wind/seismic load. Wind load/seismic load shall be considered along with Running belt tension for the analysis of transfer house and crusher house, however monorail load may not be considered.

Stresses for all CHP structures shall be checked for the higher of the forces obtained from gust factor method and the peak wind speed method.

The permissible vertical deflection for beams supporting drive machinery shall be restricted to span / 500 and for other beams it shall be within span / 325.

Horizontal bracing system shall be provided at floor levels around the openings for plan area greater than 2 sqm.

Shear force in steel columns shall be transferred to the pedestals / foundations exclusively either through foundation bolts or the shear key arrangement.

Contractor can also use tubular steel sections for roof truss of conveyor galleries/cable trestle only.

	For design of liquid retaining structures, IS : 3370 (Part - I to IV) (latest) shall be followed. Face of the structure in contact with liquid shall be designed as un - cracked section. For design of RCC pipes for culverts, latest editions of IS: 458, IS: 783 should be followed. For design of all underground structures / foundations, ground water table shall be assumed at the formation level (i. e. the adjoining ground level).For all underground structures like wagon tippler, track hopper, reclaim hopper, tunnels and underground transfer points crack width shall be restricted to 0.2 mm. Design of Hopper walls shall be done for both Static & Dynamic flow condition using Walker's theory. For foundations of transfer points, crusher house & trestles, pedestals of isolated footings/pile caps shall necessarily be tied with RCC beams. For all RCC buildings, tie beams shall be provided at lintel level. Design of masonry walls shall be made as per IS : 1905. For metal roofing and side cladding, the spacing of purlins/runners shall be such that the deflection of metal sheet used is limited to span/250 under adverse loading condition. Minimum reinforcement (0.12% of total cross sectional area in each direction) shall be provided at the top face of the footing, even if, no reinforcements are required as per design
6.03.08.01	All liquid retaining structures shall be designed for following load conditions. Underground structures: a. Water filled inside up to design level and no earth outside. b. Earth pressure with surcharge of 2.0 T/m2 and ground water table up to FGL outside and no water inside. c. Stability against uplift shall be checked for completed structure and under construction stage with no water inside and ground water table up to FGL, with a minimum factor of safety of 1.20 against uplift. Installation of pressure relief valves shall not be permitted in the base slab of any liquid retaining / conveying structure. d. The structure shall also be checked for normal working condition with water filled inside up to design level and earth pressure outside with no effect of surcharge and ground water table. For design of over - ground liquid retaining structures appropriate load cases shall be considered.
6.03.08.02	All liquid retaining and conveying structures shall be designed as per IS 3370 with limiting crack width of 0.1mm.
6.03.08.03	In the wall of liquid retaining structures with cylindrical shape such as clarifiers, vertical reinforcement shall be checked assuming the walls were fully fixed at the base, and the horizontal reinforcement shall be provided to resist horizontal (hoop) tension assuming hinged condition at the junction of the base slab & wall.
6.03.08.04	Wherever sandwich slabs are provided in liquid retaining structures to take care of stability against uplift, only well graded sand of approved quality shall be used as fill material. The sand compaction shall be done with plate / disc compactors in such a manner that the bottom slab is not structurally damaged.
6.03.08.05	Clear free board of at least 300 mm above design (total) water level shall be provided in all liquid retaining / conveying structures.

6.03.08.06 Coefficient of active earth pressure shall be considered for design of free standing retaining walls and coefficient of earth pressure at rest shall be considered for design of top propped retaining walls.

6.03.08.07 The minimum concrete clear cover to reinforcement bars in all RCC structures shall be as per IS:456 and IS:3370(Part 2 - Latest) for water retaining structures. Durability of concrete shall conform to moderate exposure conditions as per Table-3 of IS 456 except noted specifically otherwise.

6.03.08.08 Factor of safety against overturning and sliding
The structure shall be checked for minimum factor of safety of 1.5 against overturning conditions (ratio of stabilizing moment to overturning moment) and 1.4 against sliding conditions as per IS: 456.

6.03.08.09 For detailing of Reinforcement IS 5525, IS 13920, IS 4326 and SP 34 shall be followed.

6.03.08.10 Two layers of reinforcement (on both faces) shall be provided for RCC sections having thickness of 150 mm and above.

6.03.08.11 Minimum diameter of main and distribution Reinforcement bars in different structural elements shall be as follows:

Sl. No.	Structural Element	Main Reinforcement	Distribution Reinforcement / Stirrups/ ties/ Anchor Bars
a)	Foundation	12 mm	10 mm
b)	Beams	12 mm	8 mm
c)	Columns	12 mm	8mm

6.03.08.12 Spacing of reinforcement bars in walls and slabs of liquid retaining / conveying structures shall not be more than 200 mm.

6.03.08.13 Buildings shall also comply to IS 4326 requirement.

6.03.08.14 Minimum Reinforcement in all elements of liquid retaining / conveying structures shall be 0.24 % of cross sectional area.

6.03.08.15 The sizing of foundation, design criteria & clear cover shall conform to IS:1904, IS:456 and other relevant Indian codes. However, minimum 0.12% of reinforcement shall be provided on the top face of the foundation concrete on either direction and minimum percentage of reinforcement at bottom face of foundation shall be same as that stipulated for beam as per IS:456.

6.03.08.16 Minimum thickness of foundation slab / raft and base slab of all liquid retaining tanks / pits shall not be less than 250 mm.

6.03.08.17 Minimum thickness of all elements of RCC liquid retaining / conveying structures (except effluent drains & launders) shall be 200mm. Effluent drains (depth more than 500mm) and launders shall have minimum element thickness of 150mm.

6.03.08.18 All Insert plates (except edge protection angles) provided in liquid retaining structures shall be 12 mm thick GI with lugs not less than 12 mm diameter or 6mm flats. Edge protection angles shall be provided as specified elsewhere.

6.03.08.19 All water retaining structures shall be tested for water tightness as per provisions of IS: 3370 and IS: 6494.

6.03.08.20 2.0m wide walkway with concrete paving shall be provided connecting all structures, buildings and facilities. The top of walkway shall be minimum 200mm above FGL.

6.03.08.21 **Design Requirements for Crusher Foundation**

6.03.08.21.2 **Dynamic Analysis**

Detailed dynamic analysis shall be done for the top deck together with springs and dampers and the natural frequencies and amplitudes of vibration shall be determined. A mathematical model of the top deck shall be formulated with three - dimensional beam / plate finite elements for the purpose of analysis with the spring idealised with vertical and horizontal stiffnesses. The mass of the machine together with that of the top deck shall be considered for the analysis.

Natural frequencies upto at least 10 % above the operating speed shall be determined and these frequencies shall be checked against the design criteria.

Forced response dynamic analysis shall be carried out for the operating condition unbalance forces using a sinusoidal forcing function. Unbalance forces as given by this specifications shall be used for this purpose. The amplitudes shall be checked against the design criteria. The dynamic forces from this analysis shall be used for structural design with a suitable fatigue factor.

Isolation Efficiency

The vibration isolation system shall be designed for about 90 % isolation efficiency.

De-coupling

A ratio of the least 10 (ten) shall be ensured between the stiffness of the supporting structure and the stiffness of the spring system in the vertical direction to achieve de-coupling between the two (the stiffness of the spring system being lower). This ensures that dynamic analysis of the supporting structure need not be carried out.

Frequency Criteria

The frequency criterion has already been laid down implicitly by the isolation efficiency criteria and de-coupling required.

The first bending mode frequency of the top deck shall be at least 20 % above the operating speed.

Unbalance Forces

Unbalance forces arising out of all the following cases shall be considered for checking the design and amplitudes.

I. Balance quality grade G 16 as per IS/ISO:21940-11.

II. One hammer broken condition. The missing hammer shall be assumed to be closest to the crusher non - drive end of the crusher.

III. Three hammers broken condition. All the three hammers broken shall be assumed to be from the same suspension bar and located at the non - drive end of the crusher.

Amplitude Criteria

The calculated amplitudes (mean to peak values) shall not exceed following limits under the specified conditions.

Operating speed of 750 RPM

I. 150 microns for an unbalance force arising out of balance quality grade G 16 as per IS/ISO:21940-11-2016.

II. 300 microns in case of a one hammer broken condition.

III. Amplitudes need not be checked for a three-hammer broken condition.

Operating speed of 450 RPM

I. 200 microns for an imbalance force arising out of balance quality grade G 16 as per IS/ISO:21940-11.

II. 400 microns in case of a one hammers broken condition.

III. Amplitude need not be checked for a three-hammer broken condition.

For intermediate operating speed between 450 to 750 RPM the amplitude limits can be linearly interpolated.

The amplitude limits mentioned above are in both vertical and horizontal directions. The amplitudes shall be calculated at critical points on the top surface of the RCC deck. The amplitudes shall be checked for the most unfavorable superposition of modes in any direction. However, phase difference between the maximum amplitude occurring in different directions due to the rotating vetor may be considered while superimposing the modes.

Transient Resonance

Transient resonance, which may occur during the start - up or coasting down condition of the crusher, shall be checked, and the amplitudes in such a condition should not exceed one - and - half times those at operating speed for each design condition.

Strength Criteria

The following criteria shall apply for the design of top deck:

a) Dead loads, live loads, Seismic loads and dynamic loads shall be considered for the design. The most unfavorable combination shall be considered for design.

b) Seismic loads shall be assumed to act together with dynamic loads for a one-millimeter eccentricity in the rotor. However, seismic loads and dynamic loads arising out of hammer breakage need not be considered together

c) Fatigue shall be considered while designing for dynamic forces. A fatigue factor of 2.0 shall be used on all dynamic forces to arrive at the equivalent static force for the purpose of design.

d) Working stress method shall be used for the design of RCC deck. In survival condition, 10 % overstressing may be permitted.

e) The RCC top deck shall be at least of M35 grade of concrete as per IS : 456.

f) Fatigue need not be considered for the three hammer broken condition.

g) For calculating unbalance forces, the heaviest hammer (plain or toothed) shall be considered.

6.03.09 Horizontal Deflection criteria

The maximum Horizontal Deflection for various structures shall not exceed and be limited to the following:

Sl. No.	Description	Maximum value of
1.	For Trestles and transfer points (Transverse deflection at Conveyor gallery supporting level)	Height/1000 (For Wind load by Peak Wind Speed Method / Seismic Load)
2.	For ESP Control Building, Compressor House, and all other steel buildings envisaged in this specification	Height /325
3.	Vertical Metal Sheeting in Cladding	Span/250

However, the maximum deflection of Grating / Chequered Plate Shall be limited to 6mm.

Note: Along wind forces on slender and wind sensitive structures and structural elements shall also be computed, for dynamic effects, using the Gust Factor or Gust Effectiveness Factor Method as defined in the standard. The structures shall be designed for the higher of the forces obtained from Gust Factor method and the Peak Wind Speed method.

Analysis for dynamic effects of wind must be undertaken for any structure which has a height to minimum lateral dimension ratio greater than “5” and/or if the fundamental frequency of the structure is less than 1 Hz.

6.03.10 a) Dispersion of load in any direction through soil shall be as per IS 8009 (relevant part).

b) Dispersion of load through concrete shall be considered at an angle of 45 degrees with horizontal from the edge of contact area.

6.03.11 a) Permissible deflection (unless specified otherwise in this specification) for latticed framework and beams of floors other than drive floor shall be span/325.

b) The allowable deflection for beams directly supporting drive machinery and equipment shall be restricted to span/500 unless specified otherwise in this specification.

c) The deflection for manually operated cranes & monorail supporting beams shall not exceed span/500.

For electric overhead cranes :

1) upto 50 Tonne capacity : span/750

2) over 50 Tonne capacity : span/1000

d) The vertical deflection of beams supporting LP Heater, HP Heater and Deaerator shall be limited to Span/500.

e) The vertical deflection of metal deck sheet for floor shall be limited to span/250.

f) Permissible deflection for all purlins, cladding runners, roofing/cladding sheets and grating / chequered plates shall be span/250. However, the maximum vertical deflection of Grating/ Chequered plate shall be limited to 6 mm.

6.03.12 Transverse coal/lime stone/biomass pressure on Bunker/Silo/Hopper walls shall be calculated as per IS: 9178. The coal/lime stone/biomass Bunker/Silo/Hopper shall be designed for the following conditions

i) The Bunker/Silo/Hopper is full up to its full capacity with top surface nearly horizontal.

ii) The Bunker/Silo/Hopper is partially empty with the top surface of coal/lime stone/biomass at an angle of repose of 37 degrees.

6.03.13 **Design criteria for ash silo**

1. Fly Ash silo shall be of RCC construction. The silo shall be designed as per the requirement of IS:4995. The static pressure calculated at rest shall be multiplied by an over pressure factor of 1.35 for the top 1/3rd – portion and by a factor of 1.75 for the bottom 2/3rd portion The effect of hot temperature of ash on the concrete wall shall also be considered. The silo shall be designed for the following conditions:

   (a) The silo is full up to its full height / capacity

   (b) The silo is partially empty with top surface of ash, at an angle of repose less than 30 degrees.

2. The following loads are to be considered for design.

   a) Density of bottom ash to be considered for volume calculation shall be 650 kg. /cum.

   b) Density of bottom ash to be considered for load calculation shall be 1600 kg/cum.

   c) Density of fly ash to be considered for volume calculation shall be 750 kg/cum.

   d) Density of fly ash to be considered for load calculation shall be 1600 kg./cum.

   e) Density of dry fly ash, to be considered for the design of supporting structures for dry fly ash conveying pipes, shall be taken as 1000 kg/cum. The pipe shall be considered full with dry fly ash.

3. Other requirements are as follows:

   a) Independent supporting structure shall be provided for each silo.

   b) The joint between the wall and roof of the silo shall be properly sealed by welding or by any other approved means.

   c) Operating platform covering total plan area wise in silo structure made of grating shall be provided.

   d) The framing system shall be provided in such a way that the trucks and closed tankers can have a clear passage to approach the underside of the silos for unloading dry ash from the silos.

4. Trestles supporting ash pipes shall be so proportioned that the transverse deflection of trestles due to wind/seismic load shall not exceed trestle height/325.

5. The corrosion allowance for design of Buffer Hopper, Bottom ash hopper, tanks etc. shall be considered as per IS9178 considering structure exposed to atmosphere. The

corrosion allowance shall be provided in addition to the requirement of minimum thickness of steel plate as per IS9178.

6.03.14 Coal Bunker (inside Mill Bunker Building) and lime stone/biomass silo shall be of MS while the hopper shall be of MS with stainless steel (grade SS 304) lining. The minimum thickness of MS plate and SS lining in hopper portion shall be as per the design concept of Mill Bunker Building specified elsewhere in the specification. Pre-formed flexible open ended bellow strap of neoprene is to be provided between top of bunker and bottom of tripper floor to avoid coal dust leakage / escape. The bellow strap shall be of minimum 200 mm wide under un-stretched condition and shall be of minimum 2mm thick.

The hopper angle with the horizontal plane be as specified elsewhere in the specification.

6.03.15 The live storage capacity of each coal bunker shall be greater of the following:

a) Total 10 hours biomass blended coal requirement of the boiler for BMCR duty with worst coal firing, equally distributed over the number of bunkers (i.e. the coal mills) required in service for this duty condition as specified elsewhere.

b) Total 10 hours biomass blended coal requirement of the boiler for BMCR duty with design coal firing, equally distributed over the number of bunkers (i.e. the coal mills) required in service for this duty condition as specified elsewhere.

c) Total 10 hours biomass blended coal requirement of the boiler for TMCR duty with worst coal firing, equally distributed over the number of bunkers (i.e. the coal mills) required to be in service for this duty condition as specified elsewhere.

6.03.16 For all capacity (volume) calculation and structural design (load calculation) unit weight of biomass blended coal shall be assumed as 760kg/cum. and 1100 kg/cum respectively.

6.03.16 a) The design and construction of RCC structures shall be carried out as per IS: 456. Working stress method shall be adopted for the design wherever specifically mentioned in this specification.

b) For design and construction of steel-concrete composite members, IS: 11384 shall be followed.

c) For reinforcement detailing, IS 5525 and SP 34 shall be followed.

d) Two layers of reinforcement (on both inner and outer faces) shall be provided for RCC wall sections having thickness 150 mm or more.

6.03.17 **DESIGN OF FOUNDATION FOR TG, TDBFP, MDBFP, COAL MILS & FAN FOUNDATIONS**

Structural Arrangement of foundations for various machine foundations like TG, TDBFP, MDBFP, Coal Mills and Fans shall be as specified elsewhere in the specification.

Analysis for the foundation

For the foundations of the all equipment, details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic forces as per IS1893. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. A minimum fatigue factor of 2.0 shall be considered for dynamic forces.

The vibration amplitudes shall be calculated at the machine bearing locations and at any other points of interest by a forced response analysis. The unbalance forces used for this analysis shall correspond to the balance quality grade of the machine as per ISO 1940 /IS:11723 or the unbalance forces as provided by the machine manufacturer whichever is higher. It shall be ensured that the calculated amplitudes do not exceed the limits specified by the machine manufacturer and relevant Standards such as ISO 10816/IS:14817.

Bidder to consider the acceleration at the top of the deck for the design of supporting / fixing arrangement of machine.

Design criteria for steel helical springs and viscous dampers

The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 5% to 10% of critical damping shall be provided in the form of viscous dampers.

Reinforcement Design

Working stress method as per IS 456 shall be used for reinforcement design. The design shall be done for the worst load combination. Minimum reinforcement shall be provided as per IS 456 and IS2974 (Part-III), if the calculated reinforcement is less than the minimum.

For TG Raft/ Pilecap, minimum percentage of reinforcement at top and bottom faces of foundation shall be same as that stipulated for beam as per IS456.

c) **Block Foundations:**

Block foundation resting on soil shall be analyzed using elastic half space theory. In case the foundation is supported over piles, Novak's approximation shall be used for determining the spring constant and damping ratio of pile groups. The mass of the RCC block shall be at least three times the mass of machine. Free vibration analysis of the foundation shall be carried out to evaluate the natural frequencies. The fundamental natural frequency shall be kept at least 20% away from the operating frequency (speed). Forced vibration analysis shall be carried out if the dynamic forces are made available by the machine supplier in which case the amplitude limits stipulated by the machine supplier and ISO 10816, whichever is lower, shall be satisfied.

Reinforcement design shall be done by working stress method as per IS 456 and IS 2974 (Part-IV).

For the foundations supporting minor rotating equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structure, floors, etc., suitable vibration isolation shall be provided by means of springs, neoprene pads, etc., and such vibration isolation system shall be designed suitably.

6.03.18 If RCC floor/roof is assumed to act as diaphragm, transmitting lateral loads to braced bays, it shall be provided with shear connectors.

The spacing of shear anchor studs on structural beams shall be minimum of the spacing required for
i) Restraining the compression flanges of beams and
ii) Transfer of the horizontal shear at floor/roof to the supporting beams.

However, whenever large / more number of cut-outs are provided in the floor slab, horizontal floor bracings shall be provided below slab to transfer horizontal force to columns without considering diaphragm action from slab.

6.03.19 All roads shall be rigid pavements specified elsewhere in this specification. The design traffic load shall be a minimum 4 million cumulative standard axle. The design of concrete pavement shall be carried out as per IRC-58.

6.03.20

a) No cable/pipe trench is envisaged in the plant area. However, if required, pipe/cable trench can be provided inside the buildings and inside switchyard or some other localized areas.

b) All pipes and cable shall generally be routed above ground.

c) A minimum clearance (clear headroom) of 8m shall be kept for all over-ground pipe/cable trestles for all road/rail crossings. For other areas, the requirement of trestle height is specified elsewhere in the specifications. All trestles shall be provided with continuous walkway of minimum 600mm width with hand-rails and toe-guards all along the length of the trestle along with approach ladders near roads, passageways, etc. Before and after the road/rail crossings, a barrier of suitable height shall be constructed

so as to prevent the approach of cranes (having height more than 8 m) etc., upto the pipe/cable racks/trestles.

d) Within AB bay in Main plant area, generally grating shall be provided for Mezzanine floor except for valve room area, cable spreader floor, air washer units, feed water heaters, equipment foundations, miscellaneous skids, etc. where the floor shall be of RCC. Oil equipment room shall also have RCC floor below the grating floor.

6.03.21 The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8 m/sec. respectively. However, minimum velocity of 0.6m/sec. for self-cleansing shall be ensured. Bed slope not milder than 1 in 1000 shall be provided. The open drains shall be open rectangular drains of RCC unless required otherwise due to functional requirement. RC box culverts shall be provided at rail, road or other crossings.

6.03.22 Sewers shall be designed for a minimum self-cleansing velocity of 0.75m/sec and the maximum velocity shall not exceed 2.4m/sec.

Manual on sewerage and sewage treatment (published by Central Public Health Environment Engineering Organisation, Government of India) shall be followed for design purpose.

Foundations for all tanks shall be designed for as per IS: 803.

6.03.23 Footings shall be so proportioned to as to minimise the differential settlement.

Plinth level of all buildings shall be kept at least 500 mm above the finished grade/formation level.

6.03.24 **Boiler/ ESP support structures shall be designed for:**

a. Dead load

b. Live/Imposed loads

c. Static and dynamic loads of piping, movable equipment and maintenance parts.

d. Loads from cable trays and walkways supported on columns.

e. Ash water piping supported on the outermost row of boiler columns.

f. All ESP hoppers filled up with ash upto the top of the hoppers or the bottom of electrodes (whichever is more) using a bulk density of not less than 1350 kg/cu.m. for the ash, along with additional ash build-up from the end of the third field up to the inlet duct bottom level at a natural repose angle (not less than 30 degree to horizontal in any case).

g. Ash load at bottom ash hopper and pent house of the boiler shall be as mentioned in the mechanical chapter of the specifications.

h. Seismic and wind loads as specified elsewhere in the specifications.

i. Temperature Loads.

j. Temperature variations under ESP operating condition.

k. The loads listed above indicate the minimum requirements.

l. For the Design of ESP Supporting Structures for Seismic, Ash Load in Hoppers filled upto to the top of the Hoppers or bottom of the electrode (whichever is higher) shall be considered as permanent Loads along with other applicable Loads.

m. Following Ash density shall be considered for the Design :

Sl. No.	Description	Density (kg/Cu. M.)

a)	Bottom Ash for volume calculations	650
b)	Bottom Ash for Load calculations	1600
c)	Fly Ash for volume calculations (For Boiler)	750
d)	Fly Ash for volume calculations (For ESP)	650
e)	Fly Ash for Load calculations	1350
f)	Dry Fly Ash for dry fly ash Pipeline supporting Structures (Pipe to be considered full)	1000

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6.03.25 Boiler supporting structures shall be so configured that the temperature of steel does not exceed 60 °C unless specified otherwise. Brackets shall be provided on both sides of the outermost row of columns of both the boiler and ESP for supporting cable trays and walkways, at a height not exceeding 10.0 m. The exact levels shall, however, be decided during detailed engineering. Each ESP hopper shall be supported at four corners by providing four columns from the ground.

6.03.26 The bracings in boiler structure shall be provided such that under no circumstance normal/convenient access to all points in the boiler is blocked or obstructed.

6.03.27 In design of boiler/ ESP support structures, dynamic piping loads need not be considered acting simultaneously with wind or seismic loads. Increase in permissible stresses shall be allowed in load combinations where dynamic piping loads are considered and shall be as permitted under seismic load conditions.

6.03.28 Design Criteria for foundations and some other facilities/areas are covered separately in this specification.

6.03.29 Plinth level of all buildings shall be kept at least 500 mm above the finished grade/formation level.

Finished floor level of boiler area paving shall be kept about 200 mm lower than the finished floor level of Main Plant buildings.

6.03.30 Joints/Connections in steel structures:

Steel structures shall be detailed and connection and joints provided as per the provisions of IS 800, IS 816, IS 9595, IS 1367, and IS 9178 and as per following requirements.

a) ~~Connection of vertical bracings with connection members and diagonals of truss members shall be designed for full tensile capacity of the bracings unless actual loads are indicated on the drawings~~.

b) Size of fillet weld for flange to web connection for built up section shall be as follows:

i) For box section weld size shall be designed for full shear capacity or actual shear whichever is more. Where fillet weld is not possible, full penetration butt weld shall be provided.

ii) For built up I section, weld size shall be designed for 80% of full shear capacity or actual shear, (if indicated, in drawings) whichever is more. However, weld size shall not be less than 0.5 times the web thickness. Weld shall be double fillet.

iii) All welds shall be continuous unless otherwise specifically approved. The minimum size of the fillet weld shall be 6mm.

Connection to be designed as per provisions of IS 800:2007. (Amendment No 02, D-1-6)

c) Shear connections shall be designed for 60% of section strength for rolled sections and 80% of section strength for built up section or rolled section with cover plates. However, if load is more than above, the connection shall be designed for actual load.

d) Moment connections between beam and column shall be designed for 100% of moment capacity of the beam section.

e) All butt welds shall be full penetration butt welds.

f) The connection between top flange and web of crane girder shall be full penetration butt weld. Bottom flange, connection with web can be fillet weld or butt weld as directed by Engineer.

g) Connection of base plate and associated stiffeners with the columns shall be designed considering the total load transferred through welds. However, minimum weld size (double fillet) shall not be less than 0.6 times the thickness of stiffeners.

h) Splicing: All work shall be full strength. Field splicing shall be done with web and flange cover plates for full strength. Shop splicing for all sections other than rolled shall be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections shall be carried out using web and flange cover plate.

6.03.31 Pipe Pedestals, pipe supports and other structures for Ash handling system:

a) The design of Pipe Pedestal and pipe supports shall be carried out considering Dead load, live load & seismic load / wind load. In addition to above, longitudinal forces equal to product of Co - efficient of friction (between contact surface of pipe and pedestal) with the load coming on each pedestal shall also be considered for the design of pedestal. In bends, suitable thrust block shall be provided to withstand the thrusts transferred from the pipelines.

b) All RCC pipes carrying water under gravity shall be designed for earth pressure, water and surcharge. Minimum grade of pipe shall be of NP - 2 class or heavier required as per design / specification.

c) The design and construction of RCC structures shall be carried out as per IS: 456. In general, limit state theory shall be followed for the design of RCC structures, however, working stress method shall be adopted for the design, wherever specifically mentioned in this specification.

d) Two layers of reinforcement (on inner and outer face) shall be provided for RCC wall sections having thickness 150mm and above.

6.03.32 **Design Criteria of RCC Floors**

a) For Mill Bunker Building, Main Power House, ESP Control Building, Transfer Houses, and other structural steel framed buildings:

These buildings being steel framed structure, all RCC floors shall comprise RCC slab supported on troughed, profiled metal deck sheet (to be used as permanent shuttering). The RCC slab shall be minimum 150mm thick above the top surface (crest) of the metal deck sheet. The spacing of structural steel secondary beams shall be based on the bending capacity of the metal deck sheet for self-weight of green concrete and additional construction load of 100 kg/m^2.

The permanent metal deck sheets shall be fixed to the top flange of secondary beams by means of drawn arc welding of headed shear anchor studs directly through the metal sheet. The details of shear anchor studs are specified elsewhere in this specification.

The RCC slab shall be designed without considering any composite action effect of metal deck sheet (i.e. the structural strength of metal deck sheet shall not be considered for RCC slab design).

(b) For Service Building & other RCC buildings.

These buildings being complete RCC framed structures, conventional RCC slabs of minimum thickness 150 mm shall be provided. The RCC slabs shall be monolithic with RCC beams and RCC columns

6.03.33 **Design Criteria of RCC roofs**

a) For Main Power House, Compressor House, ESP Control Building and Other Steel framed Buildings:

The roof system shall comprise minimum 40mm thick RCC slab on top of profiled permanent metal deck sheet. The permanent metal deck sheets shall be fixed to the top flange of secondary beams by means of arc welding of headed shear anchor studs to the purlins directly through the metal sheet. The details of shear anchor studs are specified elsewhere in this specification. Water proofing treatment to roof slab shall be provided as per details specified elsewhere in this specification).

The RCC slab shall be designed without considering any composite action effect of metal deck sheet (i.e. the structural strength of metal deck sheet shall not be considered for RCC slab design.

b) For Mill Bunker Building, Transfer Houses.

Insulated sandwiched metal sheet for roofing shall be provided comprising troughed permanently colour coated sheet at top and plain permanently colour coated sheet at bottom with 50mm thick insulation sandwiched between the two sheets, the details of which are specified elsewhere in this specification.

c) Roofing system for Ash Handling Plant Pump Houses and Buildings shall be as specified in relevant clauses

d) Other RCC Buildings.

Cast-in-Situ RCC slab shall be provided using removable plywood shuttering. Water proofing treatment to roof slab shall be provided as per details specified elsewhere in this specification).

6.03.34 **Design Criteria for Foundation**

The founding depth / cut off level of piles shall be decided based on functional requirement.

Where structural steel columns are envisaged, the bottom of the base plate shall be kept suitably below the paving level such that the top level of the gusset plate and foundation bolt remain at least 200 mm below the top level of paving except for Boiler Structure, Bunker Building Columns, TP & Trestle Columns, ESP Control Building Columns for which the requirement of levels for bottom of base plates is specified elsewhere in this specification. Further the gusset plate and foundation bolts are to be encased in concrete up to the top of the paving level. For outdoor structural steel columns, about 300 mm height of steel columns above the top of paving level shall be provided with at least 125 mm thick encasement with minimum reinforcement to prevent corrosion of the steel columns from surface water

a) OPEN Foundations

For foundations, the minimum founding depth and the minimum size of foundation shall be as per foundation system and geotechnical data specified in the foundation chapter include hereafter in this specification.

For open foundations, the total permissible settlement shall be as per the criteria furnished under the foundation system specified elsewhere in this specification.

The sizing of foundation, design criteria & clear cover shall conform to IS:1904, IS:456 and other relevant Indian codes. However minimum 0.12% of reinforcement shall be provided on the top face of the foundation concrete on either direction and minimum percentage of

reinforcement both in case of bottom face and also for tension face of foundation shall be same as that stipulated for beam as per IS:456.

b) PILE Foundations

Minimum centre to centre spacing of the piles shall be as per IS: 2911. Incase single piles are used, these piles are to be interconnected with tie beams along both orthogonal directions perpendicular to each other.

Minimum penetration of piles into Pilecap shall be 75 mm and clear cover to the main reinforcement at the bottom face of the pile cap shall be 100 mm. Structural design of pile cap and reinforcement shall conform to IS:2911 and IS:456. However minimum 0.12% of cross section of the pile cap shall be provided on the top face of the pile cap along two orthogonal directions and minimum percentage of reinforcement at bottom face of pile cap shall be same as that stipulated for beam as per IS:456.

Detailed requirement of pile foundation have been presented in the foundation chapter specified hereafter in this specification.

6.04.00 **CORROSION PROTECTION**

6.04.01 **General**

(a) All Steel structures shall be provided with painting as given in the specification. Further, painting system shall also meet the requirements of Corrosivity category (as mentioned in Part A IID Civil Works for the project as per ISO 12944).

Painting system for steel surfaces embedded in Concrete is given separately.

(b) All Painting shall be done as per Technical Specification Painting scheme shall submitted by the Bidder.

(c) All steel structures shall be designed by following basic design considerations in ISO 12944 Part 3. Where steel is fully accessible for cleaning and repainting and where it is feasible to follow design criteria given in ISO 12944 part 3, minimum thicknesses of structural members shall be as follows

Structural Sections	Minimum thickness	Minimum Flange thickness	Minimum Web thickness
Plates	6		
Built up Sections		6	6
Angle sections	6		
ISMB /ISMC		6	4.5
NPB/ WPB		6	4.5
RHS/SHS/ Tubular Sections	4		
All dimensions in mm			

Where steel surfaces are inaccessible for cleaning and repainting (such as back-to-back sections, lap joints etc.) or where it is not feasible to follow design criteria given in ISO 12944 part 3, corrosion allowance of 1.5 mm shall be kept in thickness (over the design thickness or minimum thickness specified above, whichever is more). The minimum thickness consideration shall apply for both web and flange.

However minimum gusset plate thicknesses shall be followed as mentioned elsewhere in the specification and minimum angle section to be used is ISA 50x50x6. Ends of tubular sections to be effectively sealed at both ends. Also tubular handrail thicknesses

will be as governed by mentioned clauses in the spec

Minimum thickness of tubular/ hollow steel sections conforming to IS 4923 shall be 4.0 mm, provided the ends of such steel sections are effectively sealed unless higher thickness is specified elsewhere for specific structure.

6.04.02 **Painting of Steel Surfaces Embedded In Concrete**

a) For the portion of Steel surfaces embedded in Concrete, the surface shall be prepared by Manual Cleaning and provided with Primer Coat of Chlorinated Rubber based Zinc Phosphate Primer of Minimum 50 Micron Dry Film Thickness (DFT).

b) All threaded and other surfaces of foundation bolts and its materials, insulation pins, Anchor channels, sleeves, etc. shall be coated with temporary rust preventive fluid and during execution of civil works, the dried film of coating shall be removed using organic solvents.

6.04.03 **Painting of Steel Surfaces (Other Than Those Embedded In Concrete)**

Following painting system corresponding to corrosion category as mentioned in Part A IID Civil Works of this specifications shall be adopted for the project.

CORROSSIVITY CATEGORY(as per ISO 12944-2)	PRIMER COAT	INERMEDIATE COAT	FINAL COAT
C3	All steel surfaces shall be provided with two component moisture curing zinc (ethyl) silicate primer coat (having minimum 80% of metallic Zinc content in dry film, solid by volume minimum 60% ±2%) of minimum 70 micron DFT to be applied over blast cleaned surface conforming to Sa 2 ½ finish of ISO 8501-1 with surface profile 40-60 Micron. The primer coat shall be applied in shop immediately after blast cleaning by airless spray technique. Zinc dust composition and properties shall be	Primer coat shall be followed with the application of Intermediate coat of two component polyamide cured epoxy with MIO Content (containing lamellar MIO minimum 30% on pigment, solid by volume minimum 80% ±2%) of minimum 100 micron DFT. This coat shall be applied in shop after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.	Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT. This coat shall be applied shop after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat),

	Type-II as per ASTM D520-00.		Colour and shade of the coat shall be as approved by the Employer.
C5	All steel surfaces shall be provided with two component moisture curing zinc (ethyl) silicate primer coat (having minimum 80% of metallic Zinc content in dry film, solid by volume minimum 60% ±2%) of minimum 70 micron DFT to be applied over blast cleaned surface conforming to Sa 2 ½ finish of ISO 8501-1 with surface profile 40-60 Micron. The primer coat shall be applied in shop immediately after blast cleaning by airless spray technique. Zinc dust composition and properties shall be Type-II as per ASTM D520-00.	Primer coat shall be followed with the application of Intermediate coat of two component polyamide cured epoxy with MIO Content (containing lamellar MIO minimum 30% on pigment, solid by volume minimum 80% ±2%) of minimum 180 micron DFT. This coat shall be applied in shop after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.	Intermediate coat shall be followed with the application of finish coat of two-pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% ±2%) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0 ΔE) and minimum 70 micron DFT. This coat shall be applied shop after an interval of minimum 10 hours and within six (6) months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer.

Notes:

1. For Primer, high quality surface preparation is necessary and good amount of moisture is required for proper curing. Below 70 % relative humidity, curing time may go up to 7 days or more. In such a case additional water sprinkling may be ensured for completion of curing. Additionally Inorganic zinc silicate cannot be recoated; even with itself. Typically it should be used when coating bare steel surface for first time.
2. The most frequent problem associated when top coating Primer is bubbling/pinholing especially with non-weathered zinc silicate coatings. To a great extent, this bubbling of finish paint can be eliminated by applying a mist coat of intermediate/topcoat as the first pass of the product, allow the bubbles to subside and then apply a full coat, as required.

3. In case top coating of zinc silicate with epoxy/polyurethane coatings, is expected to be delayed, it is advisable to use a suitable tie coat to avoid formation of white rust. However, if white rust forms then clean the surface with high pressure water, dry and apply the subsequent coats as required.

4. Touch up paintings on damaged areas: Surface preparation by manual tools, wire brush/ emery paper etc. Minimum 6 inches peripheral area, adjoining to damaged area to be covered. If metal surface is exposed, it is to be painted with Zinc rich epoxy (70 micron) or suitable primer with existing paint scheme. If primer is intact, intermediate & top coat to be done with specified DFT in scheme.

6.04.04 **Coating for Mild Steel parts in contact with Water**.

a) All mild Steel parts coming in contact with water or water vapour shall be hot dip galvanised. The Minimum Coating of Zinc shall be 610 g/ Sq.m. for galvanised Structures and shall comply with IS: 4759 and other relevant Codes. Galvanising shall be checked and tested in accordance with IS: 2629.

b) The galvanising shall be followed by the application of an etching Primer and dipping in black bitumen in accordance with BS: 3416, unless otherwise specified.

6.04.05 **Gratings**

All gratings shall be blast cleaned to Sa 2 ½ finish or cleaned by acid pickling as per ISO 8501-1 and shall be hot dip galvanized at the rate of 610 gm/sqm.

6.04.06 **Hand Railings and Ladders**

All Mild steel (MS) handrails and ladders in outdoor locations and in pump valve pits shall be galvanised at the rate of 610 gm/sqm as per IS 4736. All other MS handrails shall be painted as specified in clause 6.04.03 above. However, Stainless steel handrails shall be provided as specified in General Architectural Specification clause 9.00.00.

6.04.07 **Sea Worthiness**

All Steel Sections and fabricated Structures, which are required to be transported on sea, shall be provided with anti-corrosive Paint before shipment to take care of sea worthiness.

6.04.08 DELETED

6.04.09 **For reinforced concrete work.**

i) The protection for concrete sub-structure shall be provided based on aggressiveness of the soil, chemical analysis of soil/sub-soil water and presence of harmful chemicals/salts.

ii) The protection to super structure shall depend on exposure condition and degree of atmospheric corrosion.

This shall require use of dense and durable concrete, control of water cement ratio, increase in clear cover, use of special type of cement and reinforcement, etc., coating of concrete surface, etc.,

Bidder shall furnish the details of corrosion protection measures.

SUB-SECTION-D-1-7

FOUNDATION SYSTEM AND GEOTECHNICAL DATA

Foundation System and Geotechnical Data - Revised.
(Amendment No 03, D-2-22)

CLAUSE NO.	TECHNICAL REQUIREMENTS

7.00.00 FOUNDATION SYSTEM AND GEOTECHNICAL DATA

7.01.00 Soil Data

The owner has carried out detailed geotechnical investigation at the project site. Bore logs data and Bearing capacity for design of foundations are given at Annexure - C of this specification. The detailed geotechnical investigation report comprising of Boreholes, Laboratory tests, Chemical analysis, etc for the sub-strata prevailing at site would be made available for the Bidder's study at the Owner's consultant office, if required. The onus of correct assessment / interpretation and understanding of the existing subsoil condition / data lies with the Bidder. **In case, bidder feels that the available data is inadequate, he may carry out his own geotechnical investigation. Further, if there is any change in layout or for any area not covered in the provided geotechnical data, the bidder has to carry out geotechnical investigation in the area at no cost to the Owner.** Geotechnical investigation work shall get executed by the Contractor through the agencies as mentioned in Clause No. 7.07.00. However, no time extension shall be given on account of the soil investigation carried out by the Bidder. The geotechnical investigation report shall be prepared with detailed recommendations regarding type of foundation and allowable bearing pressure for various structures/ facilities and other soil parameters. Net allowable bearing pressure shall be limited to Table-1 of Annexure-C. The report shall be submitted for Owner's approval prior to commencement of design of foundation.

Bidder may refer enclosed topographical survey drawing and general layout plan along with borelogs for variation in existing ground level (EGL) / natural ground level (NGL) and finished ground level (FGL). For variation in Natural ground level, topographical survey drawing and borelog data may be referred. Further, wherever ash/coal deposit/brickbats etc. is found the same shall be treated as filled up soil.

7.01.01 **The furnished borelog details are specific to the co-ordinates where the boreholes have been carried out and are provided for bidder's information only. The soil profile in the proposed area may vary with respect to the borelogs enclosed for bidder's information. The bidder has to consider all such variations in his estimation, over the extent of the work to be carried out. The Bidder should note that nothing extra whatsoever on account of variation between soil data collected by Owner and that found by the Bidder during geotechnical investigation by him or during execution of works, shall be Payable.**

7.01.02 Tank Foundations

a) The tanks shall rest on flexible tank pad foundation, resting on sand with concrete ring wall to retain sand. The base of the concrete ring wall shall not rest on the expansive soil, if any.

b) Entire loose/ soft soil inside the concrete ring wall shall be removed and shall be filled with natural sand/ sand manufactured from other than natural sources as specified elsewhere in the technical specification. Sand for filling shall be clean and well graded conforming to IS 383 with grading Zone I to III.

c) Natural sand/ sand manufactured from other than natural sources as specified elsewhere in the technical specification shall be spread in layers not exceeding 30cm compacted thickness over the area. Each layer shall be uniformly compacted by mechanical means like plate vibrators, small vibratory rollers, etc to achieve a relative density of not less than 80%.

d) Other requirements of tank foundations shall be as per IS 803 and as specified elsewhere in the specifications.

7.02.00 **Foundation System**

The requirements for the foundation system to be adopted are as given in subsequent clauses. Depending upon the depth of competent strata/stratum, type of structures, functional requirement of facility, extent of cutting / filling, suitable foundation, open or pile

shall be adopted with approval of owner's consultant.

7.02.01 General Requirements

a) All structures/equipment shall be supported on suitable open foundations (isolated, combined, raft) or pile foundation depending on type of structures/facilities, sub-strata, topography etc.

b) The roads, ground floor slabs, trenches, pipe pedestals (except thrust blocks), channels/drains and staircase foundation with foundation loading intensity less than 4 T / M2 may be supported on open / shallow foundations resting on virgin / controlled compacted filled up soil.

c) No other foundation (other than as mentioned in (b) above and (g) below) shall rest on the filled-up ground / soil.

d) All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian Standards.

e) The water table for design purpose shall be considered at Finished Ground Level.

f) A combination of open and pile foundations shall not be permitted under the same equipment / structure / building.

g) Foundation for equipments on ground floor

For equipments of static weight upto 1.5 T, the equipment may be supported on the ground floor slab by locally thickening the slab. Thickening of the ground floor slab shall be done upto an extent of about 0.6 m beyond the plan area of the equipment on all the sides. Further, the load intensity below the equipment shall be limited to 4T/m2. Other requirements of floor slab and compaction below the floor slab shall be adhered, as specified elsewhere in the specifications.

For equipment's of static weight between 1.5 T and 20 T, the equipment may be supported on compacted sand filling from Natural Ground Level (NGL) or excavation level of nearby footing whichever is deeper with the load intensity below the equipment limited to 4T/m2. The minimum depth of foundation is 1.0m below FFL. Other requirements of sand compaction below the foundation shall be adhered, as specified elsewhere in the specifications.

For equipment of static weight more than 20 T, the equipment foundation shall be taken to the founding level or shall be built up with PCC from the level as mentioned in Table 1. The pedestal of equipment foundation or the foundation Block shall be isolated from the adjoining floor slab by providing bitumen impregnated fiber board of minimum 50 mm thick, conforming to IS: 1838 all around the equipment pedestal for the full depth of the floor slab.

7.02.02 Open Foundations

In case open foundations are adopted, the following shall be adhered to.

a) The minimum width of the foundation shall be 1.0 m.

b) The minimum founding level shall be 1.0m below Finished ground level (FGL) or, 1.0m below Natural ground level (NGL) whichever is lower.
For meeting the bearing capacity and /or functional requirement lower depth to be adopted based on requirement.

c) It shall be ensured that all foundations of a particular structure/ buildings/ facility shall rest on one bearing stratum.

d) Wherever the intended bearing sub-strata is virgin soil stratum but the actual stratum encountered during foundation excavation consists of filled up soil at founding level, under such cases either the foundation shall be lowered completely into the virgin

stratum or the filled up soil upto the virgin layers shall be removed and built up through PCC M7.5 up to designed foundation level.

e) The last layer of about 300 mm before reaching the founding level shall be excavated carefully by such equipment so that soil / rock at the required level will be left in its natural condition.

f) Wherever the new facilities (excluding roads, ground floor slabs, trenches, pipe pedestals, channels/drains and staircase foundation) are to be constructed after dismantling existing facilities; it is to be ensured that the new foundations shall be taken at least 0.5m below the existing founding depth of the dismantled structures.

7.03.00 Pile Foundations – In case piles are adopted, following shall be adhered to:

i) The pile foundation shall be of RCC, Cast-in-situ bored piles as per IS:2911. Pile boring shall be done using Self erecting Crawler mounted Rotary Hydraulic Rigs. Two stages flushing of pile bore shall be ensured by airlift technique duly approved by the Employer.

ii) If required, temporary or permanent MS liner may be provided for piling.

The allowable load capacity of the pile in different modes (vertical compression, Lateral and pullout) shall be least of below three i.e.

a) design value based on borelog along with lab test data furnished in Annexure-C, AND

b) pile capacity achieved in pile load tests AND

c) the values furnished in following table:

Dia. (mm)	Structures/ Facilities	Cut off Level	Min. Pile Length below COL (m)	Vertical compression capacity (T)	Uplift capacity (T)	Lateral capacity (T)
600	Except Stacker area, Crusher, Silo, Biomass area (BH139-BH161)	2.0m below NGL	*Rock Socketed Pile	140	80	9.0
		4.0m below NGL		140	80	11.0
		7.0m below NGL		140	80	13.0
760		2.0m below NGL		240	130	13.0
		4.0m below NGL		240	130	14.0
		7.0m below NGL		240	130	16.0
1000		3.0m below NGL		410	240	17.0
		4.0m below NGL		410	240	18.0
		7.0m below NGL		410	240	20.0
600	Stacker area, Crusher, Silo, Biomass area (BH139-BH161)	2.0m below FGL	18	70	40	10.0
		2.0m below FGL	24	80	50	10.0
		2.0m below FGL	28	100	60	10.0
760		2.0m below FGL	24	120	80	14.0
		2.0m below FGL	28	140	90	14.0
1000		2.0m below FGL	24	210	120	19.0
		2.0m below FGL	28	230	150	19.0

*The pile shall be socketed 5d (minimum) into rock. Where d is the diameter of pile.

iii) Only straight shaft piles shall be used. Minimum cast length of pile above cutoff level shall be 1.0 m.

iv) The contractor shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, pile load test arrangement, locations of initial test piles etc.) for Engineer's approval.

v) The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.

vi) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical

Lateral Minimum of 2 Nos. in each mode.

Uplift

vii) The initial pile load test shall be conducted with test load three times the pile capacity. In case of vertical compression test (initial test) the method of loading shall be cyclic as per IS:2911 (relevant part).

viii) The load test shall be conducted at pile Cut-off Level (COL). If the water table is above the COL the test pit shall be kept dry throughout the test period by suitable de-watering methods. Alternatively, the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter.

ix) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under:

i) Vertical: 0.5% of the total number of piles provided.

ii) Lateral: 0.5% of the total number of piles provided.

x) The routine tests on piles shall be conducted test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.

xi) In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.

xii) Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). The contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.

xiii) The test load on initial test piles shall be applied by means of Kentledge with concrete blocks / reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge with concrete blocks.

xiv) The Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the routine load test and not intended to replace the use of static load test. This test is limited to assess the imperfection of the pile shaft and shall be undertaken by an independent specialist agency to be approved by Engineering department of owner's consultant. The test equipment shall be of TNO or PDI make or equivalent. The process shall confirm to ASTM.

xv) Routine pile load tests to be performed on 0.5% of the total number of piles provided for each diameter/allowable capacity. High Strain dynamic load test may be carried out for routine load testing of working piles. However, at least two numbers of static routine vertical load tests shall be carried out on pile on which high strain dynamic load test has already been carried out for establishing the correlation between the two tests. In case of discrepancy if any between dynamic and static vertical load tests, then additional static routine vertical load tests shall be conducted as decided by the Engineer and the results of static routine vertical load shall prevail. Number of routine vertical pile load tests as per clause 7.03.00 (ix) shall be total of static routine vertical load test and high strain dynamic load tests.

In case agency wish to carry out only static routine vertical load test on 0.5% of total number of piles, he may adopt the same.

The procedure to carry out the test shall be submitted to the Engineer. The test and equipment shall conform to ASTM D4945-00. The test shall be conducted by an experienced independent test agency approved by the owner's consultant. Field data shall be submitted to the site engineer and shall include force velocity curves, pile capacity, simulated static load test curve, net and total pile displacement, pile integrity. A (Case pile wave analysis) CAPWAP or equivalent software analysis shall be conducted on the field data for correct capacity estimation and to evaluate end bearing and skin friction components of the pile.

xvi) From load considerations, single pile may be used under a column/tower. In that case, pile shall be connected with tie beams at pile cut off level in both directions.

xvii) Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.

xviii) Reinforcement for job piles shall be designed as following:

(a) Compression + bending piles: For these piles, the allowable safe pile capacities in compression and bending shall be considered.

(b) Tension + bending piles: For these piles, the actual pile forces to be considered. However, maximum 3 types of combinations for varying percentage of tension capacity + bending case may be designed & adopted by contractor for the entire scope of work under this package.

7.05.00 Excavation, Filling and Dewatering

7.05.01 For excavation works, comprehensive dewatering with well point or deep wells arrangement, if required, shall be adopted. Scheme for dewatering and design with all computations and back up data for dewatering shall be submitted for the owner's consultant information. The water table shall be maintained at 0.5m below the founding depth.

7.05.02 Excavation for shallow foundations shall be covered with PCC immediately after reaching the founding level. In case of any local loosening of soil or any loose pockets are encountered at founding level during excavation the same shall be removed and compensated by PCC M7.5. The final layer of about 300 mm thickness above the founding level shall be excavated by suitable means, so as to avoid disturbance to the founding stratum.

7.05.03 **Backfilling in Powerhouse & Boiler Area**

Backfilling around foundations, trenches, sumps, pits, plinths, etc. shall be carried out with natural sand/ sand manufactured from other than natural sources as specified elsewhere in the technical specification in layers not exceeding 300 mm compacted thickness and each layer shall be compacted to minimum 80% of relative density. **Controlled Low Strength Material (CLSM) as specified elsewhere in technical specification may also be used for backfilling in Powerhouse and Boiler area.**

Backfilling in other area

Backfilling around foundations, pipes, trenches, sumps, pits, plinths, etc. shall be carried out with approved material in layers not exceeding 300 mm compacted thickness (higher thickness of layers upto 500mm with heavy mechanical compacting equipment) and each layer shall be compacted to 90% of standard proctor density for cohesive soils and to 80% of relative density for non-cohesive soils.

7.05.04 Founding level for trenches/channels shall be decided as per functional requirement. The bottom of excavation shall be properly compacted prior to casting of bottom slab of trenches / channels.

7.05.05 CBR tests for pavement/road design shall be carried out by the Contractor after earth filling (if applicable) has been completed upto the formation level.

7.05.06 The contractor shall take all necessary measures during excavation to prevent the hazards of falling or sliding of material or article from any bank or side of such excavation which is more than one and a half meter above the footing by providing adequate piling, shoring, bracing etc. against such bank or sides.

Adequate and suitable warning signs shall be put up at conspicuous places at the excavation work to prevent any persons or vehicles falling into the excavation trench. No worker should be allowed to work where he may be stuck or endangered by excavation machinery or collapse of excavations or trenches.

7.06.00 Sheeting & Shoring

The contractor shall ascertain for himself the nature of materials to be excavated and difficulties, if any, likely to be encountered in excavation while executing the work. Sheet piling, sheeting and shoring, bracing and maintaining suitable slopes, drainage, etc. shall be provided and installed by the Contractor, to the satisfaction of the Engineer.

7.07.00 **Geotechnical investigation work shall be got executed by the Contractor through the following agencies**

1. C.E. TESTING COMPANY Pvt. Ltd, Kolkata

2. Cengrs Geotechnica Pvt. Ltd, New Delhi
3. KCT Consultancy Services, Ahmedabad
4. M.K. Soil Testing Laboratory, Ahmedabad
5. Secon Private Limited, Bangalore
6. Soil Engineering Consultants, New Delhi
7. CEG Test House and Research Centre Private Limited, Jaipur
8. Geomarine Consultants Pvt Ltd., Chennai
9. Soiltech India Private Limited, Pune

Annexure-C

SOIL DATA AND FOUNDATION SYSTEM

The employer has carried out geotechnical investigation in the proposed area. Logs of boreholes of proposed area are enclosed with this Annexure.

a) The minimum founding level and the corresponding net allowable bearing pressure shall be as given in Table – 1 below.

Table-1

Structure	Depth of Foundation	Width of Foundation	Net Allowable Bearing Capacity (t/sqm)		
			S=25mm(soil)	S=40mm(soil)	S=75mm(soil)
Boiler, Main Powerhouse, ID Fan, FD & PA Fan, Mill reject silo	1.5m below NGL	1m to 3m	11	18	-
		3m to 6m	6	10	-
		>6m	7	-	13
	2.5m below NGL	1m to 3m	12	20	-
		3m to 6m	07	11	-
		>6m	07	-	13
	3.5m below NGL	1m to 3m	13	21	-
		3m to 6m	08	12	-
		>6m	08	-	14
	4.5 or more than 4.5m below NGL	1m to 3m	14	22	-
		3m to 6m	09	13	-
		>6m	09	-	15

Structure	Founding Depth/ Stratum	Net Allowable Bearing Pressure T/m2		
		Isolated / Strip Foundation S=40mm		Rafts (width > 6m) S=75mm
		Width upto 3.0m	width >3 to 6m	

Fire Water PH area (BH42, BH43)	1.5m below NGL	18	13	15
	2.5m below NGL	22	15	17
	3.5m below NGL	25	16	19
	>=5.0m below NGL	28	17	20
NDCT (BH04-BH06, BH10-BH13)	2.0m below FGL	20	12	16
	3.0m below FGL	21	13	18
	4.0m below FGL	22	15	20
	6.0m below FGL	28	18	20
	>=7.0m below FGL	32	18	21
NDCT, LHP, GHP (BH15-BH21, BH25-BH29, BH84, BH118)	1.0m below FGL	20	11	13
	2.0m below FGL	22	12	14
	3.0m below FGL	24	13	15
	6.0m below FGL	28	18	21
	>=7.0m below FGL	30	19	22
H2 Plant area, O&M Store, Worker rest room (BH02, BH03, BH07-BH09)	1.0m below NGL	15	12	13
	2.0m below NGL	20	13	15
	3.0m below NGL	24	15	17
	>=4.0m below NGL	27	16	19
Switch yard area (BH01, BH175-BH183)	1.0m below FGL	14	08	10
	2.0m below FGL	18	10	13
	3.0m below FGL	20	11	13
	>=4.0m below FGL	21	12	14
WTP area (BH76, BH184-BH195)	1.0m below NGL	14	08	10
	2.0m below NGL	20	12	15
	3.0m below NGL	26	15	18
	>=4.0m below NGL	30	18	20
Safety Control room, Gate Complex area (BH196, BH197)	1.0m below NGL	14	08	10
	2.0m below NGL	20	11	14
	3.0m below NGL	23	13	15
	>=4.0m below NGL	25	15	17
AWPH, TAC, CAC, SUMP AWPH, HCSD PH, FOPH, FOUPH, FO Tank, AHP Clarifier (BH102-BH109, BH129-BH132, BH138)	1.0m below NGL	12	08	09
	2.0m below NGL	18	10	13
	3.0m below NGL	20	12	14
	>=4.0m below NGL	21	13	15
ESP, ASPH, ESP Control room, (BH82, BH83, BH85, BH86, BH88, BH91, BH94-BH97, BH99, BH111, BH112, BH127)	1.0m below NGL	10	07	08
	2.0m below NGL	14	08	09
	3.0m below NGL	16	10	11
	4.0m below NGL	18	12	14
	>=5.0m below NGL	26	15	18
Con43, Con45, Con46, CPU Reg, DSPH1, FWBPH, TP25 to TP29 (BH67, BH68, BH74, BH77, BH79, BH81, BH87, BH89, BH98, BH100, BH101)	1.0m below NGL	12	08	09
	2.0m below NGL	18	10	13
	3.0m below NGL	20	11	13
	>=4.0m below NGL	21	12	14
	1.0m below NGL	14	10	12

CWPH, CW Chem Plant, SSF Sump (BH22, BH23, BH30, BH33)	2.0m below NGL	24	12	16
	3.0m below NGL	28	15	18
	4.0m below NGL	32	20	22
	>=5.0m below NGL	34	22	25
GT, Air Comp House, Service Bldg. (BH34, BH35, BH37-BH41, BH45, BH47, BH62, BH73)	1.0m below NGL	14	09	10
	2.0m below NGL	24	12	16
	3.0m below NGL	28	15	18
	>=4.0m below NGL	30	18	20
Chimney, FGD area (BH115-BH117, BH135, BH136 BH119-BH126)	1.5m below FGL	18	10	13
	2.5m below FGL	20	11	13
	3.5m below FGL	21	12	14
	>=4.5m below FGL	25	15	17
Silo, Utility bldg., Stacker, Con 53, TP34, Blomass area, Stacker, Crusher House, TP32, Con 51, TP31, Con 48, Con49, TP33, TP34, Con53, CSSP, Track Hopper (BH139-BH161)	1.0m below FGL	16	10	12
	2.0m below FGL	22	12	14
	3.0m below FGL	23	14	16
	4.0m below FGL	25	16	18
	6.0m below FGL	30	18	20
	>=11.0m below FGL	30	25	24
TP24, Con41(except between BH163 to BH165), Con42 (BH75, BH162, BH163)	1.5m below NGL	12	07	08
	2.5m below NGL	14	07	08
	3.5m below NGL	15	08	08
	>=4.5m below NGL	20	09	09
Reclaim Hopper, TP30, Con 47(except between BH167 to BH170) (BH165, BH167, BH170- BH173)	1.5m below NGL	20	11	14
	2.5m below NGL	22	13	15
	3.5m below NGL	23	15	17
	>=4.5m below NGL	28	17	19
TP21, TP22, TP23, Con 39, Con40, Con41 between BH163 to BH165, Con 47 between BH167 and BH170 (BH164, BH168)	1.5m below NGL	06	04	08
	2.5m below NGL	08	06	09
	3.5m below NGL	10	07	11
	>=5.5m below NGL	24	14	18
RWPH, MCC SWGR near RWPH (BH212, BH213)	1.5m below NGL	09	08	12
	2.5m below NGL	14	09	17
	3.5m below NGL	20	11	20
	>=4.5m below NGL	24	15	24
RW Pipeline (BH206 to BH211, BH195, BH198, BH199)	1.5m below NGL	08	05	07
	2.5m below NGL	10	06	07
	3.5m below NGL	14	08	09
	>=4.5m below NGL	17	09	09
Transmission line Corridor (BH200 to BH205)	1.5m below NGL	20	10	14
	2.5m below NGL	22	13	15
	3.5m below NGL	25	15	17
	>=4.5m below NGL	27	17	20
Ash Dyke area (BHAD01 & BHAD02)	1.5m below NGL	15	12	14
	2.5m below NGL	17	16	15
	3.5m below NGL	24	22	22

	>=4.0m below NGL	25	25	25
Ash Dyke area (BHAD02)	1.5m below NGL	25	25	25
	>=2.5m below NGL	40	40	40
Ash Dyke area (BHAD03)	1.5m below NGL	04	04	07
	2.5m below NGL	07	05	08
	3.5m below NGL	10	06	10
	>=7.5m below NGL	20	15	18
Any other structure/facilities not mentioned above	1.5m below NGL	08	06	08
	2.5m below NGL	10	08	10
	3.5m below NGL	14	10	14
	>=4.0m below NGL	18	14	18

For Finished ground level (FGL) refer General layout plan (GLP)

To determine the Natural Ground Level (NGL), tender drawings titled "TOPGRAPHICAL SURVEY" shall be referred. Further the above tender drawings shall also be referred in conjunction with borelog data attached at Annexure to this chapter.

The NGL for any particular structure/facility shall be the lowest of all the NGLs mentioned in the extent of the building/facility.

The NGL of any point shall be the lowest of the levels at (a) TOPGRAPHICAL SURVEY and (b) Borelog data attached at Annexure to this chapter.

In case any loose/soft pockets are encountered at founding level, the same shall be removed completely upto the hard strata and filled up with PCC M7.5.

The net allowable bearing pressure higher than above mentioned values shall not be permitted. At intermediate levels the bearing capacity shall be same as the net allowable bearing pressure corresponding to the immediate shallower level mentioned above.

For the new facilities to be constructed after dismantling existing facilities; founding level of new facilities shall be taken at least 0.5m below the existing founding depth of the dismantled structures.

For open foundations, the total permissible settlement shall be governed by IS: 1904 / IS: 13063 and from functional requirements whichever is more stringent. However, total settlement shall be restricted to the following:

Isolated & Raft (Main powerhouse, TG Area Footings, Boiler, Mill, Bunker Footings & Fans) resting on soil	25 mm
Isolated & Strip (other than Main powerhouse, TG Area Footings, Boiler, Mill, Bunker Footings & Fans) resting on soil	40 mm
Raft (other than Main powerhouse, TG Area Footings, Boiler, Mill, Bunker Footings & Fans) resting on soil	75 mm

In case the total permissible settlement is to be restricted to less than as above specified from functional requirements, then the net allowable bearing pressure shall be reduced after review in consultation with Engineer.

Special Requirements:

i) Chemicals in ground water and subsoil, as observed during investigation are:

Chemical	Sulphates	Chlorides	pH
Ground Water	60-180 mg/l	20-82 mg/l	6.7-7.4
Sub-soil	< 0.05%	0.008-0.014%	4.7-6.6

SUB-SECTION-D-1-8

GENERAL SPECIFICATION

D-1-8 GENERAL SPECIFICATION

8.01.00 **GENERAL REQUIREMENTS**

8.01.01 **JOINTS IN CONCRETE STRUCTURES**

Construction Joints

All horizontal construction joints shall be provided with a groove (shear key) for transfer of shear force.

For construction joint in concrete wall, the maximum height of any lift should not exceed 2 meters. However, the time interval between the successive lifts should be as small as possible and the wall should be built to its full height in the least possible time.

Expansion joints for all underground structures shall be made watertight by using ribbed PVC water stops with central bulb or of kicker type. The thickness and width of PVC water stops shall be as per the requirement of design. However, the minimum thickness and width shall be 6mm and 225mm respectively.

Expansions Joints

In case of expansion joints, preformed bitumen impregnated fibre board conforming to IS 1838 shall be used as joint filler. The joints shall be sealed with bitumen sealing compound conforming to IS 1834, however in case of liquid retaining/carrying structures, two parts polysulphide sealant conforming to IS 12118 or silicon sealing compound shall be used.

IS 3414 shall be followed for details of joints in buildings. 3 mm thick stainless-steel strip in matt or buff finish shall be provided over building expansion joints.

8.01.02 **Miscellaneous General Requirements**

8.01.02.1 All steel sections and fabricated structures, which are required to be transported on sea, shall be provided with anti-corrosive paint before shipment to take care of sea worthiness.

8.01.02.2 Monorails, monorail girders and fixtures shall be provided, wherever required to facilitate erection / maintenance of equipment.

8.01.02.3 Wherever possible all floor openings shall be provided with 100 mm thick 150 mm high RCC kerb all around.

8.01.02.4 Angles 75 x 75 x 6 mm (minimum) with 8mm diameter and 150mm long MS lugs @ 150 c/c shall be provided for edge protection all around cut outs/openings in floor slabs. Angles 50 x 50 x 6mm with effective anchor lugs shall be provided for edges of concrete drains supporting grating/covers, edges of RCC cable / pipe trenches supporting covers/chequered plates/ grating, edges of manholes supporting covers, supporting edges of precast RCC covers and any other place where breakage of corners of concrete is expected.

8.01.02.5 Floor of switchgear room shall be provided with embedded M.S. channel suitable for easy movement of breaker panels.

8.01.02.6 Anti-termite constructional measures and chemical treatment measures shall be given to all vulnerable areas susceptible to termite including column pits, wall trenches, foundations of buildings, filling below the floors, etc., as per IS 6313 and other relevant Indian Standards.

8.01.02.7 All cable & pipe routing shall be done as per system requirement and as stipulated elsewhere in the specification and shall run above ground on elevated trestles or other supporting structures except in some localized area (as approved by Employer) where the same can run in trenches. In case, pipes are to be routed on RCC pedestals, the height should not be less than 500mm above formation level/paving level. All trenches shall be of RCC with removable RCC covers.

	All cable trenches located inside buildings shall have minimum 6mm thick (o/p) chequered plate covers. Cable trenches, where allowed, located outside the buildings shall project at least 200mm above the finished formation level unless noted otherwise elsewhere in this specification so that no storm water shall enter the trench. The bottom of the trench shall be provided with a longitudinal slope of 1:500.The downstream end of trenches shall be connected through pipe drains to the nearby RCC manholes (to convey water from trenches) of storm water drainage system, but avoiding back flow of storm water. In general, the precast covers shall not be more than 300 mm in width and shall not weigh more than 65 kg. Lifting hooks shall be provided in the precast covers. All cable trenches, wherever required, shall be provided with suitable insert plates for fixing support angles of cable trays. In Main plant area wherever fire water pipe trenches are envisaged, these trenches shall be of RCC and provided with precast RCC cover flush with finished level of paving in that area. R. C. C. cable slits shall be filled with sand after erection of cables, up to top level and covered with 75mm thick PCC cover of minimum M15 grade.
8.01.02.8	All steel platforms above grade shall be provided with 100 x 6 thick kick plates at edge of platform.
8.01.02.9	Duct banks consisting of PVC conduits conforming to IS 4985 for cables shall be provided with proper sealing arrangement consisting of fire retardant sealing compound.
8.01.02.10	Independent network of lines for sewerage and drainage shall be provided. Plant effluent shall not be mixed with either storm water or sewage.
8.01.02.11	The sub-grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor density at Optimum moisture content (OMC.)
8.01.02.12	Detailed scheme for dewatering shall be prepared, wherever required, before starting of deep excavation work. IS 9758 shall be followed as general guidance for dewatering.
8.01.02.13	Structural steel column base plates and bolts, gussets, etc., shall not project above the floor level unless and noted otherwise. These shall be encased by concrete cover up to floor level with concrete grade M 25.
8.01.02.14	Non-shrink flow able grout shall be used for under-pinning work below base plate of columns. Nominal thickness of grout shall be 50 mm. Non-shrink cum plasticizer admixture shall be added in the grout. Crushing strength of the grout shall generally be one grade higher than that of the base concrete. Minimum grade of grout shall be M-30. Grouting of all pockets, blockouts, sleeves and the openings around the embedment, inserts, bolts etc. and under pinning below the base / sole plate shall be with non - shrink flow able grout. Grade of grout shall be one grade higher than concrete. However minimum grade of grout shall be M - 30. However, for equipment foundations, high strength (minimum characteristic compressive strength of 60 N/sq.mm at 28 days) ready mixed non-shrink, chloride free, cement based, free flowing, non-metallic grout as recommended by equipment manufacturer shall be used.
8.01.02.15	All the buildings and site development including landscaping shall be designed to take care of rain water harvesting & ground water recharging. Development of rain water harvesting scheme for the buildings, structures, facilities in Bidder's scope and obtaining approval of the scheme from Central Ground Water board is in Bidder's scope.
8.01.02.16	As required suitable steel frames shall be provided around openings in the roof and external walls for mounting exhaust fans.

8.01.02.17	750mm wide x 100 mm thick plinth protection in PCC (M-15) shall be provided around all buildings, pits / sumps, clarifiers, tanks, etc.
8.01.02.18	All masonry walls shall be provided with Damp Proof Course at plinth level.
8.01.02.19	All monorail openings in the walls shall be provided with double plate flush steel door shutters with suitable access platform and ladder as required.
8.01.02.20	Hand rail (of minimum 1m height), size and material to be adopted shall be as per general architectural specification.
8.01.02.21	In all buildings, suitable arrangement for draining out water collected from equipment blow downs, leakages, floor washings, firefighting etc. shall be provided for each floor with suitable floor drains.
8.01.02.22	Unless specified all sand filling shall be compacted to minimum 80% of the relative density and backfilled earth shall be compacted to minimum 90% of the Standard proctor density at OMC.
8.01.02.23	All buildings shall be provided with peripheral drains by the side of plinth protection for catering to the rain water from roofs and storm water from adjacent area. Plinth protection drains shall be provided all around the building and to be connected with nearest storm water drain. Minimum size of plinth protection drain will be 300mmx300mm.
8.01.02.24	Minimum 2.0m wide walkway with plain cement concrete (nominal mix M15 grade) paving 150 mm thick laid over 75 mm thick bed of dry aggregate shall be provided connecting all buildings and facilities. The top of walkway shall be minimum 200mm above FGL, unless specified otherwise.
8.01.02.25	For all buildings, finished floor level (FFL) shall be minimum 500mm above finished ground level (FGL).
8.01.02.26	40mm Diameter MS rods as earthing mat, placed at a distance of 1.0m away and at depths between 0.60m and 1.00m shall be supplied and laid all around the periphery of buildings, structures, and outdoor equipment, as per approved drawings. Riser of 40mm Dia. MS rods and connecting to the above Earthing mat shall also be supplied and laid in position by the Contractor, as per the approved drawings. Raiser shall be laid up to a height of 300 mm above the local Ground level, at each of the columns of the buildings on the outside of the buildings, and minimum 2 (two) numbers for each structures and equipment. The contractor shall also supply and lay necessary number of 3.0 m deep 40 mm diameter MS rods Earthing electrodes and connect electrodes to the Earthing mat, as per the approved drawings and supplying and laying of 40 mm Dia. MS rods for connecting the Contractor's earthing mat with the Employer's earthing mat separately.
8.01.02.27	Hume pipes of required class shall be as per IS: 458. Hume pipe made of Geopolymer concrete may also be used. Details of ingredients for Geopolymer concrete is as per details specified elsewhere.
8.01.02.28	Coefficient of active earth pressure shall be considered for design of free standing retaining walls and coefficient of earth pressure at rest shall be considered for design of top propped retaining walls.
8.01.02.29	Interlocking concrete block confirming to IS:15658, kerb blocks or concrete block specified for various uses shall be precast blocks made of alkali-activated concrete /Geopolymer concrete as per IS:17452- 2020.
8.01.02.30	Rail-track from transformer yard to unloading bay of Main Power House shall be provided with rigid type RCC foundation. Rail weighing 52 kg/m(minimum) shall be used.
8.01.02.31	All openings in floors / roofs / Walls / Cladding for routing of Pipes / cables / Ducts shall be suitably sealed by the contractor after completion of erection works.

8.01.03 **Acid/ Alkali Resistant Lining**

All structures receiving acid / alkali resistant lining shall be tested for water tightness and made leak proof before lining work.

The acid / alkali resistant lining shall be provided broadly in the areas identified. The Bidder shall give a guarantee for satisfactory functioning of the lining for a period of 36 months from the date of completion of the work or date of handing over the site to the Engineer, whichever is later. The Bidder shall replace / rectify defects is any, observed in the lining to the satisfaction of the Engineer without any extra cost during this period.

The material for Acid/ Alkali Resistant Lining shall conform to the following:

i) Bitumen primer shall conform to IS: 158.

ii) Bitumastic compound shall conform to IS: 9510. Where the height of bitumastic layer on vertical surface is more than 2.0 m, the bitumastic layer shall be reinforced with diamond pattern expanded metal steel sheets conforming to IS: 412.

iii) A.R. Bricks/ Tiles shall conform to class II of IS: 4860 & IS: 4457 respectively.

iv) Mortar: Potassium silicate & resin type mortars shall conform to IS: 4832 Part-I&II respectively.

8.02.00 **CONCRETE**

8.02.01 **GENERAL**

a) Concrete work shall be of grade as per IS 456. Mix design concrete shall be used for all areas other than lean concrete work and plain cement concrete where nominal/volume mix can be permitted. Design mix shall be carried out as per IS10262. Specific approval of the Engineer shall be obtained regarding degree of quality control to be adopted for design mix.

b) Minimum grade of reinforced cement concrete for all foundations shall be M25 unless noted otherwise. Minimum grade of concrete for other structures/areas (other than machine foundations) shall be M25 for all superstructure and substructure unless noted otherwise elsewhere in this specification.

c) The minimum grades of concrete for different machine foundations and some of other important structural members shall be as follows:

Sl No	Description	Minimum grade of concrete
i)	Foundations & Pedestals; Column Encasements; Tank Foundations (of over-ground steel tanks); Paving/ Ground floor slabs/ Grade slabs/ Floor Slabs/ Roof slabs; Drains/ Trenches/ Sump pits/ Box Culverts; Foundations, sub-structures & super-structures of all buildings UNO; DG/ Transformer foundations; RCC encasement of CW Pipes & other pipes; Thrust blocks etc	M25
ii)	ID, FD, PA fan & Mill foundations (block foundations); CWPH/ RWPH, channels & forebays; Wet/ Dry Chimney; NDCT (in-situ)/ IDCT; Water retaining structures/ Pits; CW & CEP Pits;	M30

	ACC; Pre-cast drains; Boundary wall;	
iii)	TG top Deck	M50
iv)	TG Raft/ Substructure Complete Track Hopper, reclaim hopper, Stacker and Reclaimer foundations, Crusher Deck foundation, Railway load bearing structures, NDCT precast elements, All spring supported machine foundations except TG	M35
v)	BFP foundations (in case of springs supported) / (in case of block foundation)	M35 / M30
vi)	PCC mat Below foundations	M7.5
vii)	PCC encasement of Pylon supports and CW Pipes; Plinth protection	M20
viii)	Road (Geopolymer concrete) DLC / PQC	M10/ M35

Concrete design mix of M50 grade concrete for TG top deck and substructure shall be carried out as per IS 10262 satisfying following conditions /Specification:

i) OPC 43 grade cement shall be used to design M50 grade of concrete mix. However, in case the mix design using OPC 43 grade cement fails to achieve the target strength of M50 grade concrete, OPC 53 grade cement may be used provided adequate precautions for higher heat of hydration and quality assurance measures are in place.

ii) The concrete slump shall be in the range of 150-180mm at pouring point.

iii) Maximum cement content (OPC) shall be limited as stipulated in IS 456.

iv) Free water-cement ratio shall be as per clause 5.1 of IS 10262.

v) PCE type superplasticizers shall be used as high range water reducing admixtures (Type F as per ASTM C494 or equivalent) in the concrete mix. Dosage & mixing methodology of this chemical admixture shall be as per manufacturer's recommendation.

vi) Fly ash shall be not be used as replacement of total cementitious materials.

d) Higher grade of concrete than specified above may be used at the discretion of the Bidder.

e) Unless otherwise specified, 20mm and down aggregates shall be used for all structural concrete works. However, 40mm and down aggregates may also be used under special conditions for mass concreting in foundation.

f) For thin concrete sections such as roof slab over profiled metal deck sheets, 12mm and down coarse aggregates shall be used for coarse aggregates.

g) Minimum 75mm thick lean concrete M-7.5 shall be provided below all other underground structures, foundations, trenches, etc., to provide a base for construction.

h) All structural(reinforced) concrete production shall be done at automated batching plant of suitable capacity, conforming to IS:4925., situated within the area allocated to the contractor. Batching plant shall also have provision to mix fly ash (by weight). The batching plant shall have facility of digitized recording of the materials added along with quantity of concrete produced in each batch and printout of the same. Batch-wise report for each shift shall be submitted to the Engineer.

8.02.02 **Reinforcement Couplers**

Reinforcement couplers (mechanical splicing systems with upset parallel threaded couplers) may be used in reinforced concrete works, subject to following conditions:

a. Couplers shall meet the performance requirements of IS 16172 for class H.
   i. It shall have minimum tensile strength corresponding to Fe550D which is 600 N/mm2 and failure shall take place outside the length of splice as per clause no 9.2.1 of IS 16172.
   ii. Percentage elongation at maximum force in the reinforcing bar outside the length of mechanical splice shall be minimum 3 % before the failure of test piece as per clause no. 9.2.2 of IS:16172.
   iii. Slip test value shall not exceed 0.10 mm. as per clause no 9.3 of IS 16172.
   iv. Cyclic tensile test corresponding to Fe550D reinforcement bar as per clause no 9.4 of IS 16172.
   v. Low cycle fatigue test as per clause no 9.5.1 of IS 16172.
   vi. High Cycle Fatigue test as per clause no 9.5.2 of IS 16172.

b. The manufacturer shall mark the coupler in such a way that all finished reinforcement couplers can be traced to the original cast from which they were made along with date of manufacture.

c. Sampling and other requirements of IS 16172 shall be complied with.

d. Each lot shall be supplied with manufacturer's test certificate (MTC) indicating values of tests in line with IS 16172.

e. The minimum clear cover requirements are to be ensured for reinforcement couplers also.

f. The couplers shall be used only at the locations where joint is required as per standard lapping purpose and couplers shall not be used for joining of several cut pieces of reinforcement in a single bar. As a general guideline, the length of the bars in which coupler is to be provided should not be less than 4m.

Vendors for the reinforcement couplers shall be subject to the approval of Engineer-In-Charge

8.02.03 Special requirements for concreting of major equipment foundations shall be as given below.

a) **Temperature Control of Concrete**

All the machine foundations such as Mills & Fans, top decks of TG & BFPs, the temperature of fresh concrete shall not exceed 25 deg C when placed. For maintaining the temperature of 25 deg C, crushed ice shall be used in mixing water.

b) **Admixture**

Plasticizer /super plasticizer admixture shall generally be added to the concrete for promoting workability. In addition, plasticizer/super plasticizer-cum-retarder shall be added to retard the setting time for mass concreting work as required. In case of pumping, suitable pumping additive shall also be added to avoid segregation and increase flowability. The slump shall generally be in the range given below:

Top decks of TG & BFP	-	150 mm to 180 mm
Block foundations	-	100 mm to 150 mm

TG Column - 100 mm to 150 mm

Admixtures in concrete for promoting workability, retarding setting, reduction in permeability, facilitating pumping of concrete, etc., shall be used as per the approved mix design after approval from the Engineer. Admixtures shall conform to clause 5.5 of IS: 456. These shall be free from injurious amount of chloride, etc. Addition of admixtures should not reduce the specified strength or durability of concrete and should not have detrimental effect on reinforcement.

The admixtures shall conform to IS: 9103 or ASTM C-494 and shall be proven performance record make and from a reputed manufacturer. Calcium chloride as accelerating admixture is not permitted to be used.

Admixtures shall either be naphthalene based or any other material approved by the Engineer. Ligno-sulphonate based materials shall not be used. Admixtures shall be used in liquid form only, quantity of which shall be as per manufacturer's recommendation and approved mix design.

c) **Form work**

Plywood with film face form work shall be used for the top decks of all machine foundations

d) **Placing of Concrete**

Base Raft and top deck of machine foundations shall be cast in a single pour.

e) **Scheme for Concreting**

Weigh Batching Plants, transit mixer, concrete pump shall be mobilized. Arrangements for standby Plant and Equipment shall also be made.

f) **Ultrasonic Testing**

Ultrasonic pulse velocity test shall be carried out for TG top deck including TG Columns & BFP top decks (in case of Block type, UPV testing is not required) to ascertain the homogeneity and integrity of concrete. In general, grid spacing of 1.0m to 1.5m may be adopted for carrying out the UPV testing. In addition, additional cubes (at the rate of one cube per 150 Cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes, to serve as reference UPV values. Testing shall be done as per IS13311 (Part-1). In case of any defect, the Bidder shall rectify the defects suitably using cement/epoxy grout, etc.

Wherever block type foundations are provided for machine foundations such as BFPs, UPV testing of foundation concrete is not required.

8.02.04 **Anchor Fasteners**

Anchor Fasteners for use in concrete shall conform to the following:

a. The safe tensile load carrying capacity of the anchors shall be arrived by providing the minimum factor of safety of 2.5 on the characteristic load of the anchor. Minimum size of the anchors shall be M8.

b. All anchors shall be from established and approved makes/ manufacturers.

c. Anchors shall be fixed in position as recommended by the manufacturer and as approved by the engineer.

d. Anchor fastener can be of mechanical type based on working principles such as keying, friction, combined friction- keying or chemical bonding type.

1) Mechanical type: The anchors shall be cold formed stud type torque controlled mechanical expansion fasteners having 3-way expansion sleeve of SS 316 grade with nut and washer and galvanized to minimum 5 microns. For coastal/ corrosive environments, the anchors shall be of Stainless Steel (min grade SS 304) or HCR (High Corrosion Resistance). The anchors shall conform to a minimum grade of 5.8 as per IS: 1367.

2) Chemical type: The anchor shall be adhesive type consisting of slow curing chemical adhesive with a proportion of resin and hardener as per manufacturer's recommendation in a soft foil pack, threaded rod of carbon steel conforming to a minimum grade of 5.8 as per IS: 1367 and minimum galvanization of 5 microns with associated nut and washer. The chemical shall be dispensed through mechanical dispenser and shall be self-curing type.

e. Capacity of the anchors shall be established after considering the effect of concrete grade, embedded depth, concrete thickness, anchor spacing and edge distance from the concrete.

f. The selection for particular type of the anchors shall be made after considering the concrete grade, available embedment depth, load to be transferred, space available for installing anchors.

8.03.00 **FORMWORK**

Formwork for building RCC Slabs/ Beams & Columns shall be of 2 different types.

Type 1 Formwork: (For RCC slab of Structural Steel Framed Buildings Only)

Troughed colour coated metal deck sheets shall be used as permanent shuttering having minimum thickness as per the criteria specified in metal deck roof material clause in Architectural Design and concept chapter and design criteria chapter. These profiled metal deck sheets shall be fixed to the structural steel secondary beams/ Purlins using Headed shear anchor studs. The detailed material property requirement of metal deck sheet is specified elsewhere in this specification.

The shear anchor studs for fixing metal deck sheet to floor structural beams shall conform to Type-B studs specified in AWS D1.1/D1.1M or equivalent as shear connector of 19mm diameter and 100mm length manufactured from cold drawn round steel bars conforming to the requirement of ASTM A 29, of grade designation 1010 through 1020, of standard quality with either semi-killed or killed, welded by Drawn Arc Stud Welding through metal deck sheet.

The shear anchor studs for fixing metal deck sheet to roof structural purlins shall conform to Type-B studs specified in AWS D1.1/D1.1M or equivalent as shear connector of 16mm diameter and 65mm length manufactured from cold drawn round steel bars conforming to the requirement of ASTM A 29, of grade designation 1010 through 1020, of standard quality with either semi-killed or killed, welded by Drawn Arc Stud Welding through metal deck sheet.

Type 2 Formwork: (For RCC Buildings)

Plywood with film face formwork shall be used for floor & roof slabs, Columns & Beams of all RCC buildings.

8.04.00 **CROSSINGS OF RAIL TRACKS**

Design of bridges/ culverts or any other structure crossing the Railway tracks shall be as per Railways/ RDSO guidelines/specifications for Dedicated Freight Corridor (DFC) 32.5 T loads. The Bidder shall obtain necessary approvals from Railways before start of construction work. Construction of these structures is to be done as per Railways guidelines. Any statutory and codal charges payable to Railways/ RDSO for approval & execution of the above crossings shall be borne by the Bidder. Engagement of approved Railway Consultant for the above work by the bidder would be at his own cost.

The levels/clearances of the above crossings are to be finalized by the bidder as per Railway standards and shall be subject to approval of Owner/Owner's Consultant.

However, for design of the above crossings above rail track, the following minimum clearance from Rail track shall be maintained:

A. Horizontal clearance: A minimum clearance of 3.5m shall be maintained between centre line of the Railway track to face of the crossing structure.

B. Vertical clearance: A minimum vertical clearance of 8.5m shall be maintained between Rail top level and bottom of structure.However, a minimum vertical clearance of 6.5m shall be maintained between Rail top level and bottom of structure in case of FA silo.

Bidder has to submit to the Owner two sets of railway approved drawings and two sets of (hard & soft copies) as built drawings.

The construction of rail network inside the plant for transportation of coal, fly ash & POL is in the scope of Owner. The bidder should plan to complete the construction work of all roads/ drainage/ pipe line/ cable crossings etc which are crossing below the rail track well in advance to facilitate owner to undertake the construction work of siding.

8.05.00 **FENCING AND GATE**

8.05.01 **FENCING**

Fencing with gate shall be provided around fuel oil area, and other areas wherever necessary due to security, safety, and statutory requirements as per following specifications. However for isolation between existing station/township and the project, the total height of fence may be reduced to 2.4m with 450mm barbed wire on top, while other details being same as given below.

The fencing, with gate (unless specified otherwise) shall comprise of PVC coated G.I. welded wire mesh fencing of minimum 4 mm diameter (including PVC coating) of mesh size 75mmX75mm of height 2.4m above the toe wall with a 600mm high galvanised concertina at the top, such that total fence height of 3.0m above the toe wall is achieved. The diameter of the steel wire for chain link fence (excluding PVC coating) shall not be less than 2.5 mm.

The PVC coated chain link will be stretched by the clips at 0.5m intervals to three strands of galvanised high tensile spring steel wire (HTSSW) of 2.5 mm diameter interwoven with chain link wire mesh and kept under tension which in turn are attached to the fence post with security nuts and bolts. On every fourth post a clamping strip will be threaded through the links of chain link and bolted to the fence post with the help of security nuts and bolts.

Above the chain link a 600mm high tensile serrated galvanised wire (HTSW) concertina made with wire diameter of 2.5mm will be stretched to 6m and attached to two strands of galvanised HTSSW of 2.5 mm diameter by means of clips at 1m intervals. These two HTSSW strands will be attached to the fence posts with 12 mm security fasteners.

All nuts, bolts, fasteners, clamping strips, clamps, clips, etc., shall be galvanised.

All fence posts shall be of 75 x 75 x 6 MS angles spaced at 2.5m c/c distance. All corner posts will have two stay posts and every tenth post will have transverse stay post. Suitable R.C.C. foundations for the post and stays shall be provided based on the prevailing soil conditions. All posts of fencing shall be painted with chlorinated rubber paint over a suitable primer.

Toe walls either of brick masonry with bricks of minimum 50 kg./sq.cm. Crushing strength or of hollow concrete block masonry shall be provided between the fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200mm above the formation level with 50mm thick P.C.C. coping (1:2:4) and shall extend minimum 300mm below the formation level. Toe wall shall be plastered with cement sand mortar (1:6) on both sides and shall be painted with two coats of textured cement point (Sandtax Matt or equivalent) of approved colour and shade. Toe wall shall be provided with weep holes at appropriate spacing.

8.05.02 **Gate along Fencing**

All gates shall be of structural steel of minimum 3.75 metre width for single lane access road and 8.00 m width for double lane access roads. The height of gate shall be same as that of the fence unless noted otherwise. Each gate shall have provision for wicket gate of size 1.0 m x 2.1 m.

The gate frame and post shall be fabricated from medium class MS pipe of nominal diameter not less than 75 mm. The panel plate shall be of minimum thickness 2.5 mm conforming to IS: 513.

The gate shall be complete with fabricated hinges, MS aldrops with locking arrangement, tempered steel pivot, guide track of MS tee, bronze aluminium ball bearing arrangement, castor wheel, etc.

8.06.00 **GRATING**

All gratings shall be electroforged types. Minimum thickness of the grating shall be 40 mm. The opening size shall not be more than 30mmx100mm. The minimum thickness of the main bearing bar shall be 5 mm or as per design requirement whichever is higher. All gratings shall be hot dip galvanised at the rate of 610 g. per sq.m. after surface preparation by means of shot blasting or cleaned by acid pickling.

8.07.00 **FABRICATION & ERECTION OF STEEL STRUCTURES**

Steel structures which are to be fabricated in factory shall have bolted field connection. Steel structure which are to be fabricated at site can have bolted field connections ~~or welded connection~~. The fabrication shall be done as per fabrication drawing which would clearly indicate various details of joints to be welded, type of weld, length and size of weld and bolt details.

deleted. (Amendment No 02, D-2-7)

For coal bunkers, hoppers and chimney flue liners, to prevent coal dust/flue gas leakages, the applicable field joints shall necessarily be welded. For factory fabricated structures, site welding can be permitted in special cases where final inputs are not available before release of fabrication drawings. Before dispatching the fabricated structural members to site, it shall be ensured that all parts in the assembly fit accurately together by carrying out pre-assembly of fabricated structural members having bolted field joints, in the factory.

All steelwork before and after manufacturing shall be smooth, straight and free of deformations, cracks, twists and burrs. All steelwork shall be cut and fabricated to a tolerance of ± 1.5 mm in its length and location of matching bolt holes for field connections.

Note:

I. Fabrication facilities (like cutting, welding, NDT, shot blasting, painting, Storage & Preservation, lifting, drilling and handling etc.) including qualified & experienced manpower shall be at par with factory.

II. Quality checks presently envisaged in MQP shall be tied up in FQP.

III. Inspection will be carried out by FQA / Site QA.

IV. For site fabricated structures, bidder has to submit a comprehensive proposal comprising of storage facilities, layout, shot blasting, painting, preservation for Owner's approval within 06 months of LOA..

8.07.01 **Welding**

a) Welding of Structural steel shall be done by an electric arc process and shall conform generally to relevant acceptable standards viz. IS:816, IS:9595, IS:814, IS:2014, IS:4354 and Indian Standard Hand Book for metal arc welding, and other standards, codes of practice internationally accepted. For welding of any particular type of joint, Bidder shall give appropriate tests as described in any of the Indian Standards - IS: 817, IS: 7307 and international standards as relevant.

b) Submerged arc-welding shall be used for welding longitudinal fillet welds (connecting flange with web) and longitudinal / transverse butt joints for fabrication of columns, framing beams and crane girders and all other built-up members, unless manual arc welding is specifically approved by the Engineer. Necessary jigs and fixtures and rotation of structures shall be so arranged that vertically down-hand position of welding becomes possible. 'Open-Arc-Welding' process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

c) Wherever welding is done for assembling the components of structures, the job shall so positioned that down hand welding is possible.

d) Any structural joint shall be welded only by those welders who are qualified for all welding procedures and positions in such type of joint that is welded.

e) All records for entire welding operations such as welders identification marks, the joints welded by the each welder, the welding procedures adopted, welding machine employed, pre and post heating done and any non-destructive test done and stress relieving /heat treatment performed on such joints shall be accessible to the Engineer for scrutiny.

f) In a fabrication of plated columns/beams and built up members all shop splices in each component part shall be done before such component part is welded to other parts of the member. Wherever weld reinforcement interferes with proper fitting between components to be assembled by welding, these welds shall be ground flush prior to assembly.

g) The members to be joined by fillet welding shall be brought and held as close together as possible and in no event shall be separated locally by more than 3mm. If the local separation is 1.5mm or greater, the fillet weld size shall be increased by the amount of separation.

Edge preparation for welding as per weld joint detail shall be prepared either by machines or by automatic gas cutting. All edges cut by flame shall be ground before they are welded.

8.07.01.1 **Electrodes**

a) The electrodes used for welding shall be of suitable type and size depending upon specification of the parent materials, the method of welding, the position of welding and quality of welds desired e.g. normal penetration welds or deep penetration welds. However, only low Hydrogen electrodes shall be used for plate thickness above 20 mm.

b) All low hydrogen electrodes shall be baked and stored before use as per manufacturer recommendation. The electrodes shall be rebaked at 250°C - 300°C for one hour and later on cooled in the same oven to 100°C. It shall be transferred to a holding oven maintained at 60°C - 70°C. The electrodes shall be drawn from this oven for use.

c) Where coated electrodes are used they shall meet the requirements of IS: 814 and

relevant ASME-Sec. Covering shall be heavy to withstand normal conditions of handling and storage.

d) Only those electrodes which give radiographic quality welds shall be used for welds which are subjected to radiographic testing

e) Where bare electrodes are used, these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform to the requirements of F-60 Class of AWSA-5-17-69 and IS: 3613. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

f) 308L and 309L electrodes / fillers shall be used for welding of stainless steel to stainless steel and stainless steel to mild steel respectively.

g) Specific approval of the Engineer shall be taken by Bidder for the various electrodes proposed to be used on the work before any welding is started.

8.07.01.2 **Preheating inter-pass Temperature and Post Weld Heat Treatment**.

a) Mild steel plates conforming to IS: 2062 and thicker than 20mm, may require preheating of the parent plate prior to welding as mentioned in Table-I.

However, higher preheat and inter-pass temperatures required due to joint restraint etc. and will be followed as per approved welding procedure. In welding materials of unequal thickness, the thicker part shall be taken for this purpose.

b) Base metal shall be preheated, notwithstanding provisions of IS: 9595, to the temperature given in Table-1 prior to welding or tack welding. Preheating shall bring the surface of the base metal to the specified preheat temperature and this temperature shall be maintained as minimum temperature while welding is in progress.

TABLE – 1

MINIMUM PREHEAT and INTER PASS TEMPERATURE FOR WELDING

Thickness of thicker part at point of Welding	**Welding using Low hydrogen electrodes or Submerged arc welding**
Upto and including 20mm	None
Over 20mm and upto and including 40m	20°C
Over 40mm and upto and including 63mm	66°C
Over 63mm	110°C

c) Preheating may be applied by external flame which is non-carbonising like LPG, by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance of four times the thickness of the plate on either side of the welding joint is obtained.

d) Thermo-chalk, thermo-couple or other approved methods, shall be used for measuring the plate temperature.

e) All butt welds with plates thicker than 50mm and all site butts weld of main framing beam shall require post weld heat treatment as per procedure given in AWS D-1.1.

Post heating shall be done up to 600°C and rate of application shall be 200°C per hour. The post heat temperature shall be maintained for 60 minutes per 2.5cm thickness. For maintaining slow and uniform cooling, asbestos free pads shall be used for covering the heated areas.

8.07.01.3 **Sequence of Welding**

a) The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect or by a counter distortion. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

b) Each case shall be carefully studied before finally following a particular sequence of welding.

c) Butt weld in flange plates and/or web plates shall be completed before the flanges and webs are welded together.

d) The beam and column stiffeners shall preferably be welded to the webs before the web and flanges are assembled unless the web and flanges to the beam or column are assembled by automatic welding process.

e) All welds shall be finished full and made with correct number of runs, the weld being kept free from slag and other inclusions, all adhering slag being removed.

f) Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid as to leave the edges unmelted.

g) Pudding shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

h) Non-uniform heating and cooling should be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.

i) The ends of butt welds shall have full throat thickness. This shall be obtained on all main butt welds by the use of run off and run on pieces adequately secured on either side of main plates. The width of these pieces shall not be less than the thickness of the thicker part joined. Additional metal remaining after the removal of extension pieces shall be removed by grinding or by other approval means and the ends and surface of the welds shall be smoothly finished. Where the abutting parts are thinner than 20mm the extension pieces may be omitted but the end be welded to provide the ends with the required reinforcement.

j) The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presetting. Correct gap and alignment shall be maintained during the welding operation.

k) All main butt welds shall have complete penetration and back surface of the weld being gouged out clean before first run of the weld is given from the back. However, partial penetration butt weld shall be permitted, when specifically shown in the design drawings.

l) Intermittent welds shall be permitted only when shown in the design drawings.

m) The welding shrinkage shall be minimised by adopting the correct welding procedure and method. In long and slender member extra length should be provided at the time of fabrication for shrinkage.

8.07.01.4 **Testing of Welders**

All the welders to be employed for the job shall have to qualify the appropriate tests laid down

in IS: 817 and IS: 1181 and ASME IX/AWS D1.1. All the necessary arrangements required for the testing of welders are to be provided by the Bidder.

8.07.01.5 **Inspection of Welds**

a) **Visual Inspection**

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The lengths and size of weld shall be as per fabrication drawings. It may be slightly oversized but should not be undersized. The profile of weld is affected by the position of the joint but it should be uniform. The welds should have regular height and width of beads. The height and spacing of ripples shall be uniform. The joints in the welds run shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from unfilled craters on the surface, under-cuts, stages on the surface and visible cracks.

Such inspection shall be done after cleaning the weld surface with steel wire brushes and chisel to remove the spatter metal, scales, slag, etc., If external defects mentioned above are noticed, there is every possibility of internal defects and further radiographic/ultrasonic examination shall be undertaken.

b) **Production Test Plate**

Test plates shall be incorporated on either side of at least one main butt welds of each flange plate and web plate of every main frame columns and crane girder. The weld shall be continuous over the test plate. The test plate extensions of the main plates and shall be fixed so that metal lies in the same direction as that of the main plate. Test plates shall be prepared and tested in accordance with the accepted Standards, in the presence of the Engineer or his authorised representative. Should any of these tests fail, further radiographic examination of the welds shall be done. These tests for test plates and radiographic examination are additional to those contemplated under inspection and testing.

c) **Non-destructive and special testing**

Radiographic / ultrasonic or other non-destructive examination shall be carried out. All tests of welds shall be carried out by the Bidder at his own cost. The cordoning of radiation zone, while Radiography testing is going on, shall be done.

In case of failure of any of the tests, re-testing of the joints shall also be carried out after rectification is done.

d) **Rectification of defective welding work**

Wherever defects like improper penetration, extensive presence of blow holes, undercuts, cracking, slag inclusion, etc., are noticed by visual inspection/other tests, the welds, in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary, and rewelded. The gouging shall as far as possible be done using gouging electrodes.

8.07.01.6 **Inspection and Testing**

a) **Fillet Welds**

i) All fillet welds shall be checked for size and visual defects.

ii) Macroetch examination on production test coupons for main fillet weld with minimum
one joint per built up beam, column, and crane girder, etc.

iii) 25% weld length of tension members of crane girder shall be subjected to dye-penetration test.

iv) On all other welds, dye-penetration test on 5% of weld length with minimum 300mm at each location shall be carried out.

b) **Butt Welds**

i) 100% visual examination.

ii) Dye penetration test on all butt welds after back gouging shall be carried out.

iii) Mechanical testing of production test coupons - minimum one joint/built up beam, column and crane girder. The engineer may reduce the frequency of the test, after getting consistently satisfactory results of initial 10 tests.

iv) 100% radiography test on butt welds of tension flange (bottom flange) of crane girder and bunker supporting girders. All other butt welds shall be subjected to radiography test on 10% of weld length of each welder.

c) **Dimensional Tolerance and Acceptance Criteria of Welds**

i) Every first and further every 10th set of identical structure shall be checked for control assembly at shop before erection.

ii) All structures, components/members shall be checked for dimensional tolerance during fabrication and erection as per IS:7215 and IS:12843 respectively

iii) Dry film thickness after painting shall be checked by using elchometer.

iv) Acceptance criteria of NDTs on welds shall be as per AWS D-1.1(Dynamically loaded structures - Tension welds).

8.07.01.7 **Correction of Defective Welds**

Correction of defective welds shall be carried out without damaging the parent metal. When a crack in the weld is removed magnetic particles inspection or any other equally positive means shall be used to ensure that the whole of the crack and material up to 25mm beyond each end of the crack has been removed.

8.07.02 **Painting**

a) Surface treatment and painting before and after delivery to site shall be in accordance with Clause no. 6.4.0 above. All steel structures shall be designed by following basic design criteria in ISO 12944 Part 3.However, where it is not feasible to follow the design criteria given in ISO 12944 Part 3 where the steel surface are inaccessible for application of protective coating, corrosion allowance in thickness(over the design thickness) of structural steel members shall be kept.

b) For parts to be bolted, the surfaces in contact shall be provided with ethyl Zinc silicate primer as specified in clause 6.4.3 (a) and shall be free of oil, dirt, loose rust, burrs and other defects, which would prevent proper seating of the parts. For design of friction type bolted joints slip factor for surfaces with ethyl zinc silicate primer as given in IS 4000 shall be considered.

c) Surfaces inaccessible after shop assembly shall receive the full-specified protective treatment before assembly. However, interior surfaces of Box-sections, which are effectively sealed from all ends, need not be painted.

8.07.03 **Bolting**

The threaded portion of each bolt shall project through the nut by at least one thread. High strength friction grip bolts, preferably the type with indicated load, shall be used where specified and shall be tightened strictly in accordance with the manufacturer's instructions and the relevant regulations.

When connections are made using high strength friction grip bolts the relevant standards shall be observed.

8.07.04 **Erection of Structures**

All erection work shall be done with the help of cranes, use of derrick is not envisaged.

Erection Marks

a) Erection marks in accordance with fabrication drawing shall be clearly painted on the fabricated steelwork. Each piece shall be marked in at least on two places. Each piece shall also have its weight marked thereon.

c) The centre lines of all columns, elevations and girder bearings shall be marked on the sections to ensure proper alignment and assembly of the pieces at site.

Erection Scheme

a) The Erection Scheme for the erection of all major structures shall be furnished. The erectability of the structure shall be checked by the Bidder before commencement of fabrication work to avoid future modification. The erection scheme shall indicate the approximate weight of the structural members, position of lifting hook, crane boom length, crane capacity at different boom length and at different boom inclination, etc.,

b) The erection scheme shall also give details of the method of handling, transport, hoisting, including false work/staging, temporary, bracing, guying, temporary strengthening, etc., It will also give the complete details of the number and capacity of the various erection equipment that will be used such as cranes, winches, etc., along with disposition at the time of erection of columns, trusses, etc.

c) The erection of columns, trusses, trestles, portals, etc., shall be carried out in one single piece as far as practicable. No column shall be fabricated and erected in more than 3 pieces. Galleries shall generally be erected as box i.e. the bottom chord and bracings, top chord and bracings, side vertical posts and bracings, end portals and roof-trusses shall be completely welded prior to erection and if required temporary strengthening during erection shall be made. The inside sheeting runners and roof sheeting purlins may be erected individually. When erection joints are provided in columns, their location shall generally be just above a floor level.

8.08.00 STEEL HELICAL SPRINGS AND VISCOUS DAMPERS UNITS

8.08.01 General Requirement

This part of the specification covers the requirement for the manufacturing, testing, supply, transport to site, pre-stressing erection, supervision of erection by the vendor, release of pre-stress, alignment, commissioning, etc. of Steel helical springs and viscous dampers units.

The Steel helical springs and viscous dampers units supplied should be of proven make.

8.08.02 Codes and Standards

Some of the relevant applicable Indian standards and codes, etc, applicable to this section of

the specification are listed below:

DIN : 4024 Machine foundations; Flexible supporting structures for machine with rotating masses.

DIN : EN 13906-1 Cylindrical helical springs made from round wire and bar: calculation & design.

DIN : 2096 Helical compression springs out of round wire and rod; quality requirements for hot formed compression springs.

ISO : 10816 /IS:14817 Criteria for assessing mechanical vibrations of machine.

ISO : 1940/IS: 11723 Criteria for assessing the state of balance of rotating rigid bodies.

8.08.03 **Design & Supply of Material**

i) **Supply**

Steel helical springs and viscous dampers and associated auxiliaries shall consist of:

(a) Steel helical springs units (fully pre-stressable) and viscous dampers units along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.

(b) Frames for pre-stressing of spring elements.

(c) Suitable hydraulic jack system including electric pumps, high pressure tubes etc. required for the erection, alignment etc., of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.

(d) Any other items which may be required for the pre-stressing, erection, release of pre-stress, alignment, and commissioning of the Steel helical springs and viscous dampers.

ii) **Design**

The spring units should have stiffness in both vertical and horizontal directions with the horizontal stiffness not less than 50% of vertical stiffness. However, for projects in high seismic zones, the minimum stiffness in horizontal direction shall be reviewed based on the design requirement and in no case it shall be less than 15% of vertical stiffness.

The stiffness should be such that the vertical natural frequency of any spring unit at its rated load carrying capacity is between 2 Hz to 4 Hz. The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of Units.

The Steel helical spring units and viscous damper units and their housings shall be designed for a minimum operating life of 30 years. Steel helical spring units shall conform to infinite life fatigue load calculations as per DIN EN 13906-1.

8.08.04 **Manufacturing & Testing**

Complete manufacturing and testing of the Steel helical springs and viscous dampers shall be done at the manufacturing shop of the approved sub vendor / supplier. For this purpose the contractor / sub vendor shall submit the detailed quality plan for approval of engineer and take up the manufacturing / testing after approval of such quality plan. The quality plan shall include

(a) Manufacturing schedule and quality check exercised during manufacturing.

(b) Detail of test to be carried out at the manufacturing shop with their schedule.

(c) Special requirements, if any, regarding concreting of top deck.

(d) Complete step-by-step procedure covering the installation and commissioning of the spring system.

(e) Manuals for erection, commissioning, testing and maintenance of the Steel helical springs and viscous dampers.

(f) A checklist for confirming the readiness of the civil fronts for erection of Steel helical springs and viscous dampers.

(g) Checklist for equipment required at each stage of erection.

(h) Bill of materials and data sheet of various elements such as spring units, viscous dampers, with their rating, stiffness etc. included in the supply.

(i) Bill of material and data sheet for frames for pre stressing, hydraulic jack including electric pump, high pressure tubes, hand operated pump etc., with their rating and umbers.

(j) Any other details which may be necessary to facilitate design and construction of the foundations / structures.

8.08.05 The springs shall conform to codes DIN EN 13906-1 and DIN 2096. The quality assurance and inspection procedure shall be finalized on the basis of the above codes and the quality plans be drawn accordingly.

8.08.06 Transportation

Steel helical springs and viscous dampers shall be suitably protected, coated, covered, boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection.

8.08.07 Erection and Commissioning

Complete erection and commissioning of the Steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements, making final adjustments and alignments etc. shall be carried out by a specialist supervisor of vendor.

The contractor shall guarantee the performance of the Steel helical springs and viscous dampers for 24 months from the date of commissioning of each machine which shall be termed as Guarantee Period".

8.08.08 Supervision

The supervision of installation of Steel helical springs and viscous dampers including pre-stressing, placing, releasing and alignment of spring units shall be done by a specialist supervisor of sub vendor / supplier, trained for this purpose.

8.08.09.1 Realignment of Spring System

If any realignment of the Steel helical springs and viscous dampers is required to be done for aligning the shaft or for any other reasons during the first one year of operation from the date of commissioning of the machine, the same shall be done by the contractor.

8.08.09.2 Acceptance Criteria

Stiffness values shall be checked. The permissible deviations shall be as per DIN 2096.

Following acceptance criteria shall be followed:

General workmanship is being good as recommended by the manufacturer and approved by Equipment supplier.

Tolerances are within the specified limit.

Manufacturer's test certificate (MTC) shall be in compliance with the applicable codes / standards.

Bought out material is from the approved manufacturer / vendor.

Bought out material is matching with the approved sample.

8.09.00 **Information on Geopolymer Concrete-**

A) Ingredients: Geo-Polymer Concrete is a special type of concrete where no cement is used unlike conventional cement concrete.

Major ingredients of Geo-polymer concrete are as below:

a) Fly Ash (to be collected from location within existing operating plant/from existing fly ash silos near plant boundary)
b) Ground Granulated Blast Furnace slag
c) Aggregates (Coarse and fine)
d) Sodium Silicate
e) Sodium Hydroxide
f) Chemical admixtures like super-plasticiser, retarder, shrink-reducing compound, evaporation reducer etc.

Fly ash produced by coal-based power stations of DVC, if available, will be issued chargeable basis for the production of Geo-polymer concrete on 'as is where is' basis.

B) Batching & Mixing: Geopolymer concrete of minimum required grades of M10 and M35 shall be prepared for Dry Lean Concrete (DLC) and Pavement Quality Concrete (PQC), respectively. The solid constituents of geo-polymer concrete mix such as coarse aggregate, fine aggregate, fly ash and slag are to be mixed dry for 2-3 minutes, then Geo-activator solution, consisting of sodium silicate and sodium hydroxide pre-mixed in tanks at site, is added to the dry mix in batching plant mixer.The whole mixture is mixed until a homogeneous cohesive mix is obtained. Pumping devices shall be used for transferring activator solution from tank to the mixer. Proportion of different ingredients and mixing process are to be finalized/established during mix design finalization and trial mix at site. However, if any constraint is observed related to initial setting time of the geopolymer concrete and time required for transporting the geopolymer concrete mix from batching plant to the point of application then suitable alternative option such as mixing of geoactivator solution may have to be mixed in transit mixer instead of batching plant.
Bidder shall make available concrete batching plant suitably customized for handling/feeding/dosing/weighing etc of ingredients and capable of production of Geo-Polymer Concrete of suitable grade.

C) Geo-activator: This solution shall be prepared using Sodium Hydroxide & Sodium silicate with water in a certain ratio. The ratio of Sodium Silicate and Sodium Hydroxide in activator solution shall be decided during finalization of Design mix. Separate tanks having adequate capacity are to be constructed close to batching plant with fencing and a lockable gate for preparation of Sodium Hydroxide and Sodium Silicate solution. These tanks shall be provided with acid-alkali resistant lining and covered with GI sheet. Each tank shall be fitted with a

chemical resistant pump of suitable capacity and dual valve in the discharge line for recirculation (to enable mixing) and also for transferring the Geo-Activator solution to mixer. This connection pipe from Pump discharge to batching plant mixer shall be HDPE of suitable Diameter.

Preparation of Geo-activator solution is a critical process and extra care needs to be taken during the preparation in respect of safety of personnel handling the chemicals. Worker handling the chemicals shall be provided with proper PPE's. A dedicated shower with water tank shall be available close to chemical handling area/tank on permanent basis for washing of affected person, in case of emergency. Bottles filled with distilled water in cupboard / Boxes near work place shall also be kept for emergency eye wash by worker exposed to such hazardous chemicals.

D) Placing: Laying /placing of Geopolymer concrete DLC and PQC manually with hand-guided means or by semi-mechanized methods may be permitted provided acceptance criteria as per MORT&H specification is achieved.

8.10.00 **Controlled Low Strength Material (CLSM)** may be used for backfilling material in foundation. The compressive strength of CLSM shall be greater than 8.3MPA at 28 days. A typical combination raw material for production of low strength flowable fills is as follows:

S. No.	Raw Material	Typical Proportion
1	Pond Ash	90% to 95%
2	Cement	5% to 10%
3	Water	*W/C ratio b/w 3 to 4

*Prior to usage, W/C of mix needs to be checked to get flowable mix.

8.10.01 **Procedure:**

Proportioning and blending materials: The dry materials Cement and Pond ash are to be weighed according to formulations presented above. All the dry materials added into mixer sequentially. The blending of these dry materials allowed for 1-2 minutes prior to the addition of water. After thorough mixing, water is to be added and allowed the mix for another 2 minutes to achieve flowable mix.

8.10.02 **Flowability:** The minimum flowability value should be 200mm as per relevant ASTM standards. Hardening time of flowable fill in the field is measured using Kelly Ball apparatus as per ASTM standards, in general, the hardening time of flowable fills is less than 5 h for low flowability mixes.

8.10.03 **Pumpability:** Flowable fills are usually pumped and placed at the site using the conventional concrete pumping equipment.

8.10.04 **Permeability:** Permeability of most excavatable CLSM is similar to compacted granular fills. It is in the range of 10-4 cm/sec to 10-5 cm/sec. 11 CLSM mixtures of higher strength and high fines content can achieve permeability as low as 10-7 cm/ sec.

8.10.05 **Shrinkage:** Shrinkage and shrinkage cracks do not affect the performance of CLSM. The linear shrinkage of CLSM is about 0.02%.

8.10.06 **Hardening time** is referred to as the approximate time required for the flowable fill to change from the initial plastic state to hardened state with an appropriate strength to handle the weight of a person in the field. Hardening time of flowable fill in the field is measured using Kelly Ball apparatus as per ASTM standards. The procedure involves raising and dropping the Kelly ball to the flowable fill specimen of 400 x 400 x 150 mm and measuring the indentations produced on the upper surface of the fill. Hardening time is represented as the time taken for the fill material to obtain an indentation diameter of less than 76 mm on the surface of the fill. The laboratory determination of hardening time is generally done by visual identification. In general, the hardening time of flowable fills is less than 5 h for low flowability mixes. The hardening time depends on the fineness of the ash used in the mix. Usually coarse grained flowable fill mixes are found to harden within less time when compared to that of finer ash based flowable fills.

8.10.07 **Quality control:** The American Society for Testing and Materials (ASTM) has introduced five standard test methods for testing freshly mixed controlled low strength material (CLSM). The standard methods are as follows:

1. ASTM D 6103 - Standard Test Method for flow Consistency of Controlled Low Strength Material (CLSM)
2. ASTM D 6023 - Standard Test Method for Unit Weight, Yield, Cement Content and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)
3. ASTM D 6024 - Standard Test Method for the Ball Drop on Controlled Low Strength Material (CLSM) to determine suitability for load application
4. ASTM D 5971 - Standard Practice for Sampling Freshly Mixed Controlled Low-Strength Material
5. ASTM D 4832 - Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders

SUB-SECTION-D-1-9

ARCHITECTURAL CONCEPTS AND DESIGN

D-1-9 **Architectural Concepts and Design**

9.01.00 For Architectural Concepts and Design refer to 5.01.00 in this specification.

9.02.00 **General Architectural Specifications**

9.02.01 **General**

a) Minimum 1000 mm high (from floor/ roof level) hand railing shall be provided around all floor/roof openings, projections/balconies, walkways, platforms, steel stairs, etc., wherever the height of the building is more than 12m, railing height shall be 1.2m. All handrails and ladder pipes (except at operating floors) shall be 32 mm nominal bore MS pipes (medium class) conforming to IS: 1161 and shall be finished with suitable paint. All rungs and ladders shall be finished with suitable paint. The spacing of vertical posts shall be maximum 1500mm. Two number of horizontal rails shall be provided including the top member. In addition, toe guard/ kick plate of min size 100x6th shall be provided above the floor level.

For handrailing at operating floors of Main Power House including RCC stairs (for one flight above and below operating floor level), passages, around all floor openings shall be Stainless Steel (SS) pipes shall be used. All floors of Service building shall be provided with SS Handrailing. Height of the handrail shall be1000 mm /1200mm in accordance with the preceding para. For SS handrail 32NB/50NB/60NB (polished) stainless steel pipe with wall thickness 1.65mm (minimum) shall be provided. The spacing of vertical posts shall not be more than 1500mm. Two number of horizontal rails shall be provided including the top member. SS Toe guard, knee guard (100 mm wide and 6mm thick) shall be provided above the floor level. The SS railing in service building shall have Glazed railing system with laminated Toughened glass panels.

b) All stairs shall have a maximum riser height of 150mm and a minimum tread width of 300 mm. Minimum clear width of stair shall be 1500 mm unless specified otherwise. The width of staircase shall meet the National Building Code requirements.

c) All buildings having metal cladding shall be provided with 1 meter high brick wall at ground floor level. All buildings having metal cladding shall be provided with a 150 mm high RCC toe kerb (on upper floor) at the edge of the floor along the metal cladding. 1000 /1200 mm high hand railing shall be provided on this RCC kerb, wherever required from the safety point of view.

d) In all buildings, structures, suitable arrangement for draining out water collected from equipment blowdowns, leakages, floor washings, fire fighting, etc., shall be provided for each floor. All the drains shall be suitably covered with grating or precast RCC panels.

e) RCC steps / staircase shall be provided for main entrance of all RCC construction buildings.

f) RCC Parapet, of 900 mm high from Finished floor level of roof for accessible roof and of 600 mm high from Finished floor level of roof for Non accessible roof, Sunshades of 450mm over window, 600mm over door and 900mm over rolling shutters, architectural facia, projections, etc., shall be provided with drip course in cement sand mortar 1:3.

g) All fire exits shall be painted with fire resistant paint P.O red/signal red colour shade which shall not be used anywhere except to indicate emergency or safety measure. Fire safety norms shall be followed as per National Building Codes and fire safety requirements for providing fire exits, escape stairs and fire fighting equipment. In

k) For MPH and Boiler structure, all stairs shall have a maximum riser height of 180mm, and a minimum tread Width of 275 mm. Minimum clear Width of stair shall be 1200 mm unless specified otherwise. (Amendment No 01, D-1-9)

detailing of all buildings, fire safety requirements conforming to IS: 1641 and IS:1642 shall be followed.

h) Ramps & Lifts for Physically challenged persons shall be provided for barrier free access to service building, Main Power House Building.

i) If the Floor area of any floor in building is more than 500 sq.m., there shall be minimum two number of staircase.

j) All electrical conduits in buildings for lighting, Air-conditioning, other services shall be of concealed type. Conduits shall be laid in RCC structures at the time of casting.

9.03.00 **Water Supply and Sanitation**

9.03.01 Roof water tanks of adequate capacities depending on the number of users and 8 hours requirement shall be provided for each building and pump house. Polyethylene water storage tanks conforming to IS:12701 shall be used. The tanks shall be complete with all fittings including lid, float valve, stop cock, vent pipe, etc.

Chlorinated Polyvinyl Chloride (CPVC) pipes, confirming to IS 15778, having thermal stability for hot & cold-water supply including all CPVC plain & brass threaded fittings shall be used for internal piping works for service water and potable water supply. For installation of CPVC pipes guidelines as stipulated in Clause No. 18.9, CPWD specifications shall be followed.

CPVC (conforming to IS:13592) shall be used for sanitary works above ground level.

All Buildings shall be designed with Toilets as per NBC norms.

All buildings shall have minimum one toilet block each. The facilities provided in the toilet block shall depend on the number of users. However, minimum facilities to be provided shall be as stipulated in subsequent clause. IS:1172 shall be followed for working out the basic requirements for water supply, drainage and sanitation.

In addition, IS:2064 and IS:2065 shall also be followed.

9.03.02 Each Toilet block shall have the following minimum facilities. Unless specified all the fittings shall be of Chromium plated brass (decorative type)

a) One number wall mounted coloured glazed vitreous China European water closet and dual flushing valve system, water faucet, health faucet, toilet paper holder as per IS:2556.

b) One number colour glazed ceramic oval shaped wash basin 450x 550 mm (2 approx..) mounted under the counter with18mm thick granite beveled edge counter fitted with photo-voltaic control system for water controls, bottle trap as per IS:2556. For common toilets, number of washbasins shall be as per requirement. However, for Pump Houses the same shall be provided without photo voltaic control system for water control.

c) For Male Toilets Urinal as per requirements, with all fittings with photovoltaic control flushing system as per IS: 2556.

d) One number looking mirror 600 x 900 x 6 mm, edge mounted with teak beading/SS Studs and minimum 12 mm thick plywood backing, one number stainless towel rail 600 x 20 mm, one number liquid soap dispenser per wash basin.

e) One toilet with required facilities shall be provided for physically challenged persons on Ground floor of Main Power House Building, on Ground floor of Gate Complex Building and at Each Floor of Service Building.

f) Janitor Space & space for drinking water cooler.

g) Electric operated hand dryer with photo voltaic control.

h) The pantry shall consist of one number stainless steel pantry sink, as per IS : 13983, of size 610 x 510 mm, bowl depth 200 mm with drain board of at least 450 mm length with coupling , CP bottle trap, hot and cold water mixer, one number geyser of 25 liters capacity, with inlet and outlet connections, one number over head water storage tank, as per IS : 12701 and of minimum 500 liters capacity, complete with float valve, overflow drainage pipe arrangement, CPVC concealed water supply pipe of minimum 12 mm diameter, CPVC sanitary pipe (with lead joints) of minimum 75 mm diameter, floor trap with Stainless Steel grating, inlet and outlet connections for supply and drainage, with all bends, tees, junctions, sockets, etc., as are necessary for the commissioning and efficient functioning of the pantry (all sanitary fittings shall be heavy duty chrome plated brass, unless noted otherwise).Steel grating, inlet and outlet connections for supply and drainage, with all bends, tees, junctions, sockets, etc., as are necessary for the commissioning and efficient functioning of the pantry (all sanitary fittings shall be heavy duty chrome plated brass, unless noted otherwise)

One number of pantry shall be provided on Control Room floor of ESP control room building and One number of pantry shall be provided in Buildings having Control Room. One number of pantry shall be proved at each floor of service Building

i) Laboratory sink shall be of white vitreous china of size 600x400x200 mm conforming to IS: 2556 (Part-5) with single 15 mm C.P. brass pillar taps with elbow operated levers ISI Marked.

j) In addition, adequate number of portable toilet units with adequate plumbing and sanitary arrangement, shall be provided during construction stage for workers.

k) Adequate number of toilet units with necessary plumbing and sanitary arrangement, shall be provided for workers (O&M workers).

l) For common toilets at each floor of Service building, toilet cubicles shall be provided. Restroom Cubicle (Fundermax/ Trespa/ Greenlam) (of following standard dimension which includes 600mm door size width) self-supporting 12mm thick compact laminates made out of, urea free, thermosetting phenolic resins treated Kraft papers as core material and Amino plastic resin treated decor papers on the finish surface, conforming to latest and applicable IS: 2046-1995, EN 438:2016 and NEMA LD3-2005 quality standards with Antivirus, Antibacterial and Antifungal properties (conforming to ISO 21702:2019, JIS Z2801:2010 and ASTM G21-2015 standards respectively) to fulfil the applicable requirements of indoor air quality certifications for Greenguard-Gold standards.

This also includes providing and fixing in position necessary hardware made out of Stainless steel (Grade 316) as per manufacturer's specifications & Architects instructions like (1) Door Knob, (2) Spring Loaded Hinges (3) Slide Bolt with Occupancy indicators, (4) Coat hook (5) U-Channels, (6) Adjustable foot (Mid Panel Mounted or Divider Setback Leg) (7) Top rail with T and L Corner connector (8) Rubber noise deafening tape, (9) Screws & wall Plugs.

The top fitting should consist brushed finish round top rail which will get fixed with pilasters with panel tube holder, 'L' corner bend (connected with top rail) will be used on the corner of cubicle in absence of brick wall and 'T' Connector in T junctions, Wall Bracket fixing is used only on the wall which will hold the top rail.

All screws also will of 316 Grade in stainless steel. All pilasters are supported by Metal Leg [Straight Leg made out either only SS Brush finish or With SS with black powder coated / Set Back Leg with Zinc casted black powder coated] . The base of the stainless-steel bottom will be anchored to the floor with a clearance height upto

m) In addition to the facilities stipulated elsewhere Bathroom With rotating type chromium plated shower including all fitting and fixtures shall also be provided in toilet at ground and operating floor of main plant. (Amendment No 01, D-1-8)

150mm. A Toilet Cubicle shall have approximate dimension of 2025mm Height x 1000mm Width x 1500mm Depth. All the necessary fittings shall be provided to make the system complete. Matching urinal partitions shall also be provided in the toilet where cubicles are provided.

Flooring

Floor finishes of approved shade and colour over under bed of cement mortar / concrete, at all levels and for all kind of works, elevations, on horizontal and vertical surfaces for all types of work (like flooring, skirting, dado, wall lining & facing, tread and risers etc.), including topping, spreading white cement slurry at an average rate of 2.5 kg/Sq. M., (unless noted otherwise), jointing and joint filling with white cement (unless noted otherwise) slurry mixed with colour pigment, to match the shade of the finishing material, laying to plumb and water level in desired pattern, line and flush butt square jointing, curing, rubbing, grinding, polishing, edge moulding, finishing and cleaning, testing, providing opening of required size and shape, casting in panels wherever specified.

9.04.01 The nominal total thickness of floor finish shall be 50/70 mm i.e. underbed and topping. The floor shall be laid on an already laid and matured concrete base. The underbed for floors and similar horizontal surfaces shall consist of cement concrete M20 grade. Stone chips shall be 12.5 mm down well graded & proper filling shall be done with brick bats/cinders. Flooring like Tiles/ Stones shall be laid with 1:4 cement sand mortar and Tile/ Stone Cladding on wall shall be laid with 1:3 cement sand mortar.

9.04.02 All toilets shall have sunken slab to accommodate sanitary pipes and the finish level of floor shall match with general floor finish level. Sunken slabs shall be made watertight by suitable water proofing treatment.

Water proofing treatment in sunken portion of WCs, bathroom, kitchen, pantry etc., shall be done in two (2) coats by applying cement slurry mixed with water proofing cement compound (confirming to IS 2645).

The First layer shall be of slurry of cement @ 0.488 kg/sqm mixed with water proofing cement compound @ 0.253 kg/ sqm. This layer shall be allowed to air cure for 4 hours.

The Second layer shall be of slurry of cement @ 0.242 kg/sqm mixed with water proofing cement compound @ 0.126 kg/sqm. This layer will be allowed to air cure for 4 hours followed with water curing. The water proofing shall be done for the entire sunken area.

9.04.03 Metallic Hardener Topping shall be 12 mm thick. Metallic Hardening Compound shall be of approved quality consisting of uniformly graded iron particles, free from non-ferrous metal particles, oil, grease sand, soluble alkaline compounds. The ratio of Metallic hardener and Cement shall be 1:4. This mix shall be mixed with 6mm nominal stone in Ratio of 1mix : 2 stone. The mixture so obtained shall be laid in 12 mm thickness, on cement concrete floor within 2 to 4 hours of its laying. For laying, The top surface pf underbed shall be roughened with brushes while the concrete is still green and the forms/strips shall be kept projecting up 12 mm over the concrete surface, to receive the metallic hardening compound topping. The topping shall be laid true to provide a uniform and even surface. It shall be firmly pressed into the bottom concrete so as to have good bond with it. After the initial set has started, the surface shall be finished smooth and true to slope with steel floats

9.04.04 Heavy duty cement concrete tiles 300 mm x 300 mm shall be provided using white cement with pigment, with hard and abrasion resistant carborundum / quartz chips for wearing course as per IS:1237. Laying of tiles shall be as per IS: 1443.

9.04.05 Digitally glazed ceramic tiles shall be as per IS: 15622. Designer digitally glazed ceramic floor and wall tiles shall be as follows -

	a) 450x450mm in white colour
	b) 300x450mm in DIGITAL series
	c) 300x600mm in DIGITAL series
9.04.06	12mm/20mm / 38mm / 75 mm/ 115mm thick acid resistant tile on horizontal and vertical surfaces, at all levels for all type of works shall include one coat of bitumen primer followed by 12 mm thick bituminastic layer, 20mm / 38mm/ 75 mm / 115mm thick A.R. tiles, 6 mm thick under-bed by potassium silicate mortar conforming to IS:4832 (Part-I), pointing of joints of tiles with acid/alkali resistant epoxy/furane mortar conforming to IS:4832 (Part-I), up to a depth of 20 mm and bituminastic end sealing. Battery Room in all buildings shall be provided with acid/ alkali resistant tiles on flooring & dado 1200mm high.
9.04.07	(i) Digitally glazed vitrified & Matt Finish Digitally glazed Vitrified tiles with 3mm groove joints as per approved pattern pointed neatly with 3x4mm stainless epoxy grout mix of 0.70kg of organic coated filter of desired shade (0.10kg of hardener and 0.20kg of resin per kg) with sizes of the tiles shall be as under: a) Digitally glazed vitrified Tile, Size of tile 600mm x 600mm / 605mm x 605mm b) Digitally glazed vitrified Tile,Size of tile 800mm x 800mm ii) Anti-Skid Full Body Vitrified Tiles Antiskid, full body Vitrified Tiles of size 600mm X 600mm X 20mm thick as specified below of approved make, shade, colour and pattern, over under bed of cement mortar / PCC shall be provided in TG Hall flooring at operating level. Full body Vitrified Tiles shall be laid on properly laid leveled floor, with joints 3 to5 mm wide & 8 to10 mm deep & shall be filled with approved Epoxy Grout mix of 0.70 kg of organic coated filler of desired shade (0.10 kg of hardner and 0.20 kg of resin per kg). Full body Vitrified Tiles shall have water absorption less than 0.5%, Modulus of Rupture more than 38N/mm2, Breaking strength more than 7500 N, Mohs scale more than 6, Abrasion resistance less than 144 mm3 and coefficient of friction more than 0.4. Vitrified Tiles shall generally conform to IS: 15622
9.04.08	For pathway, chequered and designed concrete tiles minimum 22 mm thick, 200mm x 200mm size conforming to IS: 13801 of approved shade and colour shall be used. 1000 wide pathways all around the parapet walls and for access to the equipment and structure shall be provided for maintenance on rooftops of all buildings.
9.04.09	**Epoxy Flooring** Epoxy Flooring shall be provided with surface preparation of concrete substrate with Captive Shot Blasting Machine OR Light Grinding to form the required anchor profile on the floor substrate followed by application of epoxy resin based moisture barrier underlay of 2 mm thickness including filling of saw cut joints with epoxy cementitious resin based moisture barrier underlay as per manufacturer specification. Application of self smoothing epoxy floor topping of epoxy based resin of 2 mm thickness over epoxy resin based moisture barrier underlay including application of solvent free epoxy resin based two component primer. It shall include application of PU Sealant at Expansion and Isolation Joint respectively including surface preparation of the joint, fixing of backup strip and application of sealant.
9.04.10	VOID

9.04.11	Mirror polished (6 layers of polish) Granite stone (slab) - 18 mm thick (minimum) / Flame finish/ (making top surface rough by burning)/ honed finish granite stone (slab) - 18 mm thick (minimum) shall be provided.
9.04.12	Decorative/designer prepolished, plain and pigmented, high wearing resistance concrete tiles of 20mm thickness (minimum) in various non-standard interlocking patterns.
9.04.13	Skirting in general shall be 150 mm high. Dado in toilets & pantries, shall be upto false ceiling level from finished floor level. Skirting and Dado shall match with the floor finish.
9.04.14	Interlocking concrete blocks shall be of various sizes and thickness having M35 grade of concrete and pigmented to specified colours, in different pattern (in different textures chequered or other patterns in indentation for guiding band/s for visually impaired persons) including the preparation of sub base with 20mm thick sand and filling of joints with sand.
9.04.15	Matt finish (with grooves) Porcelain tiles (for guiding band/s for visually impaired persons in service building) shall be with 3mm groove joints as per approved pattern pointed neatly with 3x4mm stainless epoxy grout SP- 100 of Laticrete or approved equivalent in approved colour to match colour of tile. Porcelain tiles shall be provided in Service Building. 24 mm x 24 mm x 3.8 mm thick (minimum) glass mosaic tiles in decorative murals and pattern. Engineered wooden flooring (15mm thick) of Mikasa/ Century/ Pergo / Equivalent shall be provided in VIP area, conference rooms of Service Building and MPH Building.
9.04.16	**Rubber Flooring** Rubber flooring shall conform to IS 809. The minimum thickness shall be 4 mm with sheet size of 602mm x 602mm. Rubber flooring shall consist of 100% virgin elastomer reinforcing agents, resins, curing agents, anti-oxidants and pigments. It shall have excellent abrasion resistance and shall have class-I fire rating. It shall be acid & alkali resistant and shall be of anti static grade. In general, BS code shall apply for their technical characteristics.
9.05.00	**Epoxy Resin Floor Finish** Self-smoothing, seamless epoxy resin floor finish shall be provided on horizontal and vertical surfaces including preparation of surface, application of epoxy based primer coat, of approved colour, quality and make to give minimum thickness of 300 micron (in two coats)
9.06.00	**Roof**
9.06.01	Except for the roofs subjected to heavy loads, roof of all buildings having structural steel frame work shall consist of permanently colour coated (on exposed face) troughed metal sheet decking of approved profile as specified in clause 9.08.00. Silicon modified polyester paint having DFT of minimum 20 microns shall be used for permanent coating. The sheeting shall be fixed by means of concealed fixing system or any other compatible method approved by the Engineer. RCC slab of minimum 40 mm clear thickness in excess of trough depth shall be provided over the metal decking. Water proofing cum plasticiser compound shall be added to concrete over the metal decking. Bidder shall demonstrate that the roof is leak proof by carrying out the water-retaining test by maintaining the minimum water depth of 50mm over the roof surface for a period of 48 hours. Water Proofing Treatment as given below for RCC roof slabs shall be provided to ensure that the roof is watertight.
9.06.02	Over-Deck Insulation Roof insulation with 40 mm thick impervious sprayed, closed cell free Rigid Polyurethane foam over deck insulation conforming to IS: 12432 Part-III (density of foam being 40-50 Kg/Cum), over a coat of Polyurethane primer applied @ 6-8 sqm per litre, laid over 400 G Polythene sheet over PUF spray and provided with a wearing course of 40 mm cement screed 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate 20 mm nominal size) in chequered rough finish, in

panels of 2.5m X2.5m and embedded with 24G wire netting and sealing the joints with polymerized mastic, shall be provided on the roof of Service Building above the waterproofing.

9.06.03 For efficient disposal of rainwater, the run off gradient for the roof shall not be less than 1:100 and the roof shall be provided with RCC water gutter, wherever required. Gutter shall be made water tight using suitable watertight treatment. This gradient can be provided either in structure or subsequently by screed concrete 1:2:4 (using 12.5 mm coarse aggregate) and/or cement mortar (1:4). However, minimum 25 mm thick cement mortar (1:4) shall be provided on top to achieve smooth surface.

9.06.04 Unplasticized PVC rain water pipes conforming to IS 13592 , Type A with joints with seal ring confirming to IS 5382 shall be provided to drain off rain water from the roof. These shall be suitably concealed with masonry work, cement concrete / or sheeting work to match with the exterior finish. The number and size of down comers shall be governed by IS 1742 and IS 2527. Roof drain level of all RCC framed buildings having cast-in-situ RCC roof shall be provided with Rain water gutter and/or 45 x 45 cm size Khurras having minimum thickness of 30 mm with 1:2:4 concrete over PVC sheet of 1 m x 1 m x 400 micron and finished with 12 mm thick cement sand plaster 1:3. All the pipes shall be provided with suitable fittings and fixtures.

9.06.05 **Roof Water Proofing**

Roof water proofing treatment shall be as follows:

a) For roofs having structural slope:

Top surface of sloped R.C.C. slab shall be finished with 15mm thick cement plaster (1:4). Over the finished surface elastomeric membrane shall be laid. The elastomeric shall comprise of high solid content liquid applied urethane laid over reinforcing layer of polyscrim cloth or non woven geo-textile. The top of the elastomeric membrane shall be finished with 20 mm thick cement: sand (1:4) mortar with chicken wire mesh and pressed precast concrete tiles of 20 mm thickness where applicable shall be laid over mortar at green stage. Provision for thermal expansion of roofing tiles shall be kept by providing an expansion gap in both directions filled up with polysulphide joint sealant. The expansion gap shall be provided in the cement sand mortar underbed layer also.

b) For roofs having no structural slope:

Screed concrete mix (1:2:4) grading having minimum 25mm thickness at the lowest point of the slope shall be laid over R.C.C. slab and shall be laid as per the slope specified elsewhere in the specification. Top surface of grading underbed shall be finished with 15mm thick cement plaster (1:4). Over the finished surface elastomeric membrane shall be laid and top of the elastomeric membrane shall be finished with 20 mm thick cement: sand (1:4) mortar with chicken wire mesh and pressed precast concrete tiles of 20 mm thickness where applicable shall be laid over mortar at green stage. Provision for thermal expansion of roofing tiles shall be kept by providing an expansion gap in both directions filled up with polysulphide joint sealant. The expansion gap shall be provided in the cement sand mortar underbed layer also.

The elastomeric membrane above mentioned for waterproofing shall be of two component, instant setting, 100% solids spray applied hybrid polyurea polyurethane liquid applied elastomeric seamless waterproofing membrane meeting the requirements of LAM as per ASTM C836 and having excellent tensile strength of 15MPa (As per ASTM D412), elongation more than 450% (as per ASTM D 412), tear strength of 60 Kn/m (As per ASTM D1004/ASTM D624), adhesion to concrete of 2MPa (as per ASTM D 4541), abrasion resistance of 60mg loss (1 Kg,CS 10 Wheels,1000 cycles - As per ASTM D4060), Shore A Hardness of 85 (As per ASTM D2240),

RCC parapet wall of minimum 900 mm height (From finish floor level of roof) with coping for all accessible roofs and 600 mm height for all non-accessible roofs (From finish floor level of roof) shall be provided. Alternatively. parapet wall comprising structural steel post, runner and sheeting may be provided for buildings with metal sheet cladding. **(Amendment No 01, D-1-9)**

resistance to hydrostatic pressure head of 7 Bar (As per ASTM D 5385/ DIN 16726), puncture resistance of 1000N (As per ASTM E154), water vapour permeability of 25 mg/m2/day (As per ASTM E96), Impact resistance of 17 N.m (As per ASTM D2794), Low temperature crack bridging ability up to 3.2mm (As per ASTM C 1305), dynamic crack bridging ability class B 3.2 (as per EN 1062-7 Method B- B3.2) with no crack observed in the coating after 20000 sinusoidal cycles, resistance to root (As per CEN TS/14416) and fire resistance of class B (As per EN 13501-1).The coating shall be applied with a total consumption of 1.6 Kg/Sqm to achieve a total system DFT of 1.5mm, thereby satisfy the requirements of LAM as per ASTM C898 and shall be applied on the entire horizontal surface extending upto 300mm above the FFL on the vertical surface as per the methodology.

The application system includes base preparation of cleaning, brushing and removal of flacky materials, grouting the porous area with cementitious grout, proper coving between slab and wall junctions and priming the surface with two component solvent free epoxy primer which is applied with a consumption of 200 grams per Sqm, followed by spray application of hybrid polyurea waterproofing coating.

Protective geo textile fabric of minimum 150GSM over the entire membrane with proper overlaps shall be applied.

9.06.06 Roof of all buildings shall be provided with access/approach through staircase or ladder. Roof where equipment are mounted shall be provided with access through staircase.

9.06.07 ~~RCC parapet wall of minimum 1000 mm height (above top of slab) with coping for all accessible roofs and 600 mm height for all non-accessible roofs shall be provided. Alternatively, parapet wall comprising structural steel post, runner and sheeting may be provided for buildings with metal sheet cladding~~.

9.06.08 Fillets at junction of roof and vertical walls shall be provided with cast-in-situ cement concrete (1:1.5:3) nominal mix followed by 12mm thick 1:4 cement sand plaster.

9.06.09 Pathways for handling of materials and movement of personals shall be provided with 22mm thick chequered cement concrete tiles as per IS:13801 for a width of 1000mm.

9.06.10 White glazed tile Above the Over deck insulation, White glazed tile (min. 5mm thick) for roofing over under bed of cement mortar/ concrete, topped with spreading the white cement slurry at an average rate of 2.5 kg/sq m (unless noted otherwise), jointing and joint filling with white cement slurry, laid to plumb and water level in desired pattern, casted in panels, wherever required, shall be provided on the roof of Service Building.

9.07.00 **Walls**

9.07.01 All walls shall be non-load bearing infill panel walls.

9.07.02 For initial height up to 1 metre in buildings one brick thick masonry wall shall be provided wherever metal cladding is specified.

9.07.03 All internal walls shall be with one brick thick in cement mortar (1:6). However, internal partition walls for toilets shall be with half brick masonry thick with cement mortar (1:4).

9.07.04 For ESP Control Room Building, wall shall be of Autoclaved Aerated Concrete Block.
Autoclaved Aerated Concrete (AAC) block masonry shall be with blocks having dimensions of 625 mm x 250 mm. thickness ranging from 100 mm to 300 mm conforming to I.S. :2185 (part III). The jointing cement sand mortar in the composition of 1: 6 (Cement: sand) shall be used with suitable plasticizer(optional). Sand having modulus of fineness 1.1 shall be used. The horizontal and vertical joint thickness shall be approximately 10 mm. In case of partition walls (100 mm /125 mm thk.) the joint reinforcement i.e. 1 number of 6-8 mm diameter bars shall be placed at every alternate course to be anchored properly with the main structure. All other

structural requirements like stiffening of masonry, joint reinforcement etc. in the AAC masonry work strictly be carried out as per instructions laid down in IS 6041 – 1985, IS - 1905. For control room, control equipment room in MPH Building, **where dry wall construction shall be used,** walls shall be of factory made composite modular light weight aerated concrete panels, (minimum 2 hours of fire rating) consisting of 2 fiber reinforced cement sheets (minimum 4 mm thick) on either side of light weight concrete core, having minimum compressive strength of 35 Kg / Cm2 and the density in the range of 700-900 Kg. / cu.m. of the thickness and fire rating as specified below, to provide external wall and internal partition at all levels, capable of sustaining wind pressure of 3.00 M height (H) within limiting deflection of span/250, fixed in position in tongue and groove jointing system by screwing the panels to top and bottom U channels, (channels minimum 1.25 mm thick and galvanised to grade 180 (minimum) as per IS : 277), fixing U profiled top and bottom channels to concrete / primary steel members which are placed at the maximum vertical spacing of 4.5m with the help of galvanised steel expansion fasteners, filling the joints from both faces with silicon acrylic paste and making the same water tight by covering with fibre glass tape (minimum 50 mm wide and minimum 0.5 mm thick) or by any other suitable material, so as to ensure that the entire construction done with the light weight aerated concrete panels are weather proof and panel surfaces are flush for painting, creating opening for doors / windows /ventilators / ducts / pipes/fans/AC etc. and finishing the opening face with the same U profiled galvanized steel channel which is used at the top and bottom.

The External wall of control room, control equipment room in MPH Building shall be made of aerated concrete panels over that 50 mm thick mineral wool insulation and metal sheeting on outside

9.07.05 Toilet Block in ESP Control Room Building shall be of Brick Masonry

9.07.06 50 mm thick DPC in Cement concrete (1:1.5:3) with water proofing compound followed by two layers of bitumen coating 85/25 grade as per IS: 702 @ 1.7 kg./sq.m. shall be provided at plinth level before starting the masonry work.

9.07.07 Enclosure of the elevator shall have 2hours fire rating and it shall be sealed from outside to ensure dust free environment.

9.08.00 **COLOUR COATED AND OTHER SHEETING WORK**

9.08.01 Material

a) Wall Cladding & Roofing Material

Troughed permanently colour coated sheet of approved shade and colour shall be

i) either of steel with minimum 0.6mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade YS250 as per IS 15961 / grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150

ii) or of minimum 0.5mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade YS350 as per IS15961/ grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150.

iii) or of steel of minimum 0.4mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade YS550 as per IS 15961/ grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD

as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150
Alternatively aluminium feed material of minimum bare metal thickness of 0.7 mm of aluminium alloy of Series 31000 and above as per IS 737 and IS: 1254.

Bidder to ensure that same profile is to be used throughout the package for all facilities to maintain uniformity.

b) Metal Deck Roof Material

Troughed permanently colour coated metal decking sheets shall be

i) either of steel with minimum 0.8mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275.

ii) or of minimum 0.6mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275.

iii) or of steel of minimum 0.6mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275.

Alternativelyaluminium feed material of minimum bare metal thickness of 0.9 mm of aluminium alloy of Series 31000 and above as per IS 737 and IS 1254 can also be used for metal decking.

Thickness tolerance of (+/-) 0.04mm is permissible. However, all design calculations shall be carried out on the basis of lowest value of sheet thickness provided.

Bidder to ensure that same profile is to be used throughout the package for all facilities to maintain uniformity. In addition, the depth of the profile shall be restricted to 60 mm (maximum) to reduce the overall thickness of floor slab and thus minimizing the dead load of the floor slab. If the bidder proposes to use two different metal deck sheets (same profile but different grades or thicknesses), the unexposed (concrete) side of the metal deck sheets shall be painted with clearly distinct colours to facilitate identification.

Bidder to ensure that both cladding sheet and decking sheet supplied at site to be provided with transparent organic film of thickness of 40 microns on each face. Also they should be stored in a covered place on wooden sleepers till erection.

9.08.02 Colour Coating

Steel shall be colour coated with total coating thickness of at least 40 microns (nominal) comprising of silicon modified polyester (SMP) paint or Super Polyester paint or SDP paint (Super Durable Polyster with no TGIC TriglycidylIsocynurate). The silicon content in the SMP paint to be 30 to 50%. The paint to be, of minimum 20 microns (nominal) dry film thickness (DFT) on external face over primer coat of minimum 5 microns (nominal) and minimum 10 microns (nominal) SMP or super polyester paint over primer coat of minimum 5 microns (nominal) on internal face. SMP and Super polyester paint/SDP systems shall be of industrial finish of product type 4 of AS/NZ2728.

Also, the heavy metal content (Lead, Cadmium, Chromium etc) to be within environmental norms so that the sheet is also suitable for rainwater harvesting.

9.08.03 Design Criteria

For wall cladding insulated / uninsulated and conveyor gallery sides and roof, permanently colour coated sheet of troughed profile shall be used. However alternative profile meeting the strength, deflection and other functional requirements such as section modulus and moment of inertia shall be provided.

Sheet shall be of profile, sectional properties, colour and shade as per specifications.

For profiled metal decking sheets (to be used for RCC floor slab or roof slab) 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 under total super imposed loading (DL +LL) comprising the self-weight of metal deck sheet, dead weight of green concrete and an additional construction load 100kg per sq.m for two span condition. The section modulus and moment of inertia of troughed profile shall be computed as per the provisions of IS 801 for satisfying the deflection and strength requirements.

For metal deck sheets used for roofing (with or without RCC) and side cladding, the sectional modulus and moment of inertia of troughed profile per metre width shall be such that the deflection of sheets is limited to span/250 under design wind pressure for two span condition. The sectional modulus and moment of inertia of troughed profile shall be computed as per the provisions of IS 801 for satisfying the deflection and strength requirements. No increase in allowable stress is permissible under wind load condition.

9.08.04 Fasteners

Side cladding/roofing/decking sheets shall be fixed to the runner/purlins using self-drilling special coated fasteners confirming to corrosion resistant class 3 of AS3566 and tested for 1000 hours salt spray test. Spacing of Self-drilling fasteners in transverse direction (along runners/purlin) shall be equal to the pitch of trough or 250(+/-100) mm, whichever is lesser and in longitudinal direction at every runner/purlin location.

Shear anchor studs shall also be provided through metal deck, which are to be used as permanent shuttering, at regular interval on all top flange / flange plate of structural beams as specified in Clause no. 8.03.00.

Alternatively, J/U type hooks shall be used in roofing which shall be provided in transverse direction (along runners/purlin) at a spacing equal to the pitch of trough or 250(+/-100) mm, whichever is lesser and in longitudinal direction at every runner/purlin location.

9.08.05 Miscellaneous Details

To minimize the number of joints, the length of the sheet shall preferably be not less than 4.5m, cut pieces shall not be used, unless specifically approved by the Engineer. However, the actual length shall be such so as to suit the purlin / runner spacing.

Lap between the sheets shall be at least 150mm in the longitudinal direction and at least one crest wide in the transverse direction which shall be properly anchored / fixed with fasteners.

Z spacers if required shall be made of at least 2 mm thick galvanised steel sheet of grade 350 as per IS 277

Sealant used for cladding shall be butyl based, two parts poly sulphide or equivalent approved, non stainless material and be flexible enough not to interface with fit of the sheets

. Filler blocks as a trough filler shall be used to seal cavities formed between the profiled sheet and the support or flashing. The filler blocks shall be manufactured from black synthetic rubber or any other material approved by the Engineer.

For insulation of cladding and other areas, mineral wool conforming to IS 8183 shall be used. The density shall be 32 or 48 kg. /cu.m for glass or rock wool respectively. The nominal thickness of insulation shall be 50mm.

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and any weather/moisture sealants with appropriate material and coating specification as mentioned above for the outer face of the metal cladding. Overlap shall be min. 150 mm or as specified by manufacturer.

The contractor shall prepare working drawings of sheeting system including end and side laps, flashing, fixing details etc. before starting sheeting work at site.

9.08.06 Pre-Fabricated Insulated Metal Sandwich Panels

For buildings where Pre-Fabricated (Factory made) Insulated Metal Sandwich Panelsshall be used for Roofing, the sandwich panels shall comprise top sheet as troughed permanently colour coated sheet & bottom sheet as plain permanently colour coated with 50mm thick insulation sandwiched between the two sheets. Each sheet shall be

i) either of steel with minimum 0.6mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade YS250 as per IS15961/ grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150

ii) or of minimum 0.5mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade YS350 as per IS15961/ grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150

iii) or of steel of minimum 0.4mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade YS550 as per IS15961/ grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150.

Alternatively aluminium feed material of minimum bare metal thickness of 0.7 mm of aluminium alloy of Series 31000 and above as per IS 737 and IS 1254.

Metal sheets (steel or aluminium) shall be colour coated with total coating thickness of at least 40 microns (nominal) dry film thickness (DFT) comprising of Silicon Modified Polyester (SMP with silicon content of 30% to 50%) paint or Polyester paint, of minimum 20 microns (nominal) SMP or polyester paint on one side (exposed face), over minimum 5 micron (nominal) primer coat and minimum 10 micron (nominal) SMP or Polyester paint over minimum 5 micron (nominal) primer coat on other side. SMP and Super Polyester paint shall conform to product type 4 of AS/NZS 2728. Troughed sheet shall be of approved profile, sectional properties, (suitable for the specified loading / deflection and purlins / runners spacing), colour and shade.

Special coated fastener conforming to corrosion resistant Class 3 of AS3566 and tested for 1000 hours salt spray test shall be used for fixing Pre-Fabricated Insulated Metal Sandwich Panels with the structural members below.

The contractor shall prepare working drawings of sheeting system including end and side laps, fixing details etc. before starting sheeting work at site. The insulation shall be of Polyurethane type. The polyurethane shall be Chlorofluorocarbon (CFC) free and self-extinguishing and shall conform to IS 12436: 1988. It shall have Modular Density 40 +/- 2 Kg/m3 and Thermal Conductivity @ 10 Deg.C 0.017 - 0.020 W/M 0k, Water absorption (% by vol) 3.1, Critical Oxygen Index 23 and Compressive Strength 1.2 Kg/sq.cm.

9.08.07	**Polycarbonate Sheets**
	The polycarbonate sheet to be used for cladding and glazing purpose in conveyor galleries, Transfer points & pump houses shall have toughed profile to match with the metal cladding profile. Minimum 3.0mm thick fire retardant and UV resistant polycarbonate clean sheet of approved make shall be used. The polycarbonate sheet shall be installed along with the metal cladding so as to have a watertight lapping arrangement. Suitable detailing shall be made to cater for the thermal expansion. IS 14434 to be referred for other details.
9.09.00	**Plastering**
9.09.01	Outer face (i.e. rough side) of all brick walls shall have 18 mm thick and inner face (i.e. smooth side) of all walls shall have 12 mm thick cement sand plaster 1:6.
9.09.02	Acrylic wall putty in two coats shall be applied over cement plastered surfaces in interior of building. The finish surface shall be smooth and shall be of 2 mm nominal thickness.
9.09.03	All R.C.C. walls shall have minimum 12mm thick cement sand plaster 1:6.
9.09.04	All RCC ceilings (except areas provided with false ceiling, cable vault ceiling and metal decking) shall be provided with 6mm thick cement sand plaster 1:4.
9.09.05	Groove of uniform size 12 x 12 mm up to 20 x 15 mm in plastered surface as per approved pattern, shall be provided as per approved drawing.
9.09.06	All plastering work shall conform to IS: 1661.
9.10.00	**Painting, Aluminium Composite Panel**
9.10.01	All painting on masonry or concrete surface shall preferably be applied by roller. If applied by brush, then same shall be finished off with roller.
9.10.02	All paints shall be of approved make including chemical resistant paint.
9.10.03	Minimum 2 finishing coats of paint shall be applied over a coat of primer/Texture coat of approved shade.
	Stonework for wall lining etc. (Veneer work) over 20 mm thick bed of cement mortar 1:3 (1 cement: 3 coarse sand) and jointed with grey cement slurry @3.3kg/sq.m, including rubbing and polishing in complete. (Black polished granite stone slab, 18 mm thick / polished Sadarhally grey granite slab 18 mm thick / other equivalent approved shade).
	The final, finished coating shall be fungus resistant, UV resistant, water repellent, alkali resistant, and extremely durable with colour fastness.
9.10.04	Acrylic emulsion paint shall be as per IS: 15489. Acrylic distemper shall be as per IS: 428. Cement paint shall conform to IS: 5410, white wash/colour wash shall conform to IS: 627.
9.10.05	All fire exits shall be painted in post office red/signal red colour shade, which shall not be used anywhere else except to indicate emergency or safety measure.
9.10.06	For painting on concrete, masonry and plastered surface IS: 2395 shall be followed. For painting on wood work IS: 2338 shall be followed.
9.10.07	For painting on steel work and ferrous metals, BS: 5493 and IS: 1477 shall be followed. The type of surface preparation, thickness and type of primer, intermediate and finishing paint shall be according to the painting system adopted.
9.10.08	Bitumen primer used in acid/alkali resistant treatment shall conform to IS: 158.
9.10.09	All internal paints shall be of low VOC (Less than 50 g /L) content.

9.10.10 Aluminium Composite Panel and High Pressure Laminates (HPL)

Aluminum Composite Panel cladding with open grooves shall be designed, fabricated, tested installed and fixed for linear as well as curvilinear portions of the building for all heights and levels including:

a) Structural analysis & design and preparation of shop drawings for pressure equalization or rain screen principle as required, proper drainage of water to make it watertight including checking of all the structural and functional design.

b) Aluminium Composite Panel cladding (Alucobond/ Aludecor /Equivalent) in pan shape in metallic/ solid colour of approved shades made out of 4mm thick aluminium composite panel. ACP consisting of 3mm thick Fire Retardant mineral filled Core comprising of around 70% Inorganic compound which is 100% non-combustible mineral and balance 30% is food grade virgin polymer sandwiched between two Aluminium sheets (each 0.5mm thick). The aluminium composite panel top and bottom skin should confirm to Aluminium Alloy 5005 (AlMg 1) marine grade series and H 22/24 temper.

The ACP sheet shall be coil coated with Kynar 500 based (70:30 ratio) PVDF / Lumiflon based fluoropolymer resin coating of approved colour and shade on face # 1 and polymer (Service) coating on face # 2 as specified using stainless steel screws, nuts, bolts, washers, cleats, weather silicone sealant, backer rods etc.

c) The fastening brackets of Aluminium alloy 6005 T5 / MS with Hot Dip Galvanised with serrations and serrated washers to arrest the wind load movement, fasteners, SS 316 Pins and anchor bolts of approved make in SS 316, Nylon separators to prevent bi-metallic contacts all complete required to perform as per specification and drawing.

High Pressure Laminates (HPL) :

8mm thick Suede Finish Greenlam or Trespa exterior grade High Pressure Laminate (HPL) made up of 1300mmx 3050mm in size and manufactured under EN438-2&3:2005 standard. HPL should made with GLE Technology & Double Layer UV Protection process under high pressure, thermosetting Phenolic resign treated Exclusive & Certified Exterior Grade Decorative paper (UV Resistant) on both side with high grade Kraft paper in between. Both the decorative and Kraft paper to be made of Virgin Pulp. HPL should be resistance to water immersion characterstic with permissible increase on thickness and mass <0.60% and have density >1.35G/cm3, UV resistance on Grey scale measurement will be measured ≥ 4, with flame retardant fulfilled the criteria of under EN13501-1:2007 with classification of BS1D0 standard property, Moisture resistant, Impact resistant, termite resistant, Scratch resistant, Weather and climatic shock resistant high pressure thermosetting resin treated balanced compact laminates HPL. The manufacturer shall provide 10 years warranty certification on manufacturing and moisture related defects. HPLshall have Green Guard Gold certification where the VOC emission level is less than 0.22 PPM. Anti-bacterial and Anti-Fungal property under JIS Z2801:2000. HPL will be installed on Aluminum tubes at 500 mm c/c distance with special L Brackets. Aluminum box size will be 25mmx50mmx1.8 mm. Boards will be fixed on the Aluminum Channels with colour match rivets (Manufacturer approved Rivets) through 8mm drill hole in Boards and 5mm dia drill holes in Aluminum Box. Rivets will be installed by automatic Rivet Guns Shade designed of clad should be finalized under direction of Engineer –in charge.

9.10.11 GRC Wall Cladding Tiles

GRC Wall Cladding Tiles shall be of Unistone or equivalent company.

Glass Reinforced Concrete (G.R.C) Wall Cladding Tiles shall be of approved design, size, texture, thickness, patter and color. The thickness of the tiles shall range between 12 to 18mm (depending on the texture of the tile), allowing variance of 2 mm in accordance with IS: 1237-1980. The composition of tiles shall be '43' Grade Portland cement, reinforced with Alkali Resistant Glass Fiber and homogeny pigmentation shall be done with exterior grade synthetic inorganic iron oxide pigments manufactured by 'BAYFERROX / Lanxess (Germany)' or equivalent.

The pigmentation shall be homogeneous and in accordance with British Standards BS EN 12878:1999. The other additives shall be fine washed graded quartz, super plasticizers and integrated water proofing agents and others.

The tiles shall be produced with high vibration technology and concrete mix design compressive strength equivalent to M-40 Grade@28 days. The top surface of the tiles shall be sealed with acrylic lacquer resulting in surface water absorption of tiles, less than 1% and water absorption by 24 hrs immersion method, less than 8%. The tiles shall be applied on a rough plaster of 1:3 cement mortar 1:3 (1cement: 3 coarse sand) and the fixing of tiles shall be done by 'Unistone' tile adhesive or equivalent as per manufacturer's laying instruction.

9.10.12 GRC Customized Screens and Dome in shapes as Specified

GRC Customized Screens shall be of 'Unistone', make or equivalent.

Glass Reinforced Concrete (G.R.C) Screens shall be casted with 'Spray Mix' concrete design in approved size, pattern, thickness of 50mm on the outer Border & 25-30mm for Internal member and shade. The Screens should be made from '53 grade' White Portland Cement manufactured by 'JK Cement' or 'Birla white', White Quartz fine graded sieved Silica Sand, Alkali Resistant Glass Fibre manufactured by 'NEG Japan, Owen Corning 'Saint Gobain' or equivalent, SuperPlasticizers manufactured by 'Karochem' or equivalent, Polymers manufactured by 'Nova' Polychem' or equivalent and U.V resistant Synthetic inorganic pigments shall be used for pigmentation manufactured by 'Phenochem industries or equivalent. The Screens casting shall take place with layering methodology using- Direct Power Spray machines. The GRC Screens flexural strength average L.O.P shall be above or equivalent to 6 N/mm2 & M.O.R shall be above or equivalent to 12 N/mm2 for tests done on 28 days cured samples.

The fixing of Screens shall be done using 'Dry fixing' method onto structural support members i.e. R.C.C, Brick work, MS Framework. SS / MS Galvanized CLAMPS & PINS also if required fasteners to be used of Wurth, Hilti & Fischer or equivalent. ALL CAST IN SOCKET TO BE EPOXY PRIMER COATED. ELECTRODES to be used of ADVANI, MANGALAM, ESAB or Victor brand or equivalent.

9.10.13 Exterior Painting on Wall (Premium Acrylic Smooth Exterior Paint with Silicone Additives over Texture Coat)

The paint shall be (premium acrylic smooth exterior paint with silicone additives) of approved brand and manufacture. This paint shall be brought to the site of work by the contractor in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the contractor and the Engineer-in-Charge. The empty containers shall

not be removed from the site of work till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge.

Preparation of Surface

For new work, the surface shall be thoroughly cleaned off all mortar dropping, dirt dust, algae, fungus or moth, grease and other foreign matter of brushing and washing, pitting in plaster shall make good, surface imperfections such as cracks, holes etc. should be repaired using white cement. The prepared surface shall have received the approval of the Engineer in charge after inspection before painting is commenced.

Textured base coat
Exterior wall Texture-New work (Two or more coats applied @ 6.5kg/10 sqm over and including priming coat of exterior primer applied @ 2.20 kg/10 sqm). High Quality Exterior Acrylic Modified resin and special quality Silica Quartz with Trowel Texture (Asian / Dulux/ Nerolac/ Berger/ Equivalent) as per selection.

Application of exterior paint

Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its container, when applying also the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform. Dilution ratio of paint with potable water can be altered taking into consideration the nature of surface climate and as per recommended dilution given by manufacturer. In all cases, the manufacturer's instructions & directions of the Engineer-in-charge shall be followed meticulously.

The lids of paint drums shall be kept tightly closed when not in use as by exposure to atmosphere the paint may thicken and also be kept safe from dust. Paint shall be applied with a brush on the cleaned and smooth surface. Horizontal strokes shall be given, First and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks.

9.11.00 **Doors, Windows& Structural Glazing:**

9.11.01 Doors, windows and ventilators of air-conditioned areas, entrance lobby of all buildings (wherever provided), and all windows and ventilators of all buildings (unless otherwise mentioned) shall have aluminium framework with glazing. The aluminium sections shall confirm to IS 733 & IS 1285 and shall have minimum 2 mm thickness. The aluminium frame shall be electro colour dyed (anodised with 15 micron coating thickness) when used on outer side of the building and it shall be powder coated (50 microns coating thickness) when used in interior of the building. All doors of toilet areas shall be of steel framed solid core flush shutter. For Mill Bunker Building, transfer points, crusher house, conveyor gallery, steel louvered windows shall be provided.

9.11.02 Control Rooms of all buildings shall be provided with Aluminium Glazed door.

9.11.03 Single glazed panels with aluminium framework shall be provided as partition between two air-conditioned areas wherever clear view is necessary.

9.11.04
a) The doors frames shall be fabricated from 1.6 mm thick MS sheets and shall meet the general requirements of IS: 4351.

b) All steel doors shall consist of double plate flush door shutters. The door shutter shall be 35 mm (min.) thick with two outer sheets of 1.2 mm rigidly connected with continuous vertical 1.0 mm stiffeners at the rate of 150 mm centre to centre. Side, top and bottom edges of shutters shall be reinforced by continuous pressed steel channel

	with minimum 1.2 mm. The door shall be sound deadened by filling the inside void with mineral wool. Doors shall be complete with all hardware and fixtures like door closer, tower bolts, handles, stoppers, aldrops, locks etc.
9.11.05	Steel windows and ventilators shall be as per IS: 1361 and IS: 1038.
9.11.06	Wherever functionally required Rolling shutter (fully closed/partly grilled) with suitable operating arrangement (manual/Electric) shall be provided to facilitate smooth operations. Rolling shutters shall conform to IS: 6248. M.S sliding doors with suitable mechanical and electrical operations fixtures as per requirement for bigger openings shall be used.
9.11.07	All windows and ventilators on ground floor of all buildings shall be provided with suitable Aluminium grill.
9.11.08	Fire-Proof doors with panic devices shall be provided at all fire exit points as per requirements. These doors shall generally be as per IS 3614 ~~(Part 2). Fire rating of the doors shall be of minimum 2 hours.~~ These doors shall be double cover plated type with mineral wool insulation.
9.11.09	Hollow extruded section of minimum 2 mm wall thickness as per IS: 1285 (**Grade of Alluminum shall be Alloy 63400)** shall be used for all aluminium doors, windows and ventilators.
9.11.10	Minimum size of door provided shall be 2.1 m high and 1.2 m wide. However, for toilets minimum width shall be 0.75 m and office areas minimum width shall be 1.20m.
9.11.11	Electrically operated, self- operable/closing, aluminium framed with tinted glass, sliding doors shall be provided at the entrance of all common control rooms, entrance lobby of facility building. The sliding door (except in MPH) shall have 10mm thick toughened tinted glass in suitable Aluminium frame. At the entrance of all common control rooms in MPH G.I. framed with fire resistant glass, sliding doors shall be provided. The other doors in common control rooms in MPH shall be G.I. framed with fire resistant glass as per fire zoning. Fire Resistant Glazed Door System (Swing / Sliding) shall be of uniform GI profile 50X50 mm with 14mm (minimum) EI 20 GLASS for Interior Application. Fire Resistant Glazed Door System shall have 120 minutes of integrity and radiation control (EW 120) with symmetrical (Bi-Directional) fire protection. The frames shall be cold rolled profiles as per EN standard EN 10327/ Indian Standard IS 513. The door frames are cold rolled from 1.5 mm steel sheet to form a profile of 50 mm x 50 mm on all sides. The door shutter shall have the top rail, side rail and bottom rail dimensions of 50 mm x 50 mm. The overall door opening shall be as per tested evidence and tested as per EN 1634-1/ ISO 834- 1 / ISO 3009 /(Indian Standard) IS 16947:2018 in an accredited laboratory. The glass must be minimum 14mm thick, clear (MADE IN INDIA)120 min fire rated for Integrity, Radiation control (EW 120) and partially insulation (EI 20) Non Wired Toughened Interlayered glass with a light transmission of 86% and a sound reduction of 38 dB and manufactured in UL & TUV audited Facility and including UL-EU Certification and compliant to class 1(B)1 category of Impact Resistance as per EN 12600. The glass shall be tested and certified for no formation of bubbles or yellowing after 5000 hours of exposure to UV radiation by TUV Rheinland as per EN 12543-4. The base glass and finished glass must made in India. The shutters shall be fixed to the frame using Weld-on hinges of dimensions 179mm X 20mm. The profiles shall have groves to incorporate Fire Resistant gaskets. The glass shall be held in its place with the help of 1.5 mm cold rolled steel beading and Kerafix 2000 ceramic tape with cross section of 4 x 15 mm as per the test evidence. Beading shall be clipped on using Stainless Steel self-tapping screws fixed at a distance of 70 mm from the edges and 150 mm

Fire rating of the doors shall be of minimum 2 hours of integrity and 30 minutes of insulation. These doors shall be double Cover plated type with mineral wool insulation. (Amendment No 01, D-1-9)

	c/c henceforth. The glass panes are to be supported on non-combustible 6 mm Calcium Silicate setting blocks. The door shall be fitted with offset pull handle and door closer of Dorma (TS 73V, TS 83V, TS93V), Geze (TS 2000NV) or equivalent. The inactive leaf (in case of double leaf only) shall be fixed to the frame using a tower bolt at meeting edge at top or as per the tested evidence. The doors shall be manufactured in a TUV audited facility. The maximum glazing size shall be as per the test certification. The profile shall be fixed to the supporting construction by means of M10 or bigger steel bolts at every 150 mm from the edges and every 500 mm (approx.) c/c. The doors shall offer C4 level of wind resistance when tested as per EN12211 and shall provide class 4 level of air permeability as per EN 1026. The door shall also be subjected to durability tests as per EN 12400 for C5 classification (200,000 cycles). The doors shall also be tested for class 5 of impact resistance when tested as per EN 13049. The doors & partition shall also be tested for class 4 level of Mechanical strength when tested as per EN13115. The door shall have water tightness level of 8A when tested as per EN 1027. The sliding door system shall be connected to the surrounding construction by means of interlocking labyrinths lined with intumescent tapes as per the test evidence and connected to the sliding mechanism at the top. The sliding mechanism shall be as mentioned in the tested evidence or Assessment and shall have steel rollers. The glass should be held in its place with the help of 1.5 mm cold rolled steel beading and Kerafix 2000 ceramic tape with cross section of 4 x 15 mm as per the test evidence. Beading shall be clipped on using Stainless Steel self-tapping screws fixed at a distance of 70 mm from the edges and 150 mm c/c henceforth. The glass panes are to be supported on non-combustible 6 mm Calcium Silicate setting blocks. The sliding mechanism shall be fixed to adequate supporting construction (MS channel / Reinforced concrete) to ensure proper support for the door.
9.11.12	Minimum area of windows in building on each floor level shall be 10% of floor area.
9.11.13	**Structural Glazing & supporting Structure:** Structural Glazing supporting Structure: Structure shall be of Aluminium extruded tubular and other aluminium sections as per the architectural drawings and approved shop drawings , the aluminium quality as per grade 6063 T5 or T6 as per BS 1474,including super durable powder coating of 60-80 microns conforming to AAMA 2604 of required colour and shade as approved by the Engineer-in-Charge. Design & Analysis of Structural Glazing: Designing, fabricating, testing, protection, installing and fixing in position semi (grid) unitized system of structural glazing (with open joints) for linear as well as curvilinear portions of the building for all heights and all levels, including: (a) Structural analysis & design and preparation of shop drawings for the specified design loads conforming to IS 875 part III (the system must passed the proof test at 1.5 times design wind pressure without any failure), including functional design of the aluminum sections for fixing glazing panels of various thicknesses, aluminium cleats, sleeves and splice plates etc. gaskets, screws, toggles, nuts, bolts, clamps etc., structural and weather silicone sealants, flashings, fire stop (barrier)- cum-smoke seals, microwave cured EPDM gaskets for water tightness, pressure equalization & drainage and protection against fire hazard including: (b) Fabricating and supplying serrated M.S. hot dip galvanised / Aluminium alloy of 6005 T5 brackets of required sizes, sections and profiles etc. to accommodate 3 Dimentional movement

for achieving perfect verticality and fixing structural glazing system rigidly to the RCC/ masonry/structural steel framework
of building structure using stainless steel anchor fasteners/ bolts, nylon seperator to prevent bimetallic contacts with nuts and washers etc. of stainless steel grade 316, of the required capacity and in required numbers.

(c) Fixing and filling, two part pump filled, structural silicone sealant and one part weather silicone sealant compatible with the structural silicone sealant of required bite size in a clean and controlled factory / work shop environment, including double sided spacer tape, setting blocks and backer rod, all of
approved grade, brand and manufacture, as per the approved sealant design, within and all around the perimeter for holding glass.

(d) Fixing in position flashings of solid aluminium sheet 1 mm thick and of sizes, shapes and profiles, as required as per the site conditions, to seal the gap between the building structure and all its interfaces with curtain glazing to make it watertight.

(e) Making provision for drainage of moisture/ water that enters the curtain glazing system to make it watertight, by incorporating principles of pressure equalization, providing suitable gutter profiles at bottom (if required), making necessary holes of required sizes and of required numbers etc. complete.

This item includes cost of all inputs of designing, labour for fabricating and installation of aluminium grid, installation of glazed units, T&P, scaffolding and other incidental charges including wastages etc., enabling temporary structures and services, cranes or cradles etc. as described above and as
specified. The item includes the cost of getting all the structural and functional design including shop drawings checked by a structural designer, dully approved by Engineer-in-charge. The item also includes the cost of all mock ups at site, cost of all samples of the individual components for testing in an approved laboratory, field tests on the assembled working structural glazing as specified, cleaning and protection till the handing over of the building for occupation. In the end, the Contractor shall provide a water tight structural glazing having all the performance characteristics etc. all complete as required, asper the Architectural drawings, as per item description, as specified, as per the approved shop drawings and as directed by the Engineer- in-Charge.

The NIT approving authority will decide the necessity of testing on the basis of cost of the work, cost of the test and importance of the work. Performance Testing of Structural glazing system Tests to be conducted in the NABL accredited lab or any other accreditation body which operates in accordance with ISO/ IEC 17011 and accredits labs as per ISO/IEC 17025

1. Performance Laboratory Test for Air Leakage Test (-50pa to - 300pa) & (+50pa to +300pa) as per ASTM E-283-04 testing method for a range of testing limit 1 to 200 mVhr
2. Static Water Penetration Test. (50pa to 1500pa) as per ASTME- 331-09 testing method for a range up to 2000 ml.
3. Dynamic Water Penetration (50pa to 1500pa) as per AAMA 501.01- 05 testing method for a range upto2000 ml.
4. Structural Performance Deflection and deformation by static air pressure test (1.5 times design wind pressure without any failure) as per ASTME-330-10 testing method for a range upto 50 mm
5. Seismic Movement Test (upto 30 mm) as per AAMA 501.4-09 testing method for Qualitative test, Tests to be conducted on site.
6. Onsite Test for Water Leakage for a pressure range 50 kpa to 240 kpa (35psi) upto 2000 ml

	IGU Panels: Fixing, assembling and supplying vision glass panels (IGUs) comprising of hermetically-sealed 6-12- 6 mm insulated glass (double glazed) vision panel / openable panels units of size and shape as required and specified, comprising of an outer heat strengthened float glass 6mm thick, of approved colour and shade with reflective soft coating on surface # 2 of approved colour and shade, an inner Heat strengthned clear float glass 6mm thick, spacer tube 12mm wide, dessicants, including primary seal and secondary seal (structural silicone sealant) etc. all complete for the required performances, as per the Architectural drawings, as per the approved shop drawings, as specified and as directed by the Engineer-in-Charge. The IGUs shall be assembled in the factory/ workshop of the glass processor. (i) Coloured tinted float glass 6mm thick substrate with reflective soft coating on face # 2, + 12mm Airgap + 6mm Heat Strengthened clear Glass of approved make having properties as visible Light transmittance (VLT) of 25 to 35 %, Light reflection internal 10 to 15%, light reflection external 10 to 20 %, shading coefficient (0.25- 0.28) and U value of 3.0 to 3.3 W/ m2 degree K etc. The properties of performance glass shall be decided by technical sanctioning authority as per the site requirement. Shadow Box: Fabricating and supplying shadow box of required size and shape, for fixing in the spandrel portion of the structural glazing, in linear as well as curvilinear portions of the building by providing semi -rigid, inorganic, non-combustible fibre glass wool insulation 50 mm thick, conforming to IS: 8183 and BS: 3958 Part 5. The insulation layer shall have facing (factory bonded on surface # 1 of the fibre glass insulation layer), of black non-woven fibre glass tissue of nominal thickness 0.5 mm and nominal mass not less than 60 gm /sqm, made of randomly oriented glass fibres distributed in a binder by a wet-lay process including fixing 1.5 mm thick solid aluminum sheet backing using, 6 mm thick cement board including SS rivets, nuts, bolts, washers etc complete.
9.12.00	**Glazing**
9.12.01	All windows and ventilators (not specified elsewhere) shall be provided with minimum 6 mm thick toughened glass conforming to IS: 5437.
9.12.02	For single glazed aluminium partitions and doors, 8mm thick clear toughened glass shall be used.
9.12.03	Toughened tinted glass of 6 mm thickness shall be used for all windows and ventilators in toilets.
9.12.04	All glazing work shall conform to IS: 1083 and IS: 3548.
9.12.05	For glazings of Air Conditioned Buildings Composite double glazing shall be 24mm thick consisting of 6mm thick clear float glass on inner side and 6mm thick reflective toughened glass on outer side. The two glasses shall be separated by 12mm air-gap and hermetically sealed by beading of anodized aluminium with outer edge sealed with silicon sealant. Outer glass of 6mm thickness shall have following technical characteristics: Solar factor 25% or less, Maximum U-value 3.3 W/ SQMK, VLT min 30%: Light reflection internal 10 to 15%, light reflection external 10 to 20 %, shading coefficient (0.25- 0.28) The glass to be used should be from the manufacturers of glass like Saint Gobain (India) or Asahi (India) or equivalent. The glass should be free from distortion and thermal stress
9.12.06	For internal glazed partition, 8mm thick clear toughened glass shall be provided.Internal Glazed partition in in MPH shall be Vetrotech Saint-Gobain / equivalent fully glazed fire rated fixed partition with 120 minutes of integrity and radiation control (EW 120) with symmetrical (Bi-Directional) fire protection. The frames shall be cold rolled profiles As per EN standard EN

	10327/Indian Standard (IS 513) . The frames are cold rolled from 1.5 mm steel sheet to form a profile of 50 mm x 50 mm on all sides. he system shall be tested as per EN 1364-1/(Indian Standars) IS 16945:2018 in an accredited laboratory.
	The glass shall be Contraflam Lite 14mm (MADE IN INDIA)clear 120 min fire rated for Integrity, Radiation control (EW 120) and partially insulation (EI 20) Non Wired Toughened Interlayered glass with a light transmission of 86% and a sound reduction of 38 dB and manufactured in UL & TUV audited Facility and including UL-EU Certification and compliant to class 1(B)1 category of Impact Resistance as per EN 12600. The glass shall be tested and certified for no formation of bubbles or yellowing after 5000 hours of exposure to UV radiation by TUV Rheinland as per EN 12543-4 The glass shall provide bi-directional (Symmetrical) fire protection. The base glass and processed glass must be made in INDIA.
	The glass shall be held in its place with the help of 1.5 mm cold rolled steel beading and Kerafix 2000 ceramic tape with cross section of 4 x 15 mm as per the test evidence. Beading shall be clipped on using Stainless Steel self-tapping screws fixed at a distance of 70 mm from the edges and 150 mm c/c henceforth. The glass panes are to be supported on non-combustible 5 mm Calcium Silicate setting blocks. The maximum glazing size shall be as per the test certification. The profile has to be fixed to the supporting construction by means of M10 or bigger steel bolts at every 150 mm from the edges and every 500 mm (approx.) c/c.
	The Partitions shall offer C4 level of wind resistance when tested as per EN12211 and shall provide class 4 level of air permeability as per EN 1026. The Partitions shall also be tested for class 5 of impact resistance when tested as per EN 13049. The Partitions shall also be tested for class 4 level of Mechanical strength when tested as per EN13115. The Partitions shall have water tightness level of 8A when tested as per EN 1027. Partitions shall be of Makes - SaintGobain,Acodor , IGI , Matrix ,Tata Pravesh.
9.12.07	11.5 mm thick laminated glass consisting of 5 mm thick heat reflective toughened glass (cool-lite / Azure/ equivalent) on outer face and 5 mm thick toughened glass on ineer face having 1.52mm PVB layer in between.
9.12.08	6 mm thick Lacquered glass (SAINT GOBAIN /ASAHI or similar approved brand) of desired colour, shade and design.
9.13.00	**False ceiling**
9.13.01	False ceiling of 12.5 mm thick tapered/square edge glass fibre reinforced gypsum board conforming to IS : 2095 having fine texture finish, including providing and fixing of frame work at all levels, for all kind of work, consisting of light weight galvanised steel member (minimum 0.8 mm thick and galvanised as per IS: 277) having maximum grid size of 1200 mm x 600 mm for supporting panels of specified size, suspended from RCC structural steel or catwalkway grid above, with 4 mm (minimum) galvanised wires (rods), with special height adjustment clips, providing angle section of minimum 25 mm width along the perimeter of ceiling, supporting grid system (minimum 0.8 mm thick and galvanised as per IS: 277), expansion fasteners for suspension arrangement from RCC, providing openings for AC ducts, return air grills, light fixtures, etc., all complete. (concealed grid and finished flat seamless and curve shape (dome etc.), finished smooth(seamless) along with the galvanised light gauge steel supporting system laid in profile to suit the profile of dome).
9.13.02	False ceiling of 12 mm thk calcium silicate board of 'HILUX' or equivalent with suspension system as per manufacturers details including supporting grid system, expansion fasteners for suspension arrangement from RCC, providing openings for AC ducts, return air grills, light fixtures, etc., all complete. (With concealed grid and finished flat seamless).

9.13.03	Aluminium False Ceiling: Aluminium false ceiling shall be in 600 mm x 600 mm tile or plank type of 0.6 mm thickness (minimum)with perforation of 2.5 mm dia in combination with built in nonwoven tissue for providing good acoustic properties. False ceiling shall have coil coating of thickness 25micron (minimum)and it shall be installed with T-Grid (of profile 24 mm) in same or contrasting colours or with 6 mm recess joints. The whole system shall be level adjusting arrangement and shall be suspended as per manufacturer guidelines.
9.13.04	Batten ceiling: Batten ceiling made up of extruded aluminum / metal of minimum 0.6mm thickness with powder coated finish (min. 40 microns) /wooden finish (minimum 0.11mm). The ceiling must have superior acoustics and must adhere to the highest health and safety standards. The battens shall have possibility of curvilinear arrangement. The batten ceiling shall be Greenguard, tested/certified from UL/Intertek. The product shall meet technical requirements of ASTM E84. Batten ceiling of 1"x1" made up of extruded aluminum with "click-on system". Sublimation/Heat transfer method should not be used for better scratch resistance. Die-casted click on joinery shall not be used.
9.13.05	Designer membrane ceiling: The ceiling shall have demountable translucent stretch ceiling membrane with harpoon, corners ready to install. It shall not get discoloured & sag. All joints shall be provided with appropriate interface trims to be able to demount the ceiling to access the lights. The ceiling shall be installed using ceiling aluminium suspension system, complete as per manufacturer's installation guidelines and as per approved shop drawings in line with the design intent and approval by Engineer In-charge. LED strips shall be installed using custom aluminium extrusions to ensure longevity of the installation. The ceiling shall have following features and properties: - Durable: The systems shall resist shocks and shall not crack with movement or under stretch conditions. Safe: The membranes and profiles shall have passed the stringent fire and safety tests. The membrane shall have been classified as non-toxic upon burning. The Flexible membrane shall be b-s1-d0 / ASTM E-84 class A tested/certified. Green: Membranes shall be 100% recyclable. There shall not be any welding defect on Membranes.
9.13.06	Additional hangers and height adjustment clips shall be provided for return air grills, light fixtures, A.C. ducts etc.
9.13.07	Suitable M.S. channel (Minimum MC75 with maximum spacing of 1.2 m C/C both ways) grid shall be provided above the false ceiling level for movement of personnel and to facilitate maintenance of lighting fixtures, AC ducts etc.
9.13.08	Underdeck insulation shall be provided on the ceiling (underside of roof slab) and underside of floor slab of air-conditioned area depending upon the functional requirements. This underdeck insulation shall consist of 50mm thick mineral wool insulation with 0.05 mm thick aluminium foil & 0.6 mm x 25mm mesh wire netting and shall be fixed to the ceiling with 2 mm wire ties.
9.13.09	Suitable cut-outs shall be provided in false ceiling to facilitate fixing of lighting fixtures, AC grills, smoke detectors, etc.
9.14.00	**Elevator Machine Room** Elevator machine room shall be as per NBC requirements in either way. a) Floor of the elevator machine room shall be of RCC and wall shall be of one brick thick masonry wall. It shall be provided with fire door and other requirements as per NBC and elevator norms.

b) Floor of Machine Room shall be provided with profiled metal decking sheet. Trough shall be filled with Insulating Material (glass wool or rock wool) and thereafter finished with Minimum 50 mm thick wooden flooring, consisting of 37 mm thick hardwood planks, finished with 11mm thick laminated wooden flooring (of 'pergo' or equivalent) with plank size 193x1195mm (material class shall be 34 as per EN13329), over 2 mm expanded polystyrene foam and polythene sheet under laying.

Roof and Side enclosure of Machine Room shall be provided with Prefabricated Insulated Metal Sandwich panels. Composition of Insulated Metal Sandwich Panels shall be as described in Clause 9.08.00 of Part-B (Civil) of Technical Specification.

Doors of Machine Room shall be Double Plate Steel flush doors of thickness 45 mm with steel sheets of 18 gauge with necessary stiffeners. Space between two sheets shall be filled with mineral wool insulation. Frame of doors shall be pressed steel sheets of 16 gauge. All necessary fittings for the doors shall be provided by the Bidder. Rubber sealing, for making the Doors airtight shall also be provided.

Windows/ventilators shall be of standard extruded anodised Aluminium Sections of minimum 2 mm thickness with 24 mm hermitically sealed double glazing consisting of two 6 mm thick toughened glass separated by 12 mm. gap.

Technical requirements of prefabricated insulated metal sandwich panels/decking sheets shall be same as given elsewhere in this specification.

9.15.00 **Interior Design**

A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving power plant technology, and architectural & civil engineering for a smooth control hierarchy and man machine interface. All the design aspects such as flooring, false ceiling, furniture, colour scheme equipment design & layout, illumination, fire fighting, acoustics and ergonomics requirements shall be detailed out so as to present an overall unified aesthetic spatial appearance.

The areas to be undertaken for this interior design process shall be control room complex including common control room, computer room, conference rooms and office areas in the buildings and the following aspects shall be reviewed and evaluated for design. Furniture to be supplied by Bidder for the control room complex and other control rooms shall be as specified under C&I specification.

a) Layout, keeping in view the man-machine interface and suitable ergonomic practices.

b) Integration of civil engineering with architecture and interior design.

c) Illumination levels, noise levels, electromagnetic interference levels, taking into account the equipment and furniture.

d) Comfort and safety requirements such as air conditioning, fire fighting, fire escapes, etc.

e) Microprocessors based control system to control the functional requirements.

The above design philosophy put into practice shall be detailed out through presentation drawings, perspective views, scale models, detail drawings, etc.

9.16.00 **Stainless Steel Hand railing**

Providing and fixing knockdown railing system comprising of SS 304 Grade Stainless Railing of 50mm diameter handrail fixed on 50 mm SS round baluster placed at maximum 1000 c/c along with five numbers 19 mm diameter midrail connected at side of baluster by special brackets, both the end of mid rail should be bush inserted for jointing and to give extra strength (joints should not be welded and invisible). The balustrade should be fixed onto floor with

	casted plate of minimum 6mm thickness. Base plate shall be concealed with suitable SS 304 cover cap so that the mounting height fasteners are not visible after installation. Only high strength anchor fasteners would be used for fixing of baluster, as giving extra strength, rust proof and more durable. Onsite welding is strictly not allowed. Wherever welding is required, it should be Tig welding process with same grade 304/316 at factory only so that floor stone and other things would not be damaged and for safety purpose also. Baluster and handrail connector should be screwed tightened and not to be welded on site. Wall thickness of all pipes shall be taken as 2 mm. Along with all visible components developed in high grade SS and whenever required, joints to be filled with bushings for extra strength. Railing Height to be taken @ 1000/ 1200 mm from floor level.
9.17.00	**Finishing Schedule** Interior and Exterior Finishes shall be as given in Tables-A&B respectively attached at the end of these specification.

TABLE –A

INTERIOR FINISHING SCHEDULE

S. NO.	DESCRIPTION OF AREA	FLOOR FINISH	WALL FINISH	CEILING FINISH
1.	Main power house Building.			
	a) Unloading Bay	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	b) Cable vault	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	c) Balance area including passage	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	d) SWAS Room	Matt Finished Vitrified ceramic tiles.	Aluminium composite panel cladding on walls and columns upto false ceiling level	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	e) Equipment Area, ESP SWGR/ ACP Room/ UAF Room	Cement concrete with Metallic hardener topping	Acrylic distemper.	Acrylic distemper (except metal deck area)
	f) UPS Battery charger room	Matt finished Vitrified ceramic tiles.	Aluminium composite panel cladding on walls and columns upto false ceiling level	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	g) Deaerator floor	Cement concrete with Metallic hardener topping.		-

	h) Operating Floor	20 mm thick heavy duty anti skid full body vitrified tile in TG Hall. Rubber flooring at TG deck.	Colour coated Metal cladding on A-Row& Gable end, up to crane girder level.	Metal deck roofing (bottom of sheeting with RAL 9002 finish)
	i) General circulation and movement areas	20 mm thick heavy duty anti skid full body vitrified tile		Acrylic distemper (except metal deck area).
	j) Switchgear room	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	k)MCC Room	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	l) Control room area including control room	Matt Finish Vitrified ceramic tiles flooring of size 1000 x1000 mm	Partition in fire rated glass with fire rated frames with 2 hr fire rating & Metal Batten panel cladding for columns and walls	Metal Batten panel ceiling in combination with demountable translucent stretch ceiling membrane or as per approved design.
	m) control equipment room,	Matt finish Vitrified ceramic tiles.	Partition in fire rated glass with fire rated frames with 2 hr fire rating &Aluminium composite panel cladding for columns and walls	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	n)Conference room, senior executive room., Computer Room	Matt finish Vitrified ceramic tiles	Partition in fire rated glass with fire rated frames with 2 hr fire rating &Aluminium composite panel cladding for columns and walls	Mineral fiber board false ceiling in combination with GRG plaster board border

	o)Record room	ceramic tiles	Acrylic distemper.	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	p)Locker room	Ceramic Tiles	Acrylic Emulsion Paint	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	q)Toilet area	ceramic tiles	Digitally glazed ceramic wall tiles up to False Ceiling Height	Calcium Silicate False Ceiling
	r) Office Room, Staff Room	Matt Finished Vitrified ceramic tiles.	Partition in fire rated glass with fire rated frames with 2 hr fire rating &Aluminium composite panel cladding for columns and walls	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	s)Laboratory area	Vitrified Ceramic / Acid/alkali resistant tiles.	Designer ceramic wall tiles up to False Ceiling Height/ Aluminium composite panel cladding for columns and walls in case of A.C Panel	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design

	t) RCC Stair case	18mm thick Granite (Polished and honed Finished) stone	Polished Granite Stone up to 1.2m. ht. & Acrylic Distemper Paint over wall putty finish for balance height.	Acrylic Distemper
	u) Lift and Staircase Lobby	18mm thick polished granite stone as pattern.	18mm thick polished granite & glass mosaic tile cladding up to False Ceiling Height	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	v) Passages and general circulation areas.	Deleted	Deleted	Deleted
	w) Battery Room	Acid and alkali resistant tile.	Acid and alkali resistant tile up to 1.2m height and chemical resistant paint for balance height	Chemical Resistant paint except in locations where Metal deck has been provided
	x) Oil canal, oil room, oil purification Tank and other areas where oil spillage is likely to occur.	75 mm thick A.R. Brick	12 mm thick A.R. Tile	As above except oil canal.
	y)Pathways including roof area.	22mm thick concrete chequered tiles.	-	-
2.	Service Building			
	a) Entrance Lobbies and Lift areas/Foyer/Exhibition space.	18mm thick polished granite stone as/ pattern.	Combination of 18mm thick polished granite cladding, lacquered	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design

			glass cladding and Fiber Reinforced Plastic murals based on local art in lift lobby & foyer	
	b) Conference room, senior executive room.	15 mmthk. Engineered wooden flooring	Glazed partition with Aluminium frame/ Acrylic emulsion paint.	Mineral fiber board false ceiling in combination with GRG plaster board border in column depth or as per approved design.
	c) Office Room, Staff Room	Digitally glazed Vitrified ceramic tiles.	Acrylic emulsion paint./ Designer Glass mosaic tile mural in combination with textured paint in Canteen	Mineral fiber board false ceiling in combination with GRG plaster board border in column depth or as per approved design
	d) Passage	Digitally glazed Vitrified ceramic tiles.	Acrylic emulsion paint.	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	e) RCC Stair case	18mm thick Granite (Polished and Honed Finished) stone	Glass Mosaic Tile cladding in murals and pattern based on local art upto ceiling level	Acrylic Distemper.
	f) Toilet/ Pantry/ Kitchen	ceramic tiles	Digitally glazed ceramic wall tiles up to False Ceiling Height	Acrylic distemper in kitchen / Calcium Silicate false ceiling in toilet and pantry

	g) AHU/ A.C. Plant room/MCC Room/Store	Cement concrete with Metallic hardener topping.	Acrylic distemper / Wall insulation in AHU as per HVAC Requirement	Acrylic distemper / Underdeck insulation in AHU as per HVAC Requirement
	h) Stilt parking area	Cement concrete with Non-Metallic hardener topping.	-	-
	i) Pathways including roof area.	22mm thick concrete chequered tiles.		
2.	ESP control building/Air compressor house			
	a) Operating/Maintenance areas	Cement concrete with Metallic hardener topping	Pre color coated metal panel cladding.	Acrylic distemper (except metal deck area)
	b) Office Room, Staff Room	Digitally glazed Vitrified tiles.	Aluminium composite panel cladding on walls and columns	Mineral fiber Board False Ceiling
	c) Control Room	Digitally glazed Vitrified tiles.	Aluminium composite panel cladding on walls and columns in ESP Control Room Building	Alluminium false ceiling in combination with GRG plaster board border in column depth or as per approved design
	d) MCC Room	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)

	e) RCC Stair case	18mm thick Granite (Polished and Honed Finished) stone	Polished Granite stone up to 1.2m.ht. & Acrylic Distemper	Acrylic Distemper (except metal deck area)
	f) Battery Room	Acid, Alkali resistant tile	Acid, Alkali resistant tile 1.2m height / chemical resistant paint above dado	Chemical resistant paint (except metal deck area)
	g) AHU/ AC Plant room/ Cable vault	Cement concrete with Metallic hardener topping	Acrylic Distemper	Acrylic Distemper (except metal deck area)
	h) Toilets	ceramic tiles.	Designer ceramic wall tiles dado up to false ceiling level.	Calcium silicate false ceiling.
4.	Mill & Bunker building/ T.P.s / Conveyor Galleries	Cement concrete with Metallic hardener topping	Acrylic distemper on masonry walls/ color coated Metal panel cladding	color coated Metal panel cladding
5.	**Watch Tower**			
	Viewing area	Cement concrete with Metallic hardener topping	Cement concrete with Metallic hardener topping	Acrylic distemper
6.	Foam Pump House/ Fire water booster water pump house.			
	a) Maintenance /Pump floor/PLC	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	b) Control room /PLC.	Matt Finished Vitrified Ceramic Tiles	Acrylic emulsion paint.	Mineral fiber board false ceiling.

	Toilet area	ceramic tiles.	Digitally glazed ceramic wall tiles dado up to 2200 mm	Acrylic distemper
7.	Ash slurry pump house/ Ash water pump house /Silo Area Utility Building / Transport air compressor house/ Fuel Oil Unloading Pump House with switchgear building& control room /FOPPH Building/ Miscellaneous Switchgear room CW Pump house, Switchgear room, control room/ RW Pump house, Switchgear room, control room/ /Safety Control Room/Water system control Room Building/Any other Building.			
	a) Operating/Maintenance areas/ MCC room /Switchgear Room	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	b) Control room/RIO Room /PLC /Office area.	Matt Finished Vitrified Ceramic Tiles	Acrylic emulsion paint.	Mineral fiber board false ceiling.

	c) Battery Room	Acid, Alkali resistant tile	Acid, Alkali resistant tile 1.2m height / chemical resistant paint above dado	Chemical resistant paint (except metal deck area)
	d) Toilet/Pantry area	ceramic tiles.	Digitally glazed ceramic wall tiles dado up to 2200 mm	Acrylic distemper
	e) RCC Stair case	18 mm thick Marble Stone with grooves	18 mm thick Marble Stone	Acrylic distemper
8.	PERMANENT STORE BUILDING			
	a) Stores	Cement concrete with Metallic hardener topping.	Acrylic distemper/ color coated Metal panel cladding	Acrylic distemper (except metal deck area)
	b)Office Room, Staff Room/ Electronic Store	Matt Finished Vitrified ceramic tiles.	Acrylic emulsion paint.	Acrylic Emulsion Paint. / Mineral Fibre Board False Ceiling in A.C area
	c)Passages	Matt Finished Vitrified Ceramic Tiles	Acrylic distemper	Acrylic distemper
	d)RCC Stair case	18mm thick polished Marble stone finish.	Marble stone up to 1.2m.ht. & Acrylic Distemper above.	Acrylic Distemper
	e) Toilets	ceramic tiles.	Designer ceramic wall tiles dado up	Acrylic distemper

			to 2.1 m Height from FFL.	
9.	Rest Room for O&M Workers			
	a) Rest room	Cement concrete with Metallic hardener topping.	Acrylic distemper	Metal roof
	b) Toilets	ceramic tiles.	Digitally glazed ceramic wall tiles dado up to 2100 high, Acrylic Distemper paint above	Metal roof
10.	**Occupational Health Centre with Crèche Facilities**			
	a) Waiting Lobby cum Reception/ Doctor's Chamber /First Aid Room/ Patient Room	Matt finish vitrified tiles	Acrylic Emulsion paint	Acrylic Emulsion paint
	b) Driver's Room	Digitally Glazed vitrified tiles	Acrylic Distemper Paint	Acrylic Distemper Paint
	c)Toilet area	ceramic tiles.	Digitally glazed ceramic wall tiles	Calcium Silicate False Ceiling

			dado up to false ceiling level.	
11.	**Car Parking**			
	a) Covered Parking	Concrete Blocks	Acrylic distemper	Acrylic distemper
12.	**Parking Shed**			
		Concrete Blocks		
13	**Switchyard Control room Building/ GIS Building**			
	a) Lounge/Passage	Marble Stone	Acrylic emulsion paint.	Mineral fiber board false ceiling.
	b) Lab	ceramic tiles.	Acrylic emulsion paint.	Mineral fiber board false ceiling.
	c) Office/ SAS Room/Conference Room/ Change Room	Matt Finished Vitrified Ceramic Tiles	Acrylic emulsion paint.	Mineral fiber board false ceiling.
	d) Porch	Marble Stone		
	e) Toilet/ Pantry	ceramic tiles.	Digitally glazed ceramic wall tiles	Calcium Silicate False Ceiling

			dado up to false ceiling level.	
	f) Switchgear room/Store Room	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	g) Battery Room	Acid, Alkali resistant tile	Acid, Alkali resistant tile 1.2m height / chemical resistant paint above dado	Chemical resistant paint (except metal deck area)
14.	**H2 generation Building**			
	a) MCC/ Rectifier Room/Hydrogen generation Room, Hydrogen Manifold area/Cylinder Room	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	b) Control Room	Matt Finished Vitrified Ceramic Tiles	Acrylic emulsion paint.	Mineral fiber board false ceiling.
	c) Battery Room	Acid, Alkali resistant tile	Acid, Alkali resistant tile 1.2m height / chemical resistant paint above dado	Chemical resistant paint (except metal deck area)
	d) Toilet/ Pantry	ceramic tiles.	Digitally glazed ceramic wall tiles	Calcium Silicate False Ceiling

			dado up to false ceiling level.	
15.	**Gate Complex**			
	a) Reception/Waiting/ Corridors	Granite stone	Textured paint	Acrylic emulsion paint/GI Metal panel false ceiling in Canteen, Gate Complex and safety centre
	b) Office/Guard Room/Conference/Viewing Gallery/ Staff room /Class Room	Vitrified ceramic tiles.	Acrylic emulsion paint	Mineral fiber board false ceiling. Acrylic emulsion paint for Fire station
	c) Detention Room/ Ammunition store/AHU/MCC Room	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic Distemper
	d) Sitting and General Area	Granite stone/Vitrified ceramic tiles.	Designer ceramic wall tiles up to 1.2 m, and Textured Paint for balance height. Glass mosaic tiles murals & Glass blocks for interior purpose in Canteen.	Acrylic distemper/ Gypsum board false ceiling./ Mineral Fiber Board false ceiling in Canteen and Gate complex and acrylic emulsion paint for Fire station

	e) Toilets/ Pantry	Heavy Duty Dust pressed ceramic tiles.	Designer ceramic wall tiles dado up to false ceiling level.	Calcium Silicate false ceiling.
	f) Stores	Cement concrete with Metallic hardener topping.	Acrylic distemper.	Acrylic distemper.
	g) RCC Stair case	18mm thick polished Marble stone.	Marble stone up to 1.2m.ht. & Acrylic Distemper above.	Acrylic Distemper
16.	**Coal, Lime, Biomass and Gypsum Handling Plant Buildings**			
	a) Non-Air-conditioned space.	Cement concrete with Metallic hardener topping	Acrylic distemper over wall putty	Acrylic distemper
	b) R.C.C Staircase	18 mm thick granite flooring	1200 high Glass mosaic tiles and Acrylic Emulsion paint over wall putty above	Acrylic distemper
	c) Toilet area	Heavy Duty Dust pressed ceramic tiles.	Designer ceramic wall tiles dado up to false ceiling level.	Calcium silicate false ceiling
	d) Battery room	Acid, Alkali resistant tile	Acid/Alkali resistant tile and chemical resistant paint above dado.	Chemical resistant paint.

	e) Entrance/ Reception	18 mm thick Granite Stone	Acrylic emulsion paint and Glass Mosaic tiles cladding	Acrylic distemper
	f) Passages	18 mm thick Granite Stone	Acrylic emulsion paint	Acrylic distemper
	g) Air-Conditioned Space	Vitrified Ceramic Tiles	Acrylic emulsion paint	GI clip in metal false ceiling
17.	**Water & Effluent treatment plant buildings & Other auxiliary building.**			
	a) Workshop/ Operating/Maint enance areas/MCC areas	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
	b) Office Room, Staff Room	Vitrified ceramic tiles.	Acrylic emulsion paint	Mineral fiber board false ceiling.
	c) Control room	Vitrified Ceramic Tiles	Acrylic emulsion paint	Mineral fiber board false ceiling.
	d) Acid/Alkali storage area/ CW treatment area/DM plant	Acid, Alkali resistant tile as per requirement.	Acid/Alkali resistant tile as per requirement and	Chemical resistant paint.

	area/ Regeneration area/ Neutralization pit etc.		chemical resistant paint above dado.	
	e) RCC Stair case	Marble stone / granite stone.	Marble stone up to1.2 m.ht. & Acrylic Distemper paint.	Acrylic Distemper

Note :

1. All wall above false ceiling shall be plastered.
2. The colour and pattern of finish shall be as per approved details.
3. All materials shall be of reputed and established brand approved by Engineer-in-charge.
4. Wherever alternative materials are specified, the final selection rests with Engineer-in-charge.
5. This finishing schedule shall also be applicable to similar functional areas for all other buildings and facilities.
6. All the finishing materials shall be applied/provided as per manufacturer specification and guidelines under the supervision & guidelines of manufacturer.
7. All electrical conduits in building for Lighting, HVAC and services shall be concealed type. The laying work of electrical conduits shall be done before finishing works.
8. All Plumbing pipes shall be of concealed type. The laying work of plumbing pipes shall be done before finishing works.

TABLE –B

EXTERIOR FINISHES SCHEDULE

Sl.No.	DESCRIPTION OF AREA	WALL AND PROJECTIONS	SOFFIT OF PROJECTIONS
1.	Auxiliary building in steel framed structure.	Premium Acrylic Smooth exterior paint with silicon additives over Texture coat over plastered surface/ Aluminium Composite Panel Approved colour/ colour combination of colour coated metal cladding	Premium Acrylic Smooth exterior paint with silicon additives over Texture Coat over plastered surface Approved colour/ colour combination of colour coated metal cladding
2.	Building with concrete frame work, etc.	Premium Acrylic Smooth exterior paint with silicon additives over Texture coat over plastered surface	Premium Acrylic Smooth exterior paint with silicon additives over Texture coat over plastered surface
3.	Steel Structure, trestles, etc.	High performance Paint of approved specification and shade.	
4	Service building	GRC Tiles, GRC Customized screens, Aluminium Composite Panels, High Pressure Laminate and Structural Glazing.	Premium Acrylic Smooth exterior paint with silicone additives over Texture coat over plastered surface

NOTE : 1. The colour and pattern of finish shall be as finalized by Engineer.

2. All materials shall be of reputed and established brand approved by Engineer.

SUB-SECTION- D-1-10

MATERIAL SPECIFICATION

D-1-10

MATERIAL SPECIFICATION

10.01.00

Cement

Fly ash based Portland pozzolana cement conforming to IS: 1489 (Part-1) shall be used for all areas other than for the critical structures identified below. Other properties shall be as per IS code.

Ordinary Portland Cement (OPC) shall necessarily be used for the following structures.

a) Ordinary Portland Cement (OPC) shall necessarily be used for RCC for Chimney shell.

b) TG foundation top deck

c) Spring supported decks of all machine foundations such as TDBFP/MDBFP

The grade of cement shall be Grade 43 for OPC conforming to IS: 269.

In place of fly ash-based Portland pozzolana cement, OPC mixed with Fly Ash can be used. Batching plant shall have facility for mixing fly ash. Fly ash shall conform to IS: 3812(Part I). Percentage of fly ash to be mixed in concrete shall be based on trial mix. Mix design shall be done with varying percentage of fly ash mix with cement

10.02.00

Aggregates

a) **Coarse Aggregate**

Coarse aggregate for concrete shall be crushed stones chemically inert, hard, strong, durable against weathering of limited porosity and free from deleterious materials. It shall be properly graded. It shall meet the requirements of IS: 383.

However, use of aggregate manufactured from other than natural sources (Listed in Annexure-A of IS 383) and Bottom Ash from Thermal Power Plants shall be permitted only in Lean Concrete of Grade M7.5 and M10 (for % of utilization refer Table-1 of IS 383).

b) **Fine Aggregate**

Fine aggregate shall be hard, durable, clean and free from adherent coatings of organic matter and clay balls or pellets. Fine aggregate in concrete shall conform to IS: 383. Bidder can use either natural sand or crushed sand, confirming to IS:383, based on availability.

For plaster, it shall conform to IS: 1542 and for masonry work to IS: 2116.

However, use of aggregate manufactured from other than natural sources (as Listed in Annexure-A of IS 383) and Bottom Ash from Thermal Power Plants conforming to IS:383 shall be permitted only in Lean Concrete of Grade M7.5 and M10 (for % of utilization refer Table-1 of IS 383).

c) Petrographic examination of aggregate shall be carried out by the contractor at National Council for Cement and Building Materials (NCB), Ballabgarh, or any other approved laboratory to ascertain the structure and rock type including presence of strained quartz and other reactive minerals for machine foundations, etc. In case, the coarse aggregate sample is of composite nature, the proportions (by weight) of different rock types in the composite sample and petrographic evaluation of each rock should also be ascertained. While determining the rock type, special emphasis should be given on identification of known reactive rocks like chalcedony, opal etc. The procedure laid down in IS 2430 for sampling of aggregates may be followed.

The laboratory shall determine potential reactivity of the aggregate, which may lead to reaction of silica in aggregate with the alkalis of cement and / or potential of some aggregates like limestone to cause residual expansion due to repeated temperature cycle. If the same is established, the contractor shall further carry out alkali aggregates

reactivity test as per IS 2386 (Pt.VII) and / or repeated temperature cycle test to establish the suitability of the aggregates for the concrete work. The test results, with the final recommendations of the laboratory, as to a suitability of the aggregate, for use in the concrete work for various structures and suggested measures, in case of results are not satisfactory, shall be submitted to the Engineer for his review, in a report form.

In case in the report, it is established, that the aggregates contain reactive silica, which would react with alkalis of the cement, the contractor shall change the source of supply of the aggregate or use low alkali cement as per recommendation or take measures as recommended in the report as instructed by Engineer. In case aggregates indicate residual expansion, under repeated temperature cycle test (from 10 degree Celsius to 65 degrees Celsius and for 60 temperature cycles) the material shall not be used for concreting of TGs', BFPs' and other equipment foundations which are likely to be subjected to repeated temperature cycle. The contractor shall use aggregates free from residual expansion under repeated temperatures cycle test.

10.03.00 **Reinforcement Steel**

Reinforcement steel shall be of high strength deformed TMT steel bars of grade Fe-415/Fe-500/Fe 500D/Fe 550D and shall conform to IS 1786 and IS 13920. However, minimum elongation shall be 14.5%.

Relevant clause of IS 13920 are quoted below for clarity:

Quote

5.3.1 Steel reinforcement shall comply with all of the following:
a) Elongation shall be at least 14.5 percent,
b) Ratio of ultimate stress to 0.2 percent proof stress shall not exceed 1.25,
c) Ratio of ultimate stress to 0.2 percent proof stress shall be at least 1.15, and
d) Steel shall be only of strength grades with minimum 0.2 percent proof stress of 415 MPa, 500 MPa or 550 MPa, in addition to other requirements of IS 1786.'

5.3.2 The actual 0.2 percent proof stress of steel bars based on tensile test must not exceed their characteristic 0.2 percent proof stress by more than 20 percent

Unquote

Mild steel and medium tensile steel bars shall conform to Grade A of IS:432-Part 1 and hard drawn steel wire shall confirm to IS:432-Part II. Welded wire fabric shall conform to IS 1566.

10.04.00 **Structural Steel**

Structural Steel (including embedded Steel) shall be straight, sound, free from twists, cracks, flaw, laminations and all other defects. Structural steel shall comprise of mild steel, medium strength steel and high tensile steel as specified below.

10.04.01 **Mild Steel**

a) Rolled sections shall be of grade designation E250, Quality A/BR, Semi-killed/ killed conforming to IS 2062. All steel plates shall be of Grade designation E250, Quality BR (fully killed), conforming to IS 2062 and shall be tested for impact resistance at room temperature. Plates beyond 12mm thickness and up to 40mm thickness shall be normalized rolled. Plates beyond 40mm thickness shall be vacuum degassed & furnace normalized and shall also be 100% ultrasonically tested as per ASTM –A578 level B-S2.

b) Pipes shall conform to IS: 1161.

c) Hollow (square and rectangular) steel sections shall be hot formed conforming to IS: 4923 and shall be of minimum Grade Yst 240 and minimum thickness shall be 4 mm.

d) Chequered plate shall conform to IS 3502 and shall be minimum 6 mm thick excluding projection. Steel for chequered plate shall conform to grade E250A semi killed of IS: 2062 or equivalent grade conforming to ASTM & BS standards only.

10.04.02 **Medium and High Tensile Steel**

Rolled Sections and plates shall be of grade designation E350 or higher, Quality B0 (Fully killed), conforming to IS: 2062. Plates beyond 12mm thickness and up to 40mm thickness shall be normalized rolled. Plates beyond 40mm thickness shall be vacuum degassed & furnace normalized and shall also be 100% ultrasonically tested as per ASTM –A578 level B-S2.

10.05.00 **Bricks**

Only fly ash bricks shall be used in all construction, except for elevator shafts, which can be either of burnt clay bricks or RCC construction as per functional / codal provisions. Bricks shall be table moulded/ machine made of uniform size, shape and sharp edges and shall have minimum compressive strength of 75kg/cm2. ~~Burnt clay fly ash bricks and fly ash lime bricks shall conform to IS: 13757 and IS: 12894 respectively~~. Minimum fly ash content in fly ash-based bricks shall be 25%.

Burnt clay fly ash bricks conforming to IS:13757 or fly ash lime bricks conforming to IS:12894 or fly ash cement bricks conforming to IS:16720 shall be used. (Amendment No 02, D-2-5)

10.06.00 **Foundation Bolts**

Material and details of foundation bolts shall conform to IS: 5624. Mild steel bars used for the fabrication of bolt assembly shall conform to grade 1of IS: 432 and/ or grade A of IS: 2062. Hexagonal nuts and lock nuts shall conform to IS: 1363 & IS: 1364 upto M36 diameter and IS: 5624 for M42 to M150 diameter.

10.07.00 **Stainless steel**

The material specification for stainless steel plates are mentioned in the design concept area of Mill Bunker building.

10.08.00 **Water**

Water used for cement concrete, mortar, plaster, grout, curing, washing of coarse aggregate, soaking of bricks, etc. shall be clean and free from oil, acids, alkalis, organic matters or other harmful substances in such amounts that may impair the strength or durability of the structure. Potable water shall generally be considered satisfactory for all masonry and concrete works, including curing. When water from the proposed source is used for making the concrete, the maximum permissible impurities, development of strength and initial setting time of concrete shall meet the requirements of IS: 456.

All materials brought for incorporation in works shall be of best quality as per IS unless specified otherwise.

10.09.00 PTFE (Poly Tetra Fluoroethylene) Bearing

The bearing shall be of reputed make and manufacturer as approved by the Engineer, for required vertical load and end displacement/rotation. PTFE bearing shall be sliding against highly polished stainless steel and the coefficient of friction between them shall be less than 0.06 at 55 kg/sq.cm. In order to prevent cold flow in PTFE surface it shall be rigidly bonded by a special high temperature resistance adhesive to the stainless-steel substrata. The stainless-steel surface that slides against the PTFE is mirror polished. The stainless steel shall be bonded to the top plate by special high strength adhesive. The thickness of stainless-steel plate shall be between 1.0 mm to 1.5 mm.

10.10.00 **Statutory Requirements**

Bidder shall comply with all the applicable statutory rules pertaining to Factories Act, Fire Safety Rules at Tariff Advisory Committee. Water Act for pollution control, Explosives Act, etc.

Provisions of safety, health and welfare according to Factories Act shall be complied with. These shall include provision of continuous walkways along the crane - girder level on both

sides of building, comfortable approach to EOT crane cabin, railing, fire escape, locker room for workmen, pantry, toilets, rest room etc.

Provisions for fireproof doors, number of staircases, fire separation wall, lath plastering/encasing the structural members (in fire prone areas), type of glazing etc. shall be made according to the recommendations of Tarrif Advisory Committee.

Statutory clearances and norms of State Pollution Control Board shall be followed.

Bidder shall obtain approval of Civil/Architectural drawings from concerned authorities before taking up the construction work.

10.11.00

Autoclave Aerated Concrete (AAC) block

Providing and laying of **Autoclave Aerated Concrete (AAC) block masonry** using blocks having dimensions of 625mm x 250mm. thickness ranging from 100 mm to 300 mm conforming to IS:2185 (Part-III), for dimension and tolerance, with minimum compressive strength of 30 kg/ sq.cm. The jointing cement sand mortar in the composition of 1:6 (Cement: Sand) shall be used with suitable plasticizer (optional). Sand having modulus of fineness 1.1 shall be used. The horizontal and vertical joint thickness shall be approximately 10 mm. In case of partition walls (1000 mm/ 125 mm thick) the jointing reinforcement i.e 1 number of 8 mm diameter bars shall be placed at every alternate course to be anchored properly with the main structure. All other structural requirements like stiffening of masonry, joint reinforcement etc. in the AAC masonry work strictly be carried out as per instruction laid down in IS:6041-1985, IS-1905) (Reinforcement bars shall be measured & paid separately under relevant items).

AAC blocks shall have the following physical properties:

Density (oven dry)	-	550-650kg/ cum.
Compressive Strength	-	Min. 30 kg/ sq. cm.
Thermal Conductivity	-	0.162W/mk (avg)
Resistant to fire	-	2-6 hrs depending upon thickness
Dry shrinkage	-	0.02% (avg)
Design gross density	-	800 kg/cum (approx)

SUB-SECTION-D-1-11

INSPECTION, TESTING AND QUALITY CONTROL

D-1-11 **Inspection, Testing and Quality Control**

11.01.00 Sampling and testing of major items of civil works viz. earthwork, concreting, structural steel work (including welding, sheeting, etc.) shall be carried out in accordance with the requirements of this specification. Wherever nothing is specified relevant Indian Standards shall be followed. In absence of Indian Standard equivalent International Standards may be used.

The Bidder shall submit and finalize a detailed field Quality Assurance Program before starting of the construction work according to the requirement of this specification. This shall include frequency of sampling and testing, nature/type of test, method of test, setting of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of format for record, Field Quality Plan, etc. Tests shall be done in the field and/or at a laboratory approved by the Engineer. The Bidder shall furnish the test certificate from the manufacturers of various materials to be used in the construction.

11.02.00 Workmanship and dimensional tolerances shall be checked as stipulated elsewhere in the specification

SUB-SECTION-D-1-12

ANNEXURES

D-1-12

ANNEXURES

D-1-12(A)

ANNEXURE (A)

(a) List of Codes and Standards

All applicable standards, references, specifications, codes of practice, etc., **shall be the latest edition including all applicable official amendments and revisions**. A complete set of all these documents shall be available at site with Bidder. List of some of the applicable Standards, in original Codes and references is as following:

Where provisions are not covered in Indian Standards, reference shall be made to ACI, AISC, EN, CICIND and other International Standards.

LIST OF CODES AND STANDARDS

Excavation and Filling

IS :2720	Methods of test for soils(relevant parts)
IS:4701	Code of practice for earth work on canals.
IS:9759	Guide lines for dewatering during construction.
IS:10379	Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.

Properties, Storage and Handling of Common Building Materials

IS:269	33 grade for ordinary Portland cement.
IS:383	Coarse and fine aggregates from natural sources for concrete.
IS:432	Specification for mild steel and medium tensile steel bars and
(Part 1&2)	hard drawn steel wires for concrete reinforcement.
IS:455	Portland slag cement.
IS:702	Industrial bitumen.
IS:712	Specification for building limes.
IS:1077	Common burnt clay buidling bricks.
IS:1161	Steel tubes for structural purposes.
IS:1239	Mild steel tubes, tubulars and other wronght steel fillting - MS tubes.
IS:1363	Hexagon head bolts, screws and nuts of productions
(Part 1-3)	grade - C.
IS:1364	Hexagon head bolts, screws and nuts of productions
(Part 1-5)	grade-A & B.
IS:1367 (Part 1-18)	Technical supply condition for threaded fasteners.
IS:1489 (Part-I)	Portland-pozzolana cement. Fly ash based
IS:1542	Sand for Plaster.

IS:1566	Hard drawn steel wire fabric for concrete reinforcement.
IS:1786	High strength deformed steel bars & wires for concrete reinforcement.
IS:2062	Hot Rolled Low, Medium and High Tensile Structural Steel
IS:2116	Sand for masonry mortars.
IS : 2185 (Part 1)	Hollow & solid concrete blocks.
(Part 2)	Hollow & solid light weight concrete blocks.
IS:2386 (Part I-VIII)	Testing of aggregates for concrete.
IS:3812	Specification for fly ash for use as pozzolona and admixture.
IS:4082	Recommendation on stacking and storage of construction materiel and components at site
IS:8112	43 grade ordinary portland cement.
IS:8500	Structural steel-Microalloyed (Medium and high strength qualities).
IS:12269	53 grade ordinary portland cement.
IS:12894	Specification for fly ash lime bricks.
IS:13757	Burnt clay fly ash building bricks.

Cast in-situ Concrete and Allied Works

IS:280	Mild steel wire for general engineering purpose.
IS:456	Code of practice for plain and reinforcement concrete.
IS:457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS:516	Method of test for strength of concrete.
IS:1199	Methods of sampling and analysis of concrete.
IS:1791	General requirement for batch type concrete mixers.
IS:1834	Hot applied sealing compound for joints in concrete.
IS:1838	Preformed fillers for expansion joints in concrete pavement and structures.
IS:2438	Specification for roller pan mixers.
IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:2505	Concrete vibrators - immersion type.

	IS:2506	General requirements for screed board concrete vibrators.
	IS:2722	Specification for Portable Swing weigh batchers for concrete (single and double bucket type).
	IS:2750	Steel scaffoldings
	IS:2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
	IS:3150	Hexagonal wire netting for general purposes.
	IS:3366	Specification for pan vibrators.
	IS:3370 (Part 1-4)	Code of practice for concrete structures for the storage of liquids.
	IS:3558	Code of practice for use of immersion vibrators for consolidating concrete.
	IS:4014 (Part-1&2)	Code of practice for steel tubular scaffolding.
	IS:4326	Code of practice for earth quake resistant design and construction of buildings.
	IS:4656	Form vibrators for concrete.
	IS:4925 IS:4990	Concrete batching and mixing plant. Plywood for concrete shuttering work.
	IS: 4995	Criteria for Design of Reinforced Concrete Bins for Storage of Granular and Powdery materials
	IS:5256	Code of practice for sealing expansion joints in concrete lining on canals.
	IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works.
	IS:6461	Glossary of terms relating to cement concrete.
	IS:6494	Code of practice for water proofing of underground reservoir and swimming pools.
	IS:6509	Code of practice for installation of joints in concrete pavements.
	IS:7861 (Part -1&2)	Code of practice for extreme weather concreting.
	IS:9012 IS:9103	Recommended practice for shotcreting. Admixtures for concrete.
	IS:9417	Recommendations for welding cold worked bars for reinforced concrete construction.
	IS:10262	Recommended guidelines for concrete mix design.
	IS:11384	Code of practice for composite construction in structural steel and concrete.

IS:12118	Two parts polysulphide based sealants.
IS:12200	Code of practice for provision of water stops at transverse construction joints in masonry and concrete dams.
IS:13311	Non destructive testing of concrete - methods of test.
(Part 1)	Ultrasonic pulse velocity.
(Part 2)	Rebound hammer.
IS:17452	Use of Alkali Activated Concrete for Precast Products-Guidelines
SP-16	Design codes for reinforced concrete to IS:456-1978.
SP-23	Hand book of concrete mixes.
SP-24	Explanatory handbook on Indian standards code for plain and reinforced concrete. (IS : 456)
SP-34	Hand book on concrete reinforcement and detailing.
ACI-318	American Concrete Institute code for structural concrete.

Precast Concrete Works

SP:7 (Part 6/Sec.7)	National Building Code - Structural Design Prefabrication and system building and mixed / composite construction.
IS:10297	Code of practice for design and construction of floors and roofs using precast reinforced/prestressed concrete ribbed or cored slab units.
IS:10505	Code of practice for construction of floors and roofs using pre-cast reinforced concrete waffle units.
IS:15658	Pre-cast concrete block for paving.

Masonry & Allied Works

IS:1905	Code of practice for structural use of unreinforced masonry.
IS: 2185	Part-1 Concrete Masonry Units - Specification Part 1 Hollow and Solid Concrete Blocks Part-3 Specification for concrete masonry units: Part 2 Hollow and solid light weight concrete blocks
IS:2212	Code of practice for brick work.
IS:2250	Code of practice for preparation and use of masonry mortars.
IS:2572	Code of practice for construction of hollow concrete block masonry.
SP:20	Hand book on masonry design and construction.

Sheeting Works

IS:277	Galvanised steel sheets (Plan & corrugated).
IS:513	Cold-rolled low carbon steel sheets & strips.
IS:730	Hook bolts for corrugated sheet roofing.
IS:801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
IS:2527	Code of practice for fixing rain water gutters and down pipe for roof drainage.
IS:7178	Technical supply condition for tapping screw.
IS:8183	Bonded mineral wool.
IS:8869	Washers for corrugated sheet roofing.
IS:12093	Code of practice for laying and fixing of sloped roof covering using plain and corrugated galvanised steel sheets.
IS:12436	Preformed rigid Polyurethane (PUR) and isocyanurate (PIR) foams for thermal insulation.
IS:12866	Plastic translucent sheets made from thermosetting polyester resin (glass fibre reinforced).
IS:14246	Continuously pre-painted galvanised steel sheets and coils.
BS:5950	Code of practice for design of light gauge profiled
(Part-6)	steel sheeting

Fabrication and Erection of Structural Steel Works

IS:800	Code of practice for General Construction of steel.
IS:813	Scheme for symbols for welding.
IS:814	Covered electrodes for manual metal arc welding of carbon & carbon manganese steel.
IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
IS:817	Code of practice for training and testing of metal arc welders.
IS:1024	Welding in bridges and substructured subject to dynamic.
IS:1181	Qualifying tests for Metal Arc welders (engaged in welding structures other than pipes).
IS:1182	Recommended practice for Radiographic examination of fusion welded butt joints in steel plates

IS:1608	Mechanical testing of metals - tensile testing
IS:1852	Rolling and Cutting Tolerances for Hot rolled steel products.
IS:2016	Specification for Plain washers.
IS:2595	Code of practice for Radiographic testing
IS:2629	Hot dip galvanising of iron and steel
IS:3502	Steel chequred plate.
IS:3613	Acceptance tests for wire flux combination for submerged arc welding.
IS:3658	Code of practice for liquid penetrant flaw detection.
IS:3664	Code of practice for ultra sonic pulse echo testing contact and immersion method
IS:3757	High strength structural bolts.
IS:4000	High strength bolts in steel structure - code of practice.
IS:4353	Sub merged arc welding of mild steel and low alloy steel Recommendation
IS:4759	Hot dip zinc coating on structural steel and other allied products.
IS:5334	Code of practice for magnetic particle flaw detection of welds.
IS:5369	General requirements for plain washers and lock washer
IS : 6623	High strength structural nuts.
IS:6649	Hardened and tampered washers for high strength structural bolts & nuts.
IS:6911	Stainless steel plate, sheet and strip.
IS:7205	Safety code for erection of structural steel.
IS:7215	Tolerances for fabrication of structural steel.
IS:7307	Approved test for welding procedures
(Part - I)	Fusion welding of steel.
IS:7310 (Part-I)	Approval test for welders working to approval welding procedure. Fusion welding of steel
IS:9178 (Part-1to 3)	Criteria for design of steel bins for storage of bulk material.
IS:9595	Recommendations for metal arc welding of carbon & carbon manganese steel.

IS:12843	Tolerances for erection of steel structures.
SP:6 (Part 1 to 7)	ISI Hand book for structural Engineers.

Plastering and Allied Works

IS:1661	Code of practice for application of cement and cement lime plaster finishes.
IS:2402	Code of practice for external rendered finishes.
IS:2547 (Parts 1&2)	Gypsum building plaster.

Acid and Alkali Resistant Lining

IS:158	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali & heat resisting.
IS:412	Expanded metal steel sheets for general purpose.
IS:4441	Code of practice for use of silica type chemical resistant mortars.
IS:4443	Code of practice for use of resin type chemical resistant mortars.
IS:4456 (Part I & II)	Method of Test for chemical resistant tiles.
IS:4457	Ceramic unglazed vitreous acid resisting tiles.
IS:4832	Specification for chemical resistant mortars.
(Part - 1)	Silicate type
(Part - 2)	Resin type
(Part - 3)	Sulfur type
IS:4860	Acid resistant bricks.
IS:9510	Bitumastic acid resisting grade.

Water Supply, Drainage and Sanitation

IS:458	Precast concrete pipes (with & without reinforcement).
IS:554	Pipe threads where pressure tight joints are made on the threads – dimensions, tolerances and designation.
IS:651	Salt glazed stoneware pipes and fittings.
IS:774	Flushing cisterns for water closets and urinals.
IS:775	Cast iron brackets and supports for wash basins and sinks.

IS:778	Copper alloy gate, globe and check valves for water works purposes.
IS:781	Cast copper alloy screw down bib taps & stop valves for water services.
IS:782	Caulking lead.
IS:783	Code of practice for laying of concrete pipes.
IS:1172	Code of basic requirements of water supply, drainage and sanitation.
IS:1230	Cast iron rain water pipes and fittings.
IS:1239 (Part 1&2)	Mild Steel tubes, tubulars and other wrought steel fittings
IS:1536	Centrifugally cast (Spun) iron pressure pipes for water.
IS:1537	Vertically cast iron pressure pipes for water, gas and sewage.
IS:1538	Cast iron fittings for pressure pipe for water, gas and sewage.
IS:1703	Copper alloy float valve for water supply fitting.
IS:1726	Cast iron manhole covers and frames.
IS:1729	Cast iron / Ductile iron drainage pipes and pipe/fittings for over ground non pressure pipeline socket and spigot series.
IS:1742	Code of practice for building drainage.
IS:2064	Selection, installation and maintenance of sanitary appliances.
IS:2065	Code of practice for water supply in buildings.
IS:2326	Automatic flushing cisterns for urinals.
IS:2548	Plastic seats and covers for water closets.
IS:2556	Vitreous sanitary appliances (vitreous china).
IS:3114	Code of practice for laying of cast iron pipes.
IS:3311	Waste plug and its accessories for sinks and wash basins.
IS:3438	Silvered glass mirrors for general purposes.
IS:3486	Cast iron spigot and socket drain pipes.
IS:3589	steel pipe for water and sewage (168.3 to 2540mm outside diameter)
IS:3989	Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS:4111 (Part 1 to 5)	Code of practice for ancillary structure in sewerage system.

	IS:4127	Code of practice for laying of glazed stone ware pipes.
	IS : 4733	Methods of sampling and testing sewage effluents.
	IS:4764	Tolerance limits for sewage effluents discharged into inland surface waters.
	IS:1068	Electroplated coating of nickel plus chromium and copper plus nickel plus chromium.
	IS:5329	Code of practice for sanitary pipe work above ground for buildings.
	IS:5382	Rubber sealing rings for gas mains, water mains and sewers.
	IS:5822	Code of practice for laying of electrically welded steel pipes for water supply.
	IS:5961	Specification for cast iron grating for drainage purpose.
	IS:7740	Code of practice for construction and maintenance of road gullies.
	IS:8931	Copper alloy fancy single taps combination tap assembly and stop valves for water services.
	IS:9762	Polyethylene floats for float valves.
	IS:10592	Industrial emergency showers, eye and face fountains and combination units.
	IS:12592	Specification for precast concrete manhole covers and frames.
	IS:12701	Rotational moulded polyethylene water storage tanks.
	IS:13983	Stainless steel sinks for domestic purposes.
	SP:35	Hand book on water supply and drainage with special emphasis on plumbing.
	CPH&EEO	Manual on sewage and sewage treatment
	Publication	- as updated.
	Doors Windows and Allied Works	
	IS:204	Tower Bolts.
	(Part 1)	Ferrous metals
	(Part 2)	Non - ferrous metals
	IS:208	Door Handles.
	IS:281	Mild steel sliding door bolts for use with padlocks.
	IS:362	Parliament Hinges.
	IS:419	Putty, for use on window frames.
	IS:451	Technical supply conditions for wood screws

IS:733	Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes.
IS:1003 (Part I)	Timber panelled and glazed shutters (doors shutters).
IS:1003	Timber panelled and glazed shutters
(Part-1)	door shutters.
IS:1038	Steel doors, windows and ventilators.
IS:1081	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
IS:1285	Wrought aluminium and aluminium alloy extruded round tube & hollow section (for general engineering purposes).
IS:1341	Steel butt hinges.
IS:1361	Steel windows for Industrial buildings.
IS:1823	Floor door stoppers.
IS:1868	Anodic coatings on Aluminium and its alloys.
IS:2202	Wooden flush door shutters (solid core type) particle
(Part-2)	board face panels and hard board face panels.
IS:2209	Mortice locks (vertical type)
IS:2553	Safety glass.
(Part-1)	General purposes
IS:2835	Flat transparent sheet glass.
IS:3548	Code of practice for glazing in buildings.
IS:3564	Door closers (Hydraulically regulated)
IS:3614	Specification for fire check doors :
(Part-1)	plate, metal covered and rolling type.
(Part-2)	Resistance test and performance criteria.
IS:4351	Specification for steel door frames.
IS:5187	Flush bolts.
IS:5437	Figured, rolled and wired glass.
IS:6248	Specification for metal rolling shutters and rolling grills.

IS:6315	Specification for floor springs (Hydraulically regulated) for heavy doors.
IS:7196	Hold fast.
IS:7452	Hot rolled steel sections for doors, windows and ventilators.
IS:10019	Mild steel stays and fasteners.
IS:10451	Steel sliding shutters (top hung type)
IS:12823	Prelaminated particle boards.

Roof Water Proofing and Allied Works

IS:3067	code of practice for general design details and preparatory work for damp proofing and water proofing of buildings.
ASTM	Standard specification for high solid content cold
C836-89a	liquid applied elastomeric water proofing membrane for use with separate wearing course.
ASTM	Standard guide for high solid content cold
C898-89	liquid applied elastomeric water proofing membrane for use with separate wearing course.

Floor Finishes and Allied Works

IS:5318	Code of practice for laying of flexible PVC sheet and tile flooring.
IS:8042	White portland cement.
IS:13755	Dust pressed ceramic tiles with water absorption of 3%, E 6% (Group B11a).
IS:13801	Chequered cement concrete tiles.

Painting and Allied Works

IS:162	Ready mixed paint, brushing fire resisting, silicate type for use on wood, colour as required.
IS:428	Distemper, oil, emulsion, colour as required.
IS:1477	Code of practice for painting of terrous metals in buildings.
(Part -1) (Part -2)	Pretreatment. Painting.
IS:1650	Specification for colours for building and decorative materials.
IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming.

	IS:2338	Code of practice for finishing of wood and wood based materials.
	(Part -1)	Operations and Workmanship.
	(Part -2)	Schedule.
	IS:2395	Code of pratice for painting concrete, masonry and plaster surfaces.
	(Part-1)	Operations and Workmanship.
	(Part -2)	Schedule.
	IS:2524	Code of practice for painting of nonferrous metals in buildings.
	(Part -1)	Pretreatment
	(Part -2)	Painting.
	IS:2932	Enamel, synthetic, exterior, (a) under coating and (b) finishing.
	IS:2933	Enamel exterior, (a) under coating, (b) finishing.
	IS:4759	Hot dip zinc coatings on structural steel and other allied products.
	IS:5410	Specification for cement paint.
	IS:15489	Plastic emulsion paint.
	IS:6278	Code of practice for white washing and Colour washing.
	IS:10403	Glossary of term related to building finish.
	IS:12027	Silicone based water repellent
	IS:13238	Epoxy based zinc phosphate primer (2 pack)
	IS:13239	Epoxy surfacer (2 pack)
	IS:13467	Chlorinated rubber for paints
	IS:14209	Epoxy enamel, two component glossy.
	BS:5493	Code of practice for protective coating of iron and steel structures against corrosion.
	Piling and Foundation	
	IS:1080	Code of practice for design and construction of shallow foundations on soils.
	IS:1904	Code of practice for design and construction of foundation in Soils : General Requirements.
	IS:2314	Steel sheet piling sections.
	IS:2911	Code of practice for design and construction of pile foundations.

	(Relevant Parts)
IS:2950	Code of practice for designs and construction of Raft foundation.
(Part-1)	Design
IS:2974 (Part-1 to 5)	Code of practice for design and construction of machine foundation.
IS:4091	Code of practice for design and construction foundations for transmission line towers and poles.
IS:6403	Code of practice for determination of Bearing capacity of Shallow foundations.
IS:8009	Code of practice for calculation of settlement of foundation.
(Part -1)	Shallow foundations.
(Part -2)	Deep foundations.
IS:12070	Code of practice for design and construction of shallow foundations on rocks.
ISO 10816	Criteria for assessing mechanical vibrations of machines.
ISO 1940	Criteria for assessing the st of balance of rotating rigid bodies.
DIN : EN 13906-1	Helical compression spring made of round wire and rod : calculation and design of compression .
DIN:2096	Helical compression spring out of round wire and rod : Quality requirements for hot formed compression spring.
DIN:4024	Flexible supporting structures for machine with rotating machines.
Roads	
IRC:5 (Section-1)	Standard specifications and Code of practice for road bridges, General Features of Design.
IRC:14	Recommended practice for 2cm thick bitumen and tar carpets.
IRC:15	Standard specifications and code of practice for construction of concrete roads.
IRC:16	Specification for priming of base course with bituminous primers.
IRC:19	Standard specifications and Code of practice for water bound macadam.
IRC:21 (Section-III)	Standard specifications and Code of practice for road bridges. Cement concrete (plain and reinforced).
IRC:34	Recommendations for road construction in water logged areas.

	IRC:36	Recommended practice for the construction of earth embankments for road works.
	IRC:37	Guidelines for the Design of flexible pavements.
	IRC:56	Recommended practice for treatment of embankment slopes for erosion control.
	IRC:58	Guidelines for the design of rigid pavements for highways.
	IRC:73	Geometric Design standards for rural (non-urban) highways.
	IRC : 86	Geometric Design standards for urban roads in plains.
	IRC:SP:13	Guidelines for the design of small bridges & culverts.
	IRC - Publication	Ministry of Surface Transport (Road wing), specifications for road and bridge works.
	IS:73	Paving bitumen.
	Loading	
	IS:875	Code of practice for design loads (other than earthquake) for (Relevant parts) buildings and structures.
	IS:1893	Criteria for earthquake resistant design of structures.
	IS:4091	Code of practice for design and construction of foundation for transmission line towers and poles.
	IRC:6 (Section-II)	Standard specifications & Code of practice for road bridges. loads and stresses
	Safety	
	IS:1641	Code of practice for fire safety of buildings - General principles of fire grading and classification.
	IS:1642	Code of practice for fire safety of buildings - Details of construction.
	IS:3696 (Part-1&2)	Safety code for scaffolds and ladders.
	IS:3764	Excavation work - code of safety.
	IS:4081 IS:4130	Safety code for blasting and related drilling operations. Demolition of buildings - code of safety.
	IS:5121	Safety code for piling and other deep foundations.
	IS:5916	Safety code for construction involving use of hot bituminous materials.
	IS:7205	Safety code for erection of structural steel work.

IS:7293	Safety code for working with construction machinery.
IS:7969	Safety code for handling and storage of building materials.
Indian Explosives Act 1940)	(As updated)

Architectural Design of Buildings

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

Tall Structures, Chimneys

IS:4998	Criteria for design of reinforced chimneys
IS:6533	Code of practice for design and construction of steel chimneys
ICAO	International Civil Aviation Organisation (ICAO)
DGCA	Instruction of Director General of Civil Aviation , India
ACI:307	Specification for the design and construction of reinforced concrete chimneys
BS:4076	Specification for steel chimneys
CICIND	Model Code for concrete chimneys Model code for steel chimneys
ASCE Code	Design and construction of steel chimney liners prepared by Task committee on steel chimney liners. Fossil power committee, Power division published by ASCE - 1975.
IS:1554	PVC insulated (heavy duty) electric cables
IS:2606	Alloy lead anodes for chromium plating
IS:3043	Code of Practice for Earthing
IS:9537	Conduits for electrical installations. The Indian Electricity Rules The Indian Electricity Act The Indian Electricity (Supply) Act The Indian Factories Act
IS:2309	Practice for protection of buildings and allied structures against lightning

Miscellaneous

IS:802 (Relevant parts)	Code of practice for use of structural steel in overhead transmission line towers.
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrically welded in storage tanks.
IS:10430	Criteria for design of lined canals and guidance for selection of type of lining.
IS:11592	Code of practice for selection and design of belt conveyors.
IS:12867	PVC handrails covers.
IS 11504	Criteria for structural design of reinforced concrete natural draught cooling towers
BS:4485 (IV)	British Standard : Code of design for water cooling towers
CIRIA Publication	Design and construction of buried thin-wall pipes.
IS 4671	Expanded polystyrene for thermal insulation purposes.

D-1-12(B)

ANNEXURE (B)

CONSTRUCTION METHODOLOGY

Construction and erection activities shall be fully mechanized from the start of the work.

All excavation and backfilling work shall be done using excavators, loaders, dumpers, dozers, poclains, excavator mounted rock breakers, rollers, sprinklers, water tankers, etc. Manual excavation can be done only on isolated places with specific approval of engineer.

For controlled rock blasting specialized agency, equipped with sensors to assess the impact of the blast on the adjoining existing structures, shall be employed.

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

Pile installation equipment suitable for flushing with air lift technique shall be used for construction of bored piles.

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

All fabrication and erection activities of structural steel shall be carried out using automatic submerged arc welding machines, cutting machines, gantry cranes, crawler mounted heavy cranes and other equipment like heavy plate bending machines, shearing machines, lathe, milling machines, etc. Use of derricks shall not be permitted. Special enclosures, for blast cleaning of steel structure surface preparation, shall be used.

All handling of materials shall be with cranes. Heavy trailers shall be used for transportation.

Mechanized modular units of scaffolding and shuttering shall be used.

Grouting shall be carried out using hydraulically controlled grouting equipment.

Roadwork shall be done using pavers, rollers and premix plant.

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

Heavy duty hoists for lifting of construction materials shall be deployed. Compressors for cleaning of foundations and other surfaces shall be used.

Field laboratory shall be provided with all modern equipment for survey, testing of soil, aggregates, concrete, welding, etc. For testing of steel works, ultrasonic testing machines, radiographic testing machines, dye penetration test equipment, destruction testing equipment, etc. shall be deployed.

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

SUB-SECTION-D-1-12

ANNEXURE-C

BORE HOLE DATA, LAB TEST DATA

SUB-SECTION D-1-12

ANNEXURE-C

BORE HOLE DATA, LAB TEST DATA

LAYOUT- BORE LOG - NDCT AREA

SUB–STATION

SCHOOL

DURGA PANDA

SCHOOL, D & E-TY

QUARTER AREA= 11.2580 H

LAND

671550 671600 671650 671700 671750 671800 671850 671900 671950 672000 672050 672100 672150 672200 672250

2480250 2480200 2480150 2480100 2480050 2480000 2479950 2479900 2479850 2479800 2479750 2479700 2479650 2479600

H.T LINE (EXTG.)

PLANT BOUND

SPACE PROVISION HYDROGEN GENERATION 19500 SQ.M.

SPACE PROVISION METHANOL PRODUCTION 15,000 SQ.M.

SPACE FOR AMMONIA

LAYDOWN & PRE-ASSEMBLY AREA

H_2PLANT

NDCT

NDCT

WATCH TOWER

MAIN ROAD DARRI– KATGHORA

FUEL STATION

BH01 BH02 BH03 BH04 BH05 BH06 BH07 BH08 BH09 BH10 BH11 BH12 BH13 BH14 BH15 BH16 BH17 BH18 BH19 BH20 BH21 BH22 BH23

ERT02 ERT03 ERT04 ERT05 ERT19 ERT20

PMT05 PMT06

TP03 PLT03

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.4

Co-ordinates E=672197.558 N=2479918.193

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	14	Undisturbed (UDS)	6
Cone (Pc)		Penetrometer (SPT)	14
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 12/05/2024
Completion Date : 13/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 308.215 M.
Water Struck At :
Standing Water Level : 10.90 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
0.00m.							
						DS-1	0.50
						DS-2	1.00
Filled up with brownish grey, clayey silt with sand mixture, kankars, boulder & brick bats.		3	2	3	5	SPT-1	1.50-1.95
						DS-3	2.50
						*UDS-1	3.00-3.45
3.50m.					22		
		9	10	12		SPT-2	3.55-4.00
						DS-4	4.50
					24		
		10	10	14		SPT-3	5.00-5.45
Very stiff, reddish brown, silty clay with sand & kankars.						UDS-2	6.00-6.40
					25		
		10	11	14		SPT-4	6.40-6.85
						DS-5	7.50
8.00m.					31		
		11	13	18		SPT-5	8.00-8.45
						UDS-3	9.00-9.45
					36		
Hard, reddish brown, silty clay with sand & kankars.		12	15	21		SPT-6	9.45-9.90
						DS-6	10.50
					42		
		13	19	23		SPT-7	11.00-11.45
11.80m.							
						*UDS-4	11.80-12.25
Medium dense to dense, light brown, silty sand. Obs. kankars.					28		
		10	12	16		SPT-8	12.40-12.85
13.00m.							

BH-4/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.4

Co-ordinates E=672197.558 N=2479918.193

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	14	Undisturbed (UDS)	6
Cone (Pc)		Penetrometer (SPT)	14
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 12/05/2024
Completion Date : 13/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 308.215 M.
Water Struck At :
Standing Water Level : 10.90 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM	SAMPLES Ref. No	SAMPLES Depth (m)
13.00m			DS-7	13.40
		9 11 18 (29)	SPT-9	14.00-14.45
			*UDS-5	15.00-15.45
Medium dense to dense, light brown, silty sand. Obs. kankars.		11 12 18 (30)	SPT-10	15.60-16.05
			DS-8	16.50
		12 12 21 (33)	SPT-11	17.00-17.45
			*UDS-6	17.90-18.35
		12 13 21 (34)	SPT-12	18.50-18.95
19.00m			DS-9	19.50
Hard, yellowish grey, silty clay with decomposed rock & sand.		19 34 50 (>100) 5.0cm Pentn.	SPT-13	20.00-20.35
20.80m		100 Refusal 4.0cm Pentn.	*SPT-14	20.80-20.84 20.80
Highly weathered, yellowish grey, medium to fine grained, fractured rock.		NX. drilling from 20.80m to 25.00m	R1	CR=21% RQD=NIL 21.50
			R2	CR=22% RQD=NIL 22.25
23.00m			R3	CR=25% RQD=NIL 23.00
Highly to moderately weathered, yellowish grey, medium to fine grained, fractured rock.			R4	CR=30% RQD=NIL 23.75
24.50m			R5	CR=42% RQD=NIL 24.50
Moderately weathered, yellowish grey, medium to fine grained, fractured rock. 25.00m			R6	CR=56% RQD=NIL 25.00

N.B. – '*' means sample could not be recovered.

BH-4/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.5

Co-ordinates E=672149.926 N=2479914.852

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	16	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	16
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 12/05/2024
Completion Date : 13/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 308.255 M.
Water Struck At :
Standing Water Level : 11.20 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
	0.00m						
						DS-1	0.50
						DS-2	1.00
Filled up soil with brownish grey, silty clay with sand mixture, kankar, boulders & brickbats.		2	2	4	6	SPT-1	1.50-1.95
						*UDS-1	2.50-2.95
	3.00m	7	11	12	23	SPT-2	3.10-3.55
						DS-3	4.00
		9	12	16	28	SPT-3	4.50-4.95
Very stiff, reddish brown, silty clay with sand mixture & kankars.						UDS-2	5.50-5.95
		10	11	19	30	SPT-4	5.95-6.40
						DS-4	7.00
	7.50m	14	15	21	36	SPT-5	7.50-7.95
						UDS-3	8.50-8.80
		16	19	24	43	SPT-6	8.80-9.25
Hard, reddish brown, silty clay with sand mixture & kankars.						DS-5	10.00
		17	21	25	46	SPT-7	10.50-10.95
						*UDS-4	11.50-11.60
		15	20	27	47	SPT-8	11.80-12.25
	12.50m						
Dense, light brownish, silty sand. Obs. kankars.	13.00m					DS-6	13.00

BH-5/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.5

Co-ordinates E=672149.926 N=2479914.852

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	16	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	16
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 12/05/2024
Completion Date : 13/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 308.255 M.
Water Struck At :
Standing Water Level : 11.20 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM	SAMPLES Ref. No	SAMPLES Depth (m)
13.00m				
Dense, light brownish, silty sand. Obs. kankars.		11 13 19 = 32	SPT-9	13.50-13.95
			*UDS-5	14.50-14.95
		10 12 21 = 33	SPT-10	15.10-15.55
			DS-7	16.00
		11 13 22 = 35	SPT-11	16.45-16.90
			*UDS-6	17.50-17.95
18.00m				
Hard, brownish grey, silty clay with decomposed rock & sand.		13 18 23 = 41	SPT-12	18.10-18.55
			DS-8	19.00
		12 19 25 = 44	SPT-13	19.50-19.95
			*UDS-7	20.50-20.60
		17 27 50 = >100 (5.0cm Pentn.)	SPT-14	20.80-21.15
			DS-9	21.50
		31 50 = >100 (5.0cm Pentn.)	SPT-15	21.80-22.00
22.20m		100 = >100 (3.0cm Pentn.)	*SPT-16	22.20-22.23
Highly weathered, yellowish grey, medium to fine grained, fractured rock.		NX. drilling from 22.20m to 25.00m	R1	CR=20% RQD=NIL 22.20 - 23.00
			R2	CR=22% RQD=NIL 23.00 - 23.75
23.75m				
Highly weathered, yellowish grey, medium to fine grained, fractured rock.			R3	CR=30% RQD=NIL 23.75 - 24.25
			R4	CR=32% RQD=NIL 24.25 - 25.00
25.00m				

N.B. - '*' means sample could not be recovered.

BH-5/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.6

Co-ordinates E=672120.122 N=2479953.398

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	14	Undisturbed (UDS)	6
Cone (Pc)		Penetrometer (SPT)	14
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 14/05/2024
Completion Date : 15/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 305.872 M.
Water Struck At :
Standing Water Level : 12.20 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
0.00m.							
Filled up soil consists of brownish grey, clayey silt with kankars, boulder & brickbats.						DS-1	0.50
						DS-2	1.00
1.20m.		5	10	11	21	SPT-1	1.50-1.95
						DS-3	2.50
						UDS-1	3.00-3.45
		7	12	14	26	SPT-2	3.45-3.90
						DS-4	4.20
		9	11	15	26	SPT-3	4.50-4.95
Very stiff to hard, reddish brownish grey, silty clay with sand mixture & kankars.						DS-5	5.50
						UDS-2	6.00-6.45
		11	14	18	32	SPT-4	6.45-6.90
						DS-6	7.50
		6	12	13	25	SPT-5	8.00-8.45
						UDS-3	9.00-9.45
		9	14	16	30	SPT-6	9.45-9.90
10.00m.							
						DS-7	10.50
Dense, brownish grey, silty sand. Obs. kankars.		12	16	19	35	SPT-7	11.00-11.45
						*UDS-4	12.00-12.45
		13	18	22	40	SPT-8	12.55-13.00
13.00m.							

BH-6/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.6

Co-ordinates E=672120.122 N=2479953.398

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	14	Undisturbed (UDS)	6
Cone (Pc)		Penetrometer (SPT)	14
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 14/05/2024
Completion Date : 15/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 305.872 M.
Water Struck At :
Standing Water Level : 12.20 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM	SAMPLES Ref. No	SAMPLES Depth (m)
13.00m.				
			DS-8	13.50
		11 19 23 = 42	SPT-9	14.00-14.45
Dense, brownish grey, silty sand. Obs. kankars.			*UDS-5	15.00-15.45
		10 16 21 = 37	SPT-10	15.55-16.00
16.50m.			DS-9	16.50
		12 17 29 = 46	SPT-11	17.00-17.45
			*UDS-6	18.00-18.10
Hard, brownish grey, silty clay with kankars & decomposed rock fragments.		13 19 32 = 51	SPT-12	18.25-18.70
			DS-10	19.25
		18 34 50 = >100 5.0cm Pentn.	SPT-13	20.00-20.35
20.80m.		100 Refusal	*SPT-14	20.80-20.84
Highly weathered, whitish pink to grey, fine to medium grained, fractured rock. Obs. boulder.		4.0cm Pentn. NX. drilling from 20.80m to 25.00m	R1	CR=27% RQD=NIL 20.80 - 21.50
21.50m.			R2	CR=23% RQD=NIL 21.50 - 22.25
Highly weathered, whitish pink to grey, fine to medium grained, fractured rock.			R3	CR=27% RQD=NIL 22.25 - 23.00
22.25m.			R4	CR=36% RQD=NIL 23.00 - 23.75
Highly to moderately weathered, yellowish brown, medium grained, fractured rock.			R5	CR=36% RQD=NIL 23.75 - 24.50
			R6	CR=48% RQD=NIL 24.50 - 25.00
25.00m.				

N.B. – '*' means sample could not be recovered.

BH-6/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.7

Co-ordinates E=671978.236 N=2479925.465

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 307.477 M.
Water Struck At :
Standing Water Level : 10.60 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
	0.00m						
						DS-1	0.50
						DS-2	1.00
		10	12	15	27	SPT-1	1.50-1.95
Very stiff, reddish brown, silty clay with sand mixture & kankars.						DS-3	2.50
						UDS-1	3.00-3.30
		11	12	18	30	SPT-2	3.30-3.75
						DS-4	4.50
	5.00m						
		13	15	18	33	SPT-3	5.00-5.45
						UDS-2	6.00-6.25
		12	17	19	36	SPT-4	6.25-6.70
						DS-5	7.50
		13	17	19	36	SPT-5	8.00-8.45
Hard, reddish brown, silty clay with sand mixture & kankars.						UDS-3	9.00-9.25
		15	15	20	35	SPT-6	9.25-9.70
						DS-6	10.50
		14	18	19	37	SPT-7	11.00-11.45
						*UDS-4	12.00-12.10
		13	17	21	38	SPT-8	12.20-12.65
	13.00m						
Medium dense to dense, light yellowish brown, silty sand. Obs. kankars.						DS-7	13.30
	13.50m						

BH-7/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.7

Co-ordinates E=671978.236 N=2479925.465

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 307.477 M.
Water Struck At :
Standing Water Level : 10.60 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
	13.50m						
		9	10	15	25	SPT-9	14.00-14.45
						*UDS-5	15.00-15.45
		10	12	14	26	SPT-10	15.60-16.05
						DS-8	16.50
Medium dense to dense, light yellowish brown, silty sand. Obs. kankars.		11	12	18	30	SPT-11	17.00-17.45
						*UDS-6	18.00-18.45
		12	14	19	33	SPT-12	18.55-19.00
						DS-9	19.50
		14	16	20	36	SPT-13	20.00-20.45
	20.50m						
						*UDS-7	21.00-21.10
		12	17	21	38	SPT-14	21.30-21.75
						DS-10	22.40
Hard, yellowish grey to grey to brownish grey, silty clay with sand & decomposed rock.		13	19	22	41	SPT-15	23.00-23.45
						DS-11	24.00
		15	17	26	43	SPT-16	24.30-24.75
		15	18	27	45	SPT-17	25.00-25.45
	25.45m						

N.B. - '*' means sample could not be recovered.

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.8

Co-ordinates E=671778.402 N=2479968.526

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 18/05/2024
Completion Date : 19/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 314.420 M.
Water Struck At :
Standing Water Level : 13.40 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
0.00m							
						DS-1	0.50
						DS-2	1.00
		7	8	10	18	SPT-1	1.50-1.95
						UDS-1	2.50-2.95
		6	9	13	22	SPT-2	2.95-3.40
						DS-3	4.00
		8	10	15	25	SPT-3	4.50-4.95
Very stiff, reddish brown, silty clay with sand mixture. Obs. kankars.						UDS-2	5.50-5.95
		10	13	14	27	SPT-4	5.95-6.40
						DS-4	7.00
		11	14	12	26	SPT-5	7.50-7.95
						*UDS-3	8.50-8.95
		10	14	15	29	SPT-6	9.05-9.50
						DS-5	10.00
		9	11	16	27	SPT-7	10.50-10.95
11.50m							
						*UDS-4	11.50-11.95
Medium dense to dense, yellowish brown, silty sand. Obs. kankars.		11	10	12	22	SPT-8	12.05-12.50
13.00m						DS-6	13.00

BH-8/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.8

Co-ordinates E=671778.402 N=2479968.526

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 18/05/2024
Completion Date : 19/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 314.420 M.
Water Struck At :
Standing Water Level : 13.40 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
13.00m.							
		9	12	11	23	SPT-9	13.50-13.95
						*UDS-5	14.50-14.95
		12	13	14	27	SPT-10	15.05-15.50
						DS-7	16.00
		13	11	10	21	SPT-11	16.50-16.95
Medium dense to dense, yellowish brown, silty sand. Obs. kankars.						*UDS-6	17.50-17.95
		12	13	16	29	SPT-12	18.05-18.50
						DS-8	19.00
		11	10	15	25	SPT-13	19.50-19.95
						*UDS-7	20.50-20.95
		12	16	17	33	SPT-14	21.05-21.50
						DS-9	22.00
22.50m.							
		14	19	22	41	SPT-15	22.50-22.95
						*UDS-8	23.50-23.60
Hard, yellowish grey, silty clay with sand mixture, kankars & gravel.		15	18	23	41	SPT-16	23.80-24.25
		18	22	24	46	SPT-17	25.00-25.45
25.45m.							

N.B. – '*' means sample could not be recovered.

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.9

Co-ordinates E=671863.628 N=2479868.815

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 19/05/2024
Completion Date : 20/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 314.751 M.
Water Struck At :
Standing Water Level : 13.30 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
0.00m							
						DS-1	0.50
						DS-2	1.00
		9	10	12	22	SPT-1	1.50-1.95
						UDS-1	2.50-2.95
		8	9	14	23	SPT-2	2.95-3.40
						DS-3	4.00
		11	11	12	23	SPT-3	4.50-4.95
Very stiff, reddish brown, silty clay with sand mixture. Obs. kankars.						UDS-2	5.50-5.95
		10	11	15	26	SPT-4	5.95-6.40
						DS-4	7.00
		12	13	16	29	SPT-5	7.50-7.95
						*UDS-3	8.50-8.95
		11	14	16	30	SPT-6	9.05-9.50
						DS-5	10.00
		13	14	15	29	SPT-7	10.50-10.95
11.70m						*UDS-4	11.50-11.95
Medium dense, yellowish brown, silty sand with kankars.		6	8	9	17	SPT-8	12.05-12.50
13.00m						DS-6	13.00

BH-9/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.9

Co-ordinates E=671863.628 N=2479868.815

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 19/05/2024
Completion Date : 20/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 314.751 M.
Water Struck At :
Standing Water Level : 13.30 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
13.00m.							
		7	10	11	21	SPT-9	13.50-13.95
						*UDS-5	14.50-14.95
		10	12	12	24	SPT-10	15.50-15.95
						DS-7	16.00
		7	8	10	18	SPT-11	16.50-16.95
Medium dense, yellowish brown, silty sand with kankars.						*UDS-6	17.50-17.95
		9	9	10	19	SPT-12	18.05-18.50
						DS-8	19.00
		11	13	14	27	SPT-13	19.50-19.95
						*UDS-7	20.50-20.95
		9	12	16	28	SPT-14	21.05-21.50
22.00m.						DS-9	22.00
		13	18	24	42	SPT-15	22.50-22.95
Hard, yellowish grey, silty clay with sand mixture, kankars & gravel.						*UDS-8	23.50-23.60
		16	21	23	44	SPT-16	23.80-24.25
		15	19	26	45	SPT-17	25.00-25.45
25.45m.							

N.B. - '*' means sample could not be recovered.

BH-9/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.10

Co-ordinates E=672066.947 N=249891.292

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.153 M.
Water Struck At :
Standing Water Level : 10.60 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
0.00m							
						DS-1	0.50
						DS-2	1.00
		7	10	11	21	SPT-1	1.50-1.95
						UDS-1	2.50-2.90
		9	14	14	28	SPT-2	2.90-3.35
Very stiff, reddish brown, silty clay with sand mixture & kankars.						DS-3	4.00
		10	12	15	27	SPT-3	4.50-4.95
						UDS-2	5.50-5.80
		11	14	16	30	SPT-4	5.80-6.25
						DS-4	7.00
7.50m							
		10	13	19	32	SPT-5	7.50-7.95
						UDS-3	8.50-8.80
		10	12	18	30	SPT-6	8.80-9.25
Hard, reddish brown, silty clay with sand mixture & kankars.						DS-5	9.80
		12	14	21	35	SPT-7	10.40-10.85
11.50m						*UDS-4	11.50-11.60
		17	29	33	62	SPT-8	11.80-12.25
Medium dense to dense, light brownish grey, silty sand. Obs. kankars.						DS-6	12.80
13.50m							

BH-10/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET — BORE HOLE NO.10

Co-ordinates E=672066.947 N=249891.292

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.153 M.
Water Struck At :
Standing Water Level : 10.60 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM	SAMPLES Ref. No	SAMPLES Depth (m)
		9 12 14 (26)	SPT-9	13.50-13.95
			*UDS-5	14.50-14.95
		10 13 19 (32)	SPT-10	15.10-15.55
			DS-7	16.00
		10 13 16 (29)	SPT-11	16.50-16.95
			*UDS-6	17.40-17.85
		11 13 21 (34)	SPT-12	18.00-18.45
			DS-8	19.00
		12 14 22 (36)	SPT-13	19.50-19.95
			*UDS-7	20.50-20.95
		14 17 21 (38)	SPT-14	21.10-21.55
			DS-9	22.00
		15 16 20 (36)	SPT-15	22.50-22.95
			*UDS-8	23.50-23.60
		15 19 23 (42)	SPT-16	23.80-24.25
		13 19 25 (44)	SPT-17	25.00-25.45

13.50m — Medium dense to dense, light brownish grey, silty sand. Obs. kankars.

21.00m — Hard, brownish grey, silty clay with decomposed rock & sand mixture.

25.45m

N.B. – '*' means sample could not be recovered.

BH-10/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.11

Co-ordinates E=672133.246 N=2479864.847

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 10/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.114 M.
Water Struck At :
Standing Water Level : 12.90 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
0.00m.							
Filled up with yellowish brown, clayey silty sand with kankars & gravel.						DS-1	0.50
1.00m.						DS-2	1.00
		8	10	11	21	SPT-1	1.50-1.95
						UDS-1	2.50-2.95
		6	12	14	26	SPT-2	2.95-3.40
						DS-3	4.00
Very stiff, reddish brown, silty clay with sand mixture. Obs. kankars.		5	7	12	19	SPT-3	4.50-4.95
						UDS-2	5.50-5.95
		4	8	9	17	SPT-4	5.95-6.40
						DS-4	7.00
		9	12	14	26	SPT-5	7.50-7.95
						UDS-3	8.50-8.95
8.95m.		13	18	17	35	SPT-6	8.95-9.40
						DS-5	10.00
Hard, reddish brown, silty clay with sand mixture. Obs. kankars.		10	15	16	31	SPT-7	10.50-10.95
						UDS-4	11.50-11.95
		11	13	17	30	SPT-8	11.95-12.40
12.50m.							
Medium dense, yellowish brown, silty sand. Obs. kankars.						DS-6	13.00
13.50m.							

BH-11/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.11

Co-ordinates E=672133.246 N=2479864.847

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 10/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.114 M.
Water Struck At :
Standing Water Level : 12.90 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
						SPT-9	13.50-13.95
						*UDS-5	14.50-14.95
						SPT-10	15.05-15.50
						DS-7	16.00
						SPT-11	16.50-16.95
						*UDS-6	17.50-17.95
						SPT-12	18.05-18.50
						DS-8	19.00
						SPT-13	19.50-19.95
						*UDS-7	20.50-20.60
						SPT-14	20.80-21.25
						DS-9	22.00
						SPT-15	22.50-22.95
						*UDS-8	23.50-23.60
						SPT-16	23.80-24.25
						SPT-17	24.80-25.25
13.50m. Medium dense, yellowish brown, silty sand. Obs. kankars.		12	13	15	28		
		13	13	16	29		
		14	15	13	28		
		12	14	16	30		
19.50m. Hard, yelllowish grey, silty clay with sand mixture, kankars & decomposed rock.		13	16	20	36		
		11	19	23	42		
		12	20	24	44		
		16	19	23	42		
25.25m.		15	21	27	48		

N.B. – '*' means sample could not be recovered.

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.12

Co-ordinates E=672112.478 N=2479820.218

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	16	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	16
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 09/05/2024
Completion Date : 09/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 307.094 M.
Water Struck At :
Standing Water Level : 12.10 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
0.00m.							
Filled up with yellowish brown, clayey silty sand with kankars, gravel & grass root.						DS-1	0.50
1.00m.						DS-2	1.00
		6	9	7	16	SPT-1	1.50-1.95
						*UDS-1	2.50-2.95
		5	6	8	14	*SPT-2	3.05-3.50
						DS-3	4.00
		6	7	9	16	SPT-3	4.50-4.95
Very stiff, reddish brown, silty clay with sand mixture. Obs. kankars.						UDS-2	5.50-5.95
		6	8	9	17	SPT-4	5.95-6.40
						DS-4	7.00
		7	8	10	18	SPT-5	7.50-7.95
						UDS-3	8.50-8.95
		6	7	13	20	SPT-6	8.95-9.40
						DS-5	10.00
10.50m.		10	11	9	20	SPT-7	10.50-10.95
Medium dense to dense, yellowish brown, silty sand. Obs. kankars.						*UDS-4	11.50-11.95
		7	8	9	17	SPT-8	12.05-12.50
						DS-6	13.00
13.50m.							

BH-12/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.12

Co-ordinates E=672112.478 N=2479820.218

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	16	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	16
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 09/05/2024
Completion Date : 09/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 307.094 M.
Water Struck At :
Standing Water Level : 12.10 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM	SAMPLES Ref. No	SAMPLES Depth (m)
13.50m.		10 12 11 (23)	SPT-9	13.50-13.95
			*UDS-5	14.50-14.95
		6 10 15 (25)	SPT-10	15.05-15.50
			DS-7	16.00
Medium dense to dense, yellowish brown, silty sand. Obs. kankars.		10 13 15 (28)	SPT-11	16.50-16.95
			*UDS-6	17.50-17.95
		11 14 16 (30)	SPT-12	18.05-18.50
			DS-8	19.00
		13 17 21 (38)	SPT-13	19.50-19.95
			*UDS-7	20.50-20.60
21.50m.		14 19 22 (41)	SPT-14	20.80-21.25
Hard, yellowish grey, silty clay with sand mixture, kankars & decomposed rock.			DS-9	22.00
		29 52 >100	SPT-15	22.50-22.70
23.00m.		100 5.0cm Pentn. Refusal	*SPT-16	23.00-23.04 23.00
Highly weathered, pinkish white to yelllowish brown, fine to medium grained, fractured rock. Obs. boulder.		4.0cm Pentn. NX. drilling from 23.00m to 25.00m	R1	CR=24% RQD=NIL 23.75
23.75m.			R2	CR=29% RQD=NIL 24.50
Highly weathered, pinkish white to yelllowish brown, fine to medium grained, fractured rock.			R3	CR=40% RQD=NIL 25.00
25.00m.				

N.B. - '*' means sample could not be recovered.

BH-12/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.13

Co-ordinates E=672197.558 N=249850.773

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 11/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 307.101 M.
Water Struck At :
Standing Water Level : 12.40 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
	0.00m						
						DS-1	0.50
						DS-2	1.00
		7	10	13	23	SPT-1	1.50-1.95
Very stiff, reddish brown, silty clay with sand mixture. Obs. kankars.						UDS-1	2.50-2.95
		7	12	15	27	SPT-2	2.95-3.40
						DS-3	4.00
	4.50m						
		12	19	18	37	SPT-3	4.50-4.95
						UDS-2	5.50-5.95
Hard, reddish brown, silty clay with sand mixture. Obs. kankars.		11	18	21	39	SPT-4	5.95-6.40
						DS-4	7.00
	7.50m						
		10	14	16	30	SPT-5	7.50-7.95
						*UDS-3	8.50-8.95
		8	13	14	27	SPT-6	9.05-9.50
Medium dense, reddish brown, clayey silty sand. Obs. kankars.						DS-5	10.00
		9	12	13	25	SPT-7	10.50-10.95
	11.50m						
						*UDS-4	11.50-11.95
		10	13	14	27	SPT-8	12.05-12.50
Medium dense to dense, yellowish brown, silty sand. Obs. kankars.						DS-6	13.00
	13.50m						

BH-13/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.13

Co-ordinates E=672197.558 N=249850.773

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 11/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm./N.X
Level Of Ground : 307.101 M.
Water Struck At :
Standing Water Level : 12.40 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM	SAMPLES Ref. No	SAMPLES Depth (m)
			SPT-9	13.50-13.95
			*UDS-5	14.50-14.95
			SPT-10	15.05-15.50
			DS-7	16.00
			SPT-11	16.50-16.95
			*UDS-6	17.50-17.95
			SPT-12	18.05-18.50
			DS-8	19.00
			SPT-13	19.50-19.95
			*UDS-7	20.50-20.60
			SPT-14	20.80-21.25
			DS-9	21.80
			SPT-15	22.30-22.75
			DS-10	23.20
			SPT-16	23.60-23.80
			*SPT-17	24.00-24.03
			R1	CR=70% RQD=NIL 24.50
			R2	CR=62% RQD=NIL 25.00

13.50m

Medium dense to dense, yellowish brown, silty sand. Obs. kankars.

7 11 15 — 26
8 12 16 — 28
11 15 14 — 29
12 16 18 — 34
14 18 23 — 41

20.50m

Hard, yellowish grey, silty clay with sand mixture, gravel & decomposed rock fragments.

15 19 24 — 43
17 20 27 — 47
34 53 100 — >100

5.0cm Pentn. Refusal
3.0cm Pentn.

NX. drilling from 24.00m to 25.00m

24.00m

Slightly weathered, yellowish grey, medium grained, fractured rock.

25.00m

N.B. – '*' means sample could not be recovered.

BH-13/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : Chandrani	Created on : 03/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.14

Co-ordinates E=671920.096 N=2479735.389

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 18/05/2024
Completion Date : 18/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 314.553 M.
Water Struck At :
Standing Water Level : 13.65 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
0.00m							
						DS-1	0.50
						DS-2	1.00
		3	4	5	9	SPT-1	1.45-1.90
						UDS-1	2.50-2.95
		4	4	7	11	SPT-2	2.95-3.40
						DS-3	4.00
		2	3	5	8	SPT-3	4.50-4.95
Medium / stiff, reddish brown, silty clay with traces of sand mixture.						UDS-2	5.50-5.95
		3	5	4	9	SPT-4	5.95-6.40
						DS-4	7.00
		3	4	4	8	SPT-5	7.50-7.95
						UDS-3	8.50-8.95
		5	6	9	15	SPT-6	8.95-9.40
						DS-5	10.00
		4	6	8	14	SPT-7	10.50-10.95
						*UDS-4	11.40-11.85
12.00m		10	13	15	28	SPT-8	12.00-12.45
Very stiff, reddish brown, silty clay with sand mixture & kankar.						DS-6	13.00
13.50m		10	15	19	34	SPT-9	13.50-13.95
Hard, reddish brown, silty clay with sand mixture & kankar. 14.00m							

BH-14/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732A	Created by : Chandrani	Created on : 03/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.14

Co-ordinates E=671920.096 N=2479735.389

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 18/05/2024
Completion Date : 18/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 314.553 M.
Water Struck At :
Standing Water Level : 13.65 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
						*UDS-5	14.50-14.75
		10	17	22	39	SPT-10	14.80-15.25
						DS-7	16.00
		11	17	24	41	SPT-11	16.50-16.95
						*UDS-6	17.45-17.55
		12	21	25	46	SPT-12	17.70-18.15
						DS-8	18.50
		10	19	24	43	SPT-13	19.00-19.45
						DS-9	20.00
						*UDS-7	20.50-20.95
		9	10	12	22	SPT-14	21.10-21.55
						DS-10	22.00
		9	11	13	24	SPT-15	22.50-22.95
						*UDS-8	23.50-23.95
		13	19	24	43	SPT-16	24.10-24.55
		15	21	24	45	SPT-17	25.00-25.45

14.00m

Hard, reddish brown, silty clay with sand mixture & kankar.

19.50m

Medium dense, yellowish brown, silty sand. Obs. kankar.

24.00m

Dense, whitish grey, silty sand.

25.00m

N.B. - '*' means sample could not be recovered.

BH-14/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.15

Co-ordinates E=672009.549 N=2479678.555

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 309.513 M.
Water Struck At :
Standing Water Level : 11.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
0.00m							
						DS-1	0.50
						DS-2	1.00
		4	8	9	17	SPT-1	1.50-1.95
						UDS-1	2.50-2.95
		5	7	9	16	SPT-2	2.95-3.40
						DS-3	4.00
		6	8	10	18	SPT-3	4.50-4.95
						UDS-2	5.50-5.95
Very stiff, reddish brown, clayey silt with sand mixture & kankars.		5	10	12	22	SPT-4	5.95-6.40
						DS-4	7.00
		7	15	12	27	SPT-5	7.50-7.95
						UDS-3	8.50-8.95
		10	13	16	29	SPT-6	8.95-9.40
						DS-5	10.00
		10	13	15	28	SPT-7	10.50-10.95
						*UDS-4	11.40-11.85
12.00m		10	14	17	31	SPT-8	12.00-12.45
Medium dense to dense, yellowish brown, silty sand with kankars.						DS-6	13.00
13.50m							

BH-15/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.15

Co-ordinates E=672009.549 N=2479678.555

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 10/05/2024
Completion Date : 11/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 309.513 M.
Water Struck At :
Standing Water Level : 11.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
13.50m							
		10	12	14	26	SPT-9	13.50-13.95
						*UDS-5	14.45-14.90
		11	13	15	28	SPT-10	15.00-15.45
						DS-7	16.00
Medium dense to dense, yellowish brown, silty sand with kankars.		13	12	16	28	SPT-11	16.50-16.95
						*UDS-6	17.40-17.85
		11	13	17	30	SPT-12	18.00-18.45
						DS-8	19.00
		10	15	16	31	SPT-13	19.50-19.95
20.20m							
						*UDS-7	20.30-20.75
		9	18	18	36	SPT-14	20.90-21.35
						DS-9	21.80
Hard, yellowish grey, silty clay with sand mixture.		13	22	32	54	SPT-15	22.50-22.95
						DS-10	23.40
		14	21	31	52	SPT-16	24.00-24.45
		15	20	33	53	SPT-17	25.00-25.45
25.45m							

N.B. – '*' means sample could not be recovered.

BH-15/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.16

Co-ordinates E=672052.485 N=2479746.133

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 11/05/2024
Completion Date : 12/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.009 M.
Water Struck At :
Standing Water Level : 10.25 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
						DS-1	0.50
						DS-2	1.00
		4	8	10	18	SPT-1	1.50-1.95
						UDS-1	2.50-2.95
		5	7	8	15	SPT-2	2.95-3.40
						DS-3	4.00
Very stiff, reddish brown, silty clay with sand mixture & kankars.		8	9	12	21	SPT-3	4.50-4.95
						UDS-2	5.50-5.95
		9	10	14	24	SPT-4	5.95-6.40
						DS-4	7.00
		11	12	16	28	SPT-5	7.50-7.95
08.50m.						UDS-3	8.50-8.95
		13	14	18	32	SPT-6	8.95-9.40
Hard, reddish brown, silty clay with sand mixture & kankars.						DS-5	10.00
10.75m.		10	12	14	26	SPT-7	10.50-10.95
						*UDS-4	11.50-11.95
Medium dense to dense, yelllowish brown, silty sand with kankars.		12	13	15	28	SPT-8	12.10-12.55
						DS-6	13.10
13.50m.							

BH-16/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.16

Co-ordinates E=672052.485 N=2479746.133

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	9
		Water Sample (WS)	0

Commencement Date : 11/05/2024
Completion Date : 12/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.009 M.
Water Struck At :
Standing Water Level : 10.25 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
13.50m		13	16	20	36	SPT-9	13.50-13.95
						*UDS-5	14.50-14.95
		13	15	18	33	SPT-10	15.10-15.55
						DS-7	16.10
		15	19	19	38	SPT-11	16.50-16.95
Medium dense to dense, yelllowish brown, silty sand with kankars.						*UDS-6	17.50-17.95
		16	17	19	36	SPT-12	18.10-18.55
						DS-8	19.10
		15	18	18	36	SPT-13	19.50-19.95
						*UDS-7	20.50-20.95
21.20m		17	18	19	37	SPT-14	21.00-21.45
						DS-9	21.70
		18	20	24	44	SPT-15	22.20-22.65
Hard, yellowish grey, silty clay with sand mixture.						*UDS-8	23.50-23.95
		15	23	32	55	SPT-16	24.10-24.55
		18	24	26	50	SPT-17	25.00-25.45
25.45m							

N.B. - '*' means sample could not be recovered.

BH-16/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.17

Co-ordinates E=E=672080.091 N=2479710.258

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	1

Commencement Date : 06/05/2024
Completion Date : 07/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 307.268 M.
Water Struck At :
Standing Water Level : 11.20 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
0.00m.							
						DS-1	0.50
						DS-2	1.00
		7	8	10	18	SPT-1	1.50-1.95
						DS-3	2.50
						UDS-1	3.15-3.50
		9	9	10	19	SPT-2	3.50-3.95
Very stiff, reddish brown, silty clay with sand mixture & kankars.						DS-4	4.50
		9	9	12	21	SPT-3	5.00-5.45
						*UDS-2	6.00-6.45
		8	11	16	27	SPT-4	6.60-7.05
						DS-5	7.50
		10	12	15	27	SPT-5	8.00-8.45
9.10m.							
						UDS-3	9.10-9.55
Hard, reddish brown, silty clay with sand mixture & kankars.		10	12	19	31	SPT-6	9.55-10.00
10.50m.						DS-6	10.50
		10	13	22	35	SPT-7 WS-1	11.00-11.45 11.20
Dense, light brown, silty sand with kankars.						*UDS-4	12.00-12.45
		12	12	21	33	SPT-8	12.60-13.05
13.50m.						DS-7	13.50

BH-17/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.17

Co-ordinates E=E=672080.091 N=2479710.258

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	1

Commencement Date : 06/05/2024
Completion Date : 07/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 307.268 M.
Water Struck At :
Standing Water Level : 11.20 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
	13.50m						
		12	13	22	35	SPT-9	14.00-14.45
						*UDS-5	15.00-15.45
		12	15	20	35	SPT-10	15.60-16.05
Dense, light brown, silty sand with kankars.						DS-8	16.50
		13	14	23	37	SPT-11	17.00-17.45
						*UDS-6	18.00-18.45
		14	15	24	39	SPT-12	18.60-19.05
	19.20m					DS-9	19.50
		11	13	20	33	SPT-13	20.00-20.45
						*UDS-7	21.00-21.10
		15	17	25	42	SPT-14	21.20-21.65
Hard, brownish grey, silty clay with sand mixture & decomposed rock.						DS-10	22.00
		12	16	23	39	SPT-15	22.60-23.05
						DS-11	23.50
	24.00m	15	18	26	44	SPT-16	24.00-24.45
Dense, brownish grey with blackish spots, silty sand with clay binder, with kankars & decomposed rock.							
		14	19	25	44	SPT-17	25.00-25.45
	25.45m						

N.B. - '*' means sample could not be recovered.

BH-17/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.18

Co-ordinates E=672135.136 N=2479723.071

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 08/05/2024
Completion Date : 08/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 306.665 M.
Water Struck At :
Standing Water Level : 11.30 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM			SAMPLES Ref. No	Depth (m)
0.00m						
					DS-1	0.50
					DS-2	1.00
		9	11	14 (25)	SPT-1	1.45-1.90
Very stiff, reddish brown, silty clay with sand mixture & kankars.					UDS-1	2.50-2.95
		9	13	17 (30)	SPT-2	2.95-3.40
					DS-3	4.00
4.50m						
		12	14	21 (35)	SPT-3	4.50-4.95
					UDS-2	5.50-5.80
		15	21	26 (47)	SPT-4	5.80-6.25
					DS-4	7.00
Hard, reddish brown, silty clay with sand mixture & kankars.		14	17	23 (40)	SPT-5	7.55-8.00
					UDS-3	8.50-8.80
		12	16	21 (37)	SPT-6	8.80-9.25
					DS-5	9.80
		13	15	24 (39)	SPT-7	10.30-10.75
10.80m						
					*UDS-4	11.50-11.95
Medium dense to dense, light brown, silty sand with kankars.		8	11	12 (23)	SPT-8	12.10-12.55
					DS-6	13.00
13.50m						

BH-18/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.18

Co-ordinates E=672135.136 N=2479723.071

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 08/05/2024
Completion Date : 08/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 306.665 M.
Water Struck At :
Standing Water Level : 11.30 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
13.50m.							
		8	10	15	25	SPT-9	13.50-13.95
						*UDS-5	14.40-14.85
		9	11	17	28	SPT-10	15.00-15.45
						DS-7	16.00
Medium dense to dense, light brown, silty sand with kankars.		10	14	17	31	SPT-11	16.50-16.95
						*UDS-6	17.50-17.95
		12	15	21	36	SPT-12	18.10-18.55
						DS-8	19.00
		12	15	24	39	SPT-13	19.50-19.95
20.30m.							
						UDS-7	20.50-20.75
		14	18	26	44	SPT-14	20.75-21.20
						DS-9	21.70
Hard, brownish grey to yellowish grey, silty clay with sand mixture & decomposed rock.		23	20	25	45	SPT-15	22.20-22.65
						DS-10	23.20
		15	21	27	48	SPT-16	23.80-24.25
						DS-11	24.70
		15	20	29	49	SPT-17	25.00-25.45
25.45m.							

N.B. - '*' means sample could not be recovered.

BH-18/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.19

Co-ordinates E=672081.829 N=2479645.992

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 09/05/2024
Completion Date : 10/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.249 M.
Water Struck At :
Standing Water Level : 10.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
						DS-1	0.50
						DS-2	1.00
		2	10	14	24	SPT-1	1.50-1.95
						UDS-1	2.80-2.95
		8	13	16	29	SPT-2	2.95-3.40
						DS-3	4.00
Very stiff, reddish brown, clayey silt with sand mixture & kankars.		12	14	13	27	SPT-3	4.50-4.95
						UDS-2	5.50-5.95
		9	10	14	24	SPT-4	5.95-6.40
						DS-4	7.00
		9	12	15	27	SPT-5	7.50-7.95
						UDS-3	8.50-8.95
		10	13	17	30	SPT-6	8.95-9.40
9.75m							
						DS-5	10.00
		10	12	14	26	SPT-7	10.50-10.95
Medium dense to dense, yellowish brown, silty sand with kankars.						*UDS-4	11.45-11.90
		12	13	15	28	SPT-8	12.00-12.45
						DS-6	13.00
13.50m							

BH-19/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.19

Co-ordinates E=672081.829 N=2479645.992

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 09/05/2024
Completion Date : 10/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.249 M.
Water Struck At :
Standing Water Level : 10.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
13.50m							
		13	15	19	34	SPT-9	13.50-13.95
						*UDS-5	14.40-14.85
		14	15	17	32	SPT-10	15.00-15.45
						DS-7	16.00
		15	17	18	35	SPT-11	16.50-16.95
Medium dense to dense, yellowish brown, silty sand with kakars.						*UDS-6	17.40-17.85
		16	18	20	38	SPT-12	18.00-18.45
						DS-8	19.00
		16	19	20	39	SPT-13	19.50-19.95
						DS-9	20.50
20.95m						*UDS-7	21.00-21.10
		17	20	21	41	SPT-14	21.30-21.75
						DS-10	22.40
Hard, yellowish grey, silty clay with sand mixture.		17	19	24	43	SPT-15	23.00-23.45
						DS-11	23.80
		15	18	29	47	SPT-16	24.20-24.65
		15	20	31	51	SPT-17	25.00-25.45
25.45m							

N.B. - '*' means sample could not be recovered.

BH-19/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.20

Co-ordinates E=672139.430 N=2479641.012

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	16	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	16
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 12/05/2024
Completion Date : 13/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 307.631 M.
Water Struck At :
Standing Water Level : 10.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
0.00m							
						DS-1	0.50
						DS-2	1.00
		7	7	8	15	SPT-1	1.50-1.95
						UDS-1	2.50-2.95
		10	11	9	20	SPT-2	2.95-3.40
						DS-3	4.00
		9	12	11	23	SPT-3	4.50-4.95
						UDS-2	5.50-5.95
Very stiff, reddish brown, silty clay with sand mixture. Obs. kankars.		11	13	12	25	SPT-4	5.95-6.40
						DS-4	7.00
		8	12	14	26	SPT-5	7.50-7.95
						UDS-3	8.50-8.95
		10	13	15	28	SPT-6	8.95-9.40
						DS-5	10.00
		9	12	13	25	SPT-7	10.50-10.95
11.70m						UDS-4	11.50-11.95
Medium dense to dense, yellowish brown, silty sand with kankars.		11	12	15	27	SPT-8	11.95-12.40
13.00m						DS-6	13.00

BH-20/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 04/06/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.20

Co-ordinates E=672139.430 N=2479641.012

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	16	Undisturbed (UDS)	8
Cone (Pc)		Penetrometer (SPT)	16
Vane (V)		Disturbed (DS)	10
		Water Sample (WS)	0

Commencement Date : 12/05/2024
Completion Date : 13/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 307.631 M.
Water Struck At :
Standing Water Level : 10.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	SAMPLES Depth (m)
13.00m.							
		10	13	15	28	SPT-9	13.50-13.95
						*UDS-5	14.50-14.95
		7	12	16	28	SPT-10	15.05-15.50
						DS-7	16.00
		11	15	14	29	SPT-11	16.50-16.95
Medium dense to dense, yellowish brown, silty sand with kankars.						*UDS-6	17.50-17.95
		12	15	20	35	SPT-12	18.05-18.50
						DS-8	19.00
		11	14	16	30	SPT-13	19.50-19.95
						*UDS-7	20.50-20.95
		12	16	18	34	SPT-14	20.60-21.05
						DS-9	21.50
21.80m.							
		12	13	18	31	SPT-15	22.00-22.45
Hard, yellowish grey, silty clay with sand mixture.						UDS-8	23.50-23.95
						DS-10	24.00
		11	14	19	33	SPT-16	25.00-25.45
25.45m.							

N.B. - '*' means sample could not be recovered.

BH-20/Sheet-2

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West. CETEST

Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.21

Co-ordinates E=672068.049 N=2479612.050

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 09/05/2024
Completion Date : 09/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.638 M.
Water Struck At :
Standing Water Level : 9.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM				SAMPLES Ref. No	Depth (m)
	0.00m						
						DS-1	0.50
						DS-2	1.00
		9	10	13	23	SPT-1	1.45-1.90
Very stiff, reddish brown, clayey silt with sand mixture & kankars.						UDS-1	2.50-2.95
		10	12	15	27	SPT-2	2.95-3.40
						DS-3	4.00
		12	13	16	29	SPT-3	4.50-4.95
	5.80m					UDS-2	5.50-5.80
		13	15	18	33	SPT-4	5.80-6.25
						DS-4	7.00
Hard, reddish brown, clayey silt with sand mixture & kankars.		12	17	21	38	SPT-5	7.55-8.00
						UDS-3	8.50-8.80
		12	19	23	42	SPT-6	8.80-9.25
						DS-5	9.80
	10.75m	13	15	24	39	SPT-7	10.30-10.75
Medium dense to dense, yellowish brown, silty sand with kankars.						*UDS-4	11.50-11.95
		9	11	12	23	SPT-8	12.10-12.55
						DS-6	13.00
	13.50m						

BH-21/Sheet-1

Project : Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.			CETEST
Job No : 4732	Created by : T.SAHA	Created on : 24/05/2024	Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.21

Co-ordinates E=672068.049 N=2479612.050

Field Test	Nos	Samples	Nos
Penetrometer (SPT)	17	Undisturbed (UDS)	7
Cone (Pc)		Penetrometer (SPT)	17
Vane (V)		Disturbed (DS)	11
		Water Sample (WS)	0

Commencement Date : 09/05/2024
Completion Date : 09/05/2024
Bore Hole Diameter : 150 mm.
Level Of Ground : 308.638 M.
Water Struck At :
Standing Water Level : 9.00 m.

DESCRIPTION	SYMBOL	N-VALUE EACH DIVN=15CM	SAMPLES Ref. No	SAMPLES Depth (m)
13.50m				
		9 10 11 (21)	SPT-9	13.50-13.95
			*UDS-5	14.50-14.95
		10 11 15 (26)	SPT-10	15.00-15.45
			DS-7	16.00
		10 14 17 (31)	SPT-11	16.50-16.95
			*UDS-6	17.50-17.95
Medium dense to dense, yellowish brown, silty sand with kankars.		12 15 21 (36)	SPT-12	18.10-18.55
			DS-8	19.00
		10 13 13 (26)	SPT-13	19.50-19.95
			*UDS-7	20.50-20.95
		12 14 16 (30)	SPT-14	21.00-21.45
			DS-9	21.70
		13 18 18 (36)	SPT-15	22.20-22.65
22.70m			DS-10	23.00
Hard, yellowish grey, silty clay with sand mixture.		14 25 24 (49)	SPT-16	23.80-24.25
			DS-11	24.70
		12 21 27 (48)	SPT-17	25.00-25.45
25.45m				

N.B. - '*' means sample could not be recovered.

Project: Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.

Job No. : 4732

Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH03	UDS02	5.50	Reddish brown clayey silt / clayey silt with traces of sand mixture.	2.06	1.78	2.64	15 S		UNCONFD		1.69	0	44	17		SC		51	40	9
							16 T		0.0	1.707										
									0.0	1.688										
									0.0	1.675										
									REMOULD		1.57	0								
									0.0	1.585										
									0.0	1.563										
									0.0	1.562										
BH03	SPT05	7.50	Reddish brown clayey silt with sand and kankars.										45	17		CI				
BH03	SPT06	9.05	Brownish grey silty sand with clay binder.													SM	4	80	16 (Silt+Clay)	
BH03	SPT09	13.50	Brownish grey silty sand.													SP		99	1 (Silt+Clay)	
BH04	UDS02	6.00	Reddish brown, clayey silt with sand mixture & decomoposed rock fragments	2.11	1.80		18 S		UNCONFD		1.06	0	40	19	12	CI		46	41	13
							17 T		0.0	1.077										
									0.0	1.054										
									0.0	1.049										
									REMOULD		0.86	0								
									0.0	0.871										
									0.0	0.861										
									0.0	0.848										
BH04	UDS03	9.00	Reddish brown, clayey silt with sand.	2.08	1.78		16 S		TRSH-UU		1.75	0				SM		52	40	8
							17 T		3.0	1.766										
									2.0	1.751										
									1.0	1.733										
BH04	SPT07	11.00	Reddish brown, clayey silt with traces of sand mixture.										46	17		CI				
BH04	SPT08	12.40	Yellowish grey silty sand with traces of gravels pieces.													SM-SP	6	85	9 (Silt+Clay)	
BH04	SPT12	18.50	Brownish grey silty sand with clay binder													SM		86	14 (Silt+Clay)	

Project: Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.

Job No. : 4732

Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH04	SPT13	20.00	Brownish grey clayey silt with traces of sand mixture.													CI*		14	70	16
BH05	UDS02	5.50	Reddish brown, clayey silt with traces of sand mixture.	2.06	1.73		18 S 19 T		TRSH-UU 3.0 2.0 1.0	1.511 1.507 1.482	1.50	0				CI*		44	40	16
BH05	UDS03	8.50	Reddish brown, clayey silt with sand mixture.	1.96	1.71		15 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	1.664 1.647 1.639 1.330 1.317 1.313	1.65 1.32	0 0	45	22		CI		36	43	21
BH05	SPT08	11.80	Yellowish grey, clayey silt with sand mixture.													SM		51	37	12
BH05	SPT09	13.50	Brownish grey, silty sand.													SP		98	2 (Silt+Clay)	
BH05	SPT11	16.45	Brownish grey, silty sand.													SP		99	1 (Silt+Clay)	
BH05	SPT12	18.10	Yellowish grey, clayey silt with sand mixture.													SM		53	40	7
BH05	SPT14	20.80	Yellowish grey clayey silt.										37	16		CI				
BH06	UDS01	3.00	Reddish brown, clayey silt with sand mixture & decomposed rock fragments	2.04	1.85		10 S 10 T		UNCONFD 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	1.668 1.460 1.460 1.373 1.180 1.180	1.53 1.24	0 0	44	20		SC		54	40	5

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH06	UDS02	6.00	Reddish brown, clayey silt with sand mixture & rock dust.						UNCONFD		1.78	0	44	20	13	CI		49	37	14
									0.0	1.792										
									0.0	1.784										
									0.0	1.764										
									REMOULD		1.50	0								
									0.0	1.511										
									0.0	1.506										
									0.0	1.483										
BH06	UDS03	9.00	Reddish brown, clayey silt with sand mixture.	2.05	1.75		16 S		TRSH-UU		1.54	0				CI*		42	38	21
							17 T		3.0	1.551										
									2.0	1.542										
									1.0	1.527										
BH06	SPT07	11.00	Brownish grey silty sand													SP		97	3 (Silt+Clay)	
BH06	SPT10	15.55	Brownish grey silty sand.													SP		96	4 (Silt+Clay)	
BH06	SPT11	17.00	Yellowish grey, clayey silt with sand mixture & kankar.													CI*		37	46	17
BH06	SPT12	18.25	Yellowish grey clayey silt with traces of kankars.										40	14		CI				
BH07	UDS01	3.00	Reddish brown clayey silt with sand mixture.	2.07	1.83		10 S		UNCONFD		1.36	0	45	20	13	CI		40	33	27
							13 T		0.0	1.374										
									0.0	1.366										
									0.0	1.340										
									REMOULD		1.10	0								
									0.0	1.112										
									0.0	1.106										
									0.0	1.082										
BH07	UDS02	6.00	Reddish brown silty clay / clayey silt with sand mixture.	2.08	1.86		11 S		TRSH-UU		1.80	0				CI*		35	53	12
							11 T		3.0	1.811										
									2.0	1.806										
									1.0	1.783										
BH07	UDS03	9.00	Reddish brown clayey silt with sand mixture.			2.66										SM		51	43	6

Project: Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.

Job No. : 4732

Sheet No.

CETEST

Project: Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.

Job No. : 4732

Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH07	SPT08	12.20	Reddish brown, clayey silt with traces of sand mixture.										46	16		CI				
BH07	SPT09	14.00	Reddish brown, silty sand with traces of clay binder.													SM		72	28 (Silt+Clay)	
BH07	SPT13	20.00	Reddish brown silty sand.													SP		97	3 (Silt+Clay)	
BH07	SPT14	21.30	Yellowish grey clayey silt with traces of sand mixture.										43	18		CI				
BH07	SPT17	25.00	Yellowish grey clayey silt with sand mixture & kankars.													CI*		34	50	16
BH08	UDS01	2.50	Reddish brown, clayey silt with sand mixture.	2.01	1.75	2.68	14 S	0.549	TRSH-UU		1.30	0	38	17	13	CI		38	40	22
							15 T		3.0	1.311										
							16 C		2.0	1.306										
									1.0	1.283										
BH08	UDS02	5.50	Reddish brown, clayey silt with sand mixture.	1.98	1.72		17 S		UNCONFD		1.43	0				CI*				
							15 T		0.0	1.446										
									0.0	1.439										
									0.0	1.405										
									REMOULD		1.29	0								
									0.0	1.302										
									0.0	1.287										
									0.0	1.281										
BH08	SPT07	10.50	Reddish brown, clayey silt with sand mixture.													CI*		45	38	18
BH08	SPT08	12.05	Brownish grey silty sand with traces of gravel pieces.													SP	4	95	1 (Silt+Clay)	
BH08	SPT11	16.50	Brownish grey silty sand. Obs. kankar													SM-SP	6	87	7 (Silt+Clay)	

Project: Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.

Job No. : 4732

Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size			
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %
BH08	SPT14	21.05	Brownish grey silty sand. Obs. kankar													SP	6	92	2 (Silt+Clay)	
BH08	SPT15	22.50	Yellowish grey, clayey silt with sand mixture & mica.													CI*		35	51	14
BH08	SPT17	25.00	Yellowish brown clayey silt with traces of sand mixtures.										35	15		CI				
BH09	UDS01	2.50	Reddish brown, clayey silt with sand & decomposed rock fragments.	2.00	1.74		14 S		UNCONFD		1.37	0	48	22	14	CI				
							15T		0.0	1.403										
									0.0	1.403										
									0.0	1.304										
									REMOULD		1.11	0								
									0.0	1.148										
									0.0	1.148										
									0.0	1.034										
BH09	UDS02	5.50	Reddish brown, clayey silt with traces of sand mixture.	2.08	1.82		14 S		TRSH-UU		1.17	8				SM		50	36	14
							14 T		3.0	1.816										
									2.0	1.703										
									1.0	1.491										
BH09	SPT07	10.50	Reddish brown, clayey silt with sand mixture.													CI*		48	34	18
BH09	SPT08	12.05	Brownish grey silty sand,													SM-SP		92	8 (Silt+Clay)	
BH09	SPT12	18.05	Brownish grey silty sand													SM-SP		90	10 (Silt+Clay)	
BH09	SPT14	21.05	Brownish grey silty sand.													SM-SP		93	7 (Silt+Clay)	
BH09	SPT15	22.50	Yellowish grey clayey silt.										45	17		CI				

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH09	SPT17	25.00	Brownish grey clayey silt with sand mixture.													CI*		20	59	21
BH10	UDS01	2.50	Reddish brown, silty clay / clayey silt with traces of sand mixture.	2.06	1.81	2.64	12 S	0.458	TRSH-UU		1.65	0				CI*		36	44	20
							14 T		3.0	1.662										
							13 C		2.0	1.649										
									1.0	1.639										
BH10	UDS02	5.50	Reddish brown clayey silt.										44	21	14	CI				
BH10	UDS03	8.50	Reddish brown, silty clay / clayey silt with traces of sand mixture.	2.10	1.86		13 S		UNCONFD		1.58	0				CI*				
							13 T		0.0	1.595										
									0.0	1.581										
									0.0	1.564										
									REMOULD		1.27	0								
									0.0	1.280										
									0.0	1.268										
									0.0	1.262										
BH10	SPT08	11.80	Brownish grey, clayey silty sand.													SM		75	23	2
BH10	SPT09	13.50	Brownish grey, silty sand													SP		99	1 (Silt+Clay)	
BH10	SPT13	19.50	Brownish grey, silty sand.													SM-SP		88	12 (Silt+Clay)	
BH10	SPT14	21.10	Brownish grey clayey silt with sand mixture													CI*		28	52	20
BH10	SPT17	25.00	Brownish grey clayey silt with sand mixture										46	20		CI				
BH11	UDS01	2.50	Reddish brown silty clay with traces of sand mixture.	2.02	1.76		13 S		TRSH-UU		1.34	0			14	CI*		33	47	20
							15 T		3.0	1.350										
									2.0	1.342										
									1.0	1.328										

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH11	UDS02	5.50	Reddish brown silty clay with traces of sand mixture.						UNCONFD		1.31	0	48	19		CI				
									0.0	1.325										
									0.0	1.306										
									0.0	1.299										
									REMOULD		1.06	0								
									0.0	1.077										
									0.0	1.064										
									0.0	1.039										
BH11	UDS03	8.50	Reddish brown silty clay with traces of sand mixture.	2.06	1.81		14 T		UNCONFD		1.25	0				CI*				
									0.0	1.264										
									0.0	1.251										
									0.0	1.235										
									REMOULD		1.00	0								
									0.0	1.099										
									0.0	1.067										
									0.0	0.834										
BH11	UDS04	11.50	Reddish brown silty clay with traces of sand mixture.						TRSH-UU		1.57	0	43	21	12	CI		37	43	20
									3.0	1.581										
									2.0	1.566										
									1.0	1.563										
BH11	SPT09	13.50	Reddish brown silty sand with traces of clay binders.													SM		71	29 (Silt+Clay)	
BH11	SPT12	18.05	Reddish brown silty sand.													SP		98	2 (Silt+Clay)	
BH11	SPT13	19.50	Yellowish grey clayey silt with traces of sand mixture.													CI*		23	56	21
BH11	SPT16	23.80	Yellowish grey clayey silt with sand mixture.										31	13		CL				
BH12	SPT01	1.50	Reddish brown clayey silt with sand & kankars.										35	13		CI				
BH12	UDS02	5.50	Reddish brown silty clay / clayey silt.	2.08	1.82		15 S		UNCONFD		0.88	0				CI*				
							14 T		0.0	0.922										
									0.0	0.871										
									0.0	0.871										

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
									REMOULD		0.60	0								
									0.0	0.611										
									0.0	0.601										
									0.0	0.588										
BH12	UDS03	8.50	Reddish brown clayey silt with sand mixture.	2.11	1.83	2.62	16 S		TRSH-UU		0.71	7				CI*		45	41	14
							15 T		3.0	1.219										
									2.0	1.080										
									1.0	0.941										
BH12	SPT07	10.50	Reddish brown silty sand with traces of clay binders.													SM		75	25 (Silt+Clay)	
BH12	SPT13	19.50	Reddish brown silty sand with clay binder.													SM		81	19 (Silt+Clay)	
BH12	SPT14	20.80	Yellowish grey, clayey silty sand.													SM		63	31	6
BH13	UDS01	2.50	Reddish brown clayey silt with sand mixture & rock pieces.	2.01	1.69		18 S		TRSH-UU		1.36	0	38	18	14	CI				
							19 T		3.0	1.371										
									2.0	1.366										
									1.0	1.343										
BH13	UDS02	5.50	Reddish brown clayey silt with traces of sand mixture.	2.09	1.76	2.66	19 S		UNCONFD		1.40	0				CI*		47	37	16
							19 T		0.0	1.411										
									0.0	1.406										
									0.0	1.383										
									REMOULD		0.93	0								
									0.0	0.940										
									0.0	0.929										
									0.0	0.921										
BH13	SPT05	7.50	Reddish brown silty sand with clay binders.													SM		63	37 (Silt+Clay)	
BH13	SPT09	13.50	Reddish brown silty sand.													SM-SP		93	7 (Silt+Clay)	
BH13	SPT13	19.50	Brownish grey, silty sand with clay binder.													SM		81	19 (Silt+Clay)	

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH13	SPT14	20.80	Reddish brown silty clay with sand & traces of kankars			2.67										SM	12	39	24	25
BH14	UDS01	2.50	Reddish brown clayey silt with traces of sand mixture.	2.06	1.79	2.68	14 S		UNCONFD		1.13	0	48	19	15	CI		36	45	19
							15 T		0.0	1.128										
									0.0	1.128										
									0.0	1.127										
									REMOULD		1.03	0								
									0.0	1.057										
									0.0	1.018										
									0.0	1.018										
BH14	UDS02	5.50	Reddish brown, clayey silt with sand.	2.10	1.81		13 S		UNCONFD		1.03	0				SM		52	35	13
							16 T		0.0	1.045										
									0.0	1.036										
									0.0	1.009										
									REMOULD		0.96	0								
									0.0	0.977										
									0.0	0.956										
									0.0	0.947										
BH14	UDS03	8.50	Reddish brown clayey silt with traces of sand mixture.	2.12	1.81		16 S		TRSH-UU		1.23	0	46	17		CI				
							17 T		3.0	1.242										
									2.0	1.236										
									1.0	1.212										
BH14	SPT08	12.00	Reddish brown clayey silt with sand mixture.													CI*		38	44	18
BH14	SPT13	19.00	Reddish brown clayey silt with traces of sand mixtures.										44	17		CI				
BH14	SPT14	21.10	Brownish grey silty sand.													SP		99	1 (Silt+Clay)	
BH14	SPT17	25.00	Brownish grey silty sand with clay binder.													SM		85	15 (Silt+Clay)	
BH15	UDS01	2.50	Brownish grey clayey silt with traces of sand mixtures and kankars			2.72										CI*		45	38	17

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH15	UDS02	5.50	Reddish brown, silty clay / clayey silt with traces of sand mixture.	2.03	1.81		11 S		UNCONFD		1.56	0	46	21	14	CI				
							12 T		0.0	1.577										
									0.0	1.555										
									0.0	1.548										
									REMOULD		1.34	0								
									0.0	1.351										
									0.0	1.342										
									0.0	1.327										
BH15	UDS03	8.50	Reddish brown, clayey silt / silty clay with traces of sand mixture.	2.03	1.83		11 S	0.349	TRSH-UU		1.60	0				CI*				
							11 T		3.0	1.616										
							11 C		2.0	1.609										
									1.0	1.575										
BH15	SPT08	12.00	Reddish brown, clayey silty sand.													SM		66	29	5
BH15	SPT09	13.50	Brownish grey, silty sand													SP		99	1 (Silt+Clay)	
BH15	SPT13	19.50	Brownish grey, silty sand.													SP		99	1 (Silt+Clay)	
BH15	SPT14	20.90	Yellowish grey clayey silt with sand mixture.										40	15		CI				
BH15	SPT17	25.00	Yellowish grey clayey silt with sand mixture & kankars.													CI*		47	43	10
BH16	UDS01	2.50	Reddish brown silty clay with traces of sand mixture.	2.07	1.78		18 S		UNCONFD		1.19	0				CI*				
							16 T		0.0	1.194										
									0.0	1.187										
									0.0	1.189										
									REMOULD		1.10	0								
									0.0	1.112										
									0.0	1.098										
									0.0	1.090										
BH16	UDS02	5.50	Reddish brown clayey silt with traces of sand mixture.			2.62							44	19		CI		42	40	18

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size			
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %
BH16	UDS03	8.50	Reddish brown clayey silt with traces of sand mixture.	2.02	1.71		17 S		TRSH-UU		1.78	0				CI*				
							18 T		3.0	1.790										
									2.0	1.784										
									1.0	1.766										
BH16	SPT07	10.50	Reddish brown silty sand with traces of gravel pieces & mica.													SP		98	2 (Silt+Clay)	
BH16	SPT13	19.50	Reddish brown, silty sand.													SP		98	2 (Silt+Clay)	
BH16	SPT14	21.00	Reddish brown, silty clay with sand.													CI*		26	43	31
BH16	SPT15	22.20	Brownish grey clayey silt.										39	17		CI				
BH17	UDS01	3.15	Reddish brown, silty clay / clayey silt with traces of sand mixture.	2.00	1.78		13 T		UNCONFD		1.39	0				CI*				
									0.0	1.401										
									0.0	1.387										
									0.0	1.382										
									REMOULD		1.18	0								
									0.0	1.192										
									0.0	1.184										
									0.0	1.164										
BH17	SPT04	6.60	Reddish brown clayey silt with sand mixture										44	23	18	CI				
BH17	UDS03	9.10	Reddish brown clayey silt with sand mixture & rock pieces.	2.06	1.75		17 S		TRSH-UU		1.52	0	42	20		SC		51	39	10
							18 T		3.0	1.531										
									2.0	1.519										
									1.0	1.510										
BH17	SPT07	11.00	Reddish brown silty sand with traces of clay binders.													SM		77	23 (Silt+Clay)	
BH17	SPT12	18.60	Reddish brown silty sand													SM-SP		94	6 (Silt+Clay)	

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH17	SPT13	20.00	Brownish grey clayey silt with sand mixture & kankars.													CI*		44	40	16
BH17	SPT17	25.00	Yellowish grey, clayey silty sand with kankar.													SM		61	32	7
BH18	UDS01	2.50	Reddish brown, clayey silt with traces of sand mixture.	1.98	1.81		10 S		UNCONFD		1.75	0				CI*				
							9 T		0.0	1.752										
									0.0	1.752										
									0.0	1.752										
									REMOULD		1.40	0								
									0.0	1.399										
									0.0	1.399										
									0.0	1.399										
BH18	UDS02	5.50	Brownish grey, clayey silt with sand mixture & kankar.			2.68										CI*		44	38	18
BH18	UDS03	8.50	Reddish brown clayey silt with traces of sand mixture.										42	19	13	CI				
BH18	SPT07	10.30	Reddish brown clayey silt with sand mixture.													CI*		49	34	17
BH18	SPT08	12.10	Brownish grey silty sand with traces of mica.													SM-SP		93	7 (Silt+Clay)	
BH18	SPT13	19.50	Reddish brown, silty sand with clay binder.													SM		84	16 (Silt+Clay)	
BH18	UDS07	20.50	Yellowish grey silty clay / clayey silt with traces of sand mixture, steel grey	2.31	2.07		11 S		TRSH-UU		1.10	8	45	18		CI		34	47	19
							12 T		3.0	1.750										
									2.0	1.589										
									1.0	1.427										
BH19	UDS01	2.80	Reddish brown, clayey silt with sand mixture.	2.00	1.70		12 S		UNCONFD		1.65	0				CI*				
							18 T		0.0	1.664										
									0.0	1.647										
									0.0	1.639										

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size			
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %
									REMOULD		1.33	0								
									0.0	1.340										
									0.0	1.327										
									0.0	1.323										
BH19	UDS02	5.50	Reddish brown, clayey silt / silty clay with traces of sand mixture.	2.04	1.82		12 S	0.479	TRSH-UU		1.59	0				CI*		46	37	17
							12 T		3.0	1.606										
							13 C		2.0	1.584										
									1.0	1.580										
BH19	UDS03	8.50	Reddish brown clayey silt with sand mixture.			2.69										CI*		42	40	18
BH19	SPT07	10.50	Reddish brown silty sand.													SP		99	1 (Silt+Clay)	
BH19	SPT13	19.50	Brownish grey, silty sand.													SP		99	1 (Silt+Clay)	
BH19	SPT14	21.30	Brownish grey clayey silt with sand mixture.										37	16		CI				
BH20	UDS01	2.50	Reddish brown clayey silt with sand mixture & kankars.			2.60	14 C	0.413								CI*		37	44	19
BH20	UDS02	5.50	Reddish brown clayey silt / silty clay with traces of sand mixture.	2.05	1.81		13 S		UNCONFD		1.36	0				CI*				
							13 T		0.0	1.374										
									0.0	1.347										
									0.0	1.347										
									REMOULD		1.22	0								
									0.0	1.226										
									0.0	1.217										
									0.0	1.217										
BH20	UDS03	8.50	Reddish brown clayey silt with sand mixture & kankars										42	19	15	CI				

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH20	UDS04	11.50	Reddish brown clayey silt with sand mixture.	2.07	1.80		13 S		TRSH-UU		0.56	7				SM		60	30	10
							15 T		3.0	1.129										
									2.0	0.968										
									1.0	0.806										
BH20	SPT08	11.95	Reddish brown silty sand.													SM-SP		91	9 (Silt+Clay)	
BH20	SPT11	16.50	Reddish brown silty sand.													SP		96	4 (Silt+Clay)	
BH20	SPT14	20.60	Reddish brown silty sand.													SM-SP		94	6 (Silt+Clay)	
BH20	SPT15	22.00	Yellowish grey clayey silt with sand.													CI*		49	35	16
BH21	UDS01	2.50	Reddish brown, clayey silt with sand mixture.													CI*		45	36	19
BH21	UDS02	5.50	Reddish brown, clayey silt with sand mixture.	2.02	1.68		19 S		UNCONFD		1.12	0				CI*				
							20 T		0.0	1.127										
									0.0	1.119										
									0.0	1.114										
									REMOULD		0.96	0								
									0.0	0.970										
									0.0	0.961										
									0.0	0.949										
BH21	UDS03	8.50	Reddish brown, clayey silt with sand mixture.	2.06	1.76		16 S		TRSH-UU		1.89	0	44	20	13	CI		48	38	14
							17 T		3.0	1.902										
									2.0	1.885										
									1.0	1.883										
BH21	SPT07	10.30	Reddish brown, clayey silt with sand mixture.													CI*		46	54 (Silt+Clay)	
BH21	SPT11	16.50	Reddish brown, silty sand with traces of clay binder													SM-SP		88	12 (Silt+Clay)	

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Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	Atter. Limits LL %	PL %	SL %	IS Classification	Grain Size Gravl %	Sand %	Silt %	Clay %
BH21	SPT15	22.20	Reddish brown, silty sand.													SP		99	1 (Silt+Clay)	
BH21	SPT16	23.80	Yellowish grey clayey silt with traces of sand mixture.													CI*		19	61	20
BH22	UDS01	2.50	Reddish brown silty clay with traces of sand mixture.	2.01	1.78	2.75	12 S	0.549	UNCONFD		1.21	0	48	22		CI		46	39	15
							13 T		0.0	1.218										
							12 C		0.0	1.206										
									0.0	1.206										
									REMOULD		1.04	0								
									0.0	1.054										
									0.0	1.042										
									0.0	1.024										
BH22	UDS02	5.50	Reddish brown silty clay with traces of sand mixture.	2.03	1.77		15 T		TRSH-UU		1.45	0	46	21		CI				
									3.0	1.464										
									2.0	1.447										
									1.0	1.439										
BH22	SPT05	7.50	Yellowish grey silty sand with traces of kankars.													SP		97	3 (Silt+Clay)	
BH22	SPT08	12.05	Yellowish grey silty sand with traces of gravels pieces.													SP		98	2 (Silt+Clay)	
BH22	SPT11	16.50	Reddish brown, silty sand.													SP		99	1 (Silt+Clay)	
BH22	SPT12	18.05	Brownish grey clayey silt with traces of sand mixture.													CI*		23	51	26
BH23	UDS01	2.50	Reddish brown silty clay with / clayey silt with traces of sand mixture.	2.04	1.81		12 S		TRSH-UU		1.25	0	44	21		CI		44	41	15
							13 T		3.0	1.264										
									2.0	1.255										
									1.0	1.231										
BH23	UDS02	5.50	Reddish brown silty clay / clayey silt with traces of sand mixture.	2.00	1.69		19 S		UNCONFD		1.45	0			14	CI*				
							18 T		0.0	1.467										
									0.0	1.445										
									0.0	1.438										

Project: Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.

Job No. : 4732

Sheet No.

CETEST

LABORATORY ROCK TEST RESULTS

BH No.	Run No.	Depth (M)	Density (gm/cc)		Water Content %	Porosity %	Specific Gravity	Unconfined Compressive Strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Slake Durability Index (%)	Hardness (Mohs Scale)	Soundness (%)	Impact value (%)	Deformbility, E (kg/sqcm)	
			Bulk	Dry				In-Situ	Saturated							In-Situ	Saturated
1	2	16.00 - 16.75	2.339	2.267	3.179	21.933	2.674	–	–	–	0.94	–	–	–	–	–	–
1	3	16.75 - 17.50	–	–	–	–	–	–	–	–	–	4.68	–	–	–	–	–
1	5	18.25 - 19.00	–	–	–	–	–	–	–	–	–	–	3.5-4	–	–	–	–
4	1	20.80 - 21.50	2.064	2.026	1.806	6.154	–	–	–	–	1.12	–	–	–	–	–	–
4	3	22.25 - 23.00	–	–	–	–	–	–	–	–	–	6.32	3.5-4.0	–	–	–	–
4	4	23.00 - 23.75	–	–	–	–	–	–	–	–	1.17	–	–	–	–	–	–
4	5	23.75 - 24.50	–	–	–	–	2.614	–	–	–	–	–	–	10.12	–	–	–
5	1	22.20 - 23.00	–	–	–	–	–	–	–	–	1.07	–	–	–	–	–	–
5	3	23.75 - 24.25	–	–	–	–	–	–	–	–	1.31	–	–	–	–	–	–
6	2	21.50 - 22.25	–	–	–	–	–	–	–		1.25	–	–	–	–	–	–
6	4	23.00 - 23.75	–	–	–	–	–	–	–	–	–	–	–	–	47.69	–	–
6	5	23.75 - 24.50	–	–	–	–	–	–	–	–	–	–	–	11.86	–	–	–
12	1	23.00 - 23.75	2.462	2.452	0.405	4.321	–	–	–	–	4.32	–	–	–	–	–	–
12	2	23.75 - 24.50	–	–	–	–	–	–	–	–	–	4.28	–	–	–	–	–
12	3	24.50 - 25.00	–	–	–	–	–	–	–	–	–	–	5.0-6.0	–	–	–	–
13	1	24.00 - 24.50	–	–	–	–	2.582	–	–	–	1.42	–	–	–	–	–	–
13	2	24.50 - 25.00	–	–	–	–	–	–	–	–	–	–	–	8.36		–	–
25	2	26.75 - 27.50	2.342	2.247	4.216	7.950	–	–	–	–	1.36	–	–	–	–	–	–
25	3	27.50 - 28.25	–	–	–	–	–	–	–	–	–	–	–	–	40.63	–	–
25	4	28.25 - 29.00	–	–	–	–	–	–	35	–	–	–	–	–	–	–	–
30	1	19.50 - 20.25	–	–	–	–	–	–	–	–	0.94	–	–	–	–	–	–
30	5	22.50 - 23.25	–	–	–	–	–	–	–	–	1.03	–	–	–	–	–	–
34	2	25.00 - 25.75	–	–	–	–	–	–	–	–	1.52	–	–	–	–	–	–

Project: Geotech. Inv. Work for setting up 2x660MW SCTPP at HTPS Korba West.

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Sheet No.

CETEST

REPORT ON
ELECTRICAL RESISTIVITY TEST FOR
SETTING UP 2X660 MW SUPER CRITICAL THERMAL POWER PROJECT AT HTPS, KORBA WEST

INTRODUCTION:

Electrical Resistivity Test was carried out for the proposed construction of 2x660 MW Super Critical Thermal Power Project at HTPS, Korba West from 10/05/2024 to 24/05/2024 at eighty (80) locations as per IS 3043 : 1987.

METHODOLOGY:

The Soil Resistivity Survey is a method to find out the Electrical Resistivity (Specific Resistance) of a medium. It is the resistance offered by a unit cube of a particular medium (so called strata below the ground level) when a unit current passes perpendicular to the surface of a cross-sectional area A. The relation is given by Ohm's Law is –

$$\rho = R - \frac{A}{l} \text{ ohm } \frac{m^2}{m} = \text{ohm} - m \text{ where}$$

ρ= Resistivity, R = resistance offered by the medium of length L and Cross-sectional area A.

In electrical resistivity survey a known current I (direct current or low frequency alternating current) is sent into the ground through a pair of current electrodes A & B and the potential difference (ΔV) created in the medium is measured between another pair of electrodes M & N. The resistivity of the formation is then given

by $\rho = K \frac{\Delta V}{I}$ where ρ is the apparent resistivity, K is the geometric factor.

In the Earth Resistivity Test, the Wenner configuration was followed. In this configuration two potential electrodes M & N are placed in a line with the current electrodes A & B, all four being situated equidistance from one to another and disposed symmetrically with respect to a central point such that AM=MN=NB=s . The outer two electrodes A & B were used for sending current (I) and inner two M & N were used for measuring the potential differences

(ΔV). The distance between each consecutive electrode (s) was kept constant and was progressively increased to reach the depth at which resistivity information are wanted. Suitable electrode spacing determines the conductivity of the top soil as well as the various subsurface layers occurring in the area under study. At each location, 4 sets of observations were taken for each of the electrode spacing (s) in ten directions (N-S, E-W, NE-SW & NW-SE) and in seven different electrode spacing viz,: s = 0.50m, 1.0m, 2.0m, 3.0m, 4.0m, 5.0m 6.0m, 7.0m, 8.0m and 10.0m were used to know the nature of change of resistivity.

The apparent resistivity was determined by the formula –

$$\rho = 6.28\, s \frac{\Delta V}{I}$$

where 's' is the distance between the two consecutive Electrodes and $\frac{\Delta V}{I}$ is R which is the observed resistance for measuring resistivity.

A Resistivity Meter model DDR-3 of GEOSENSOR make was used during the operation. The mean value of the resistivity estimated was taken as the representative one.

The depth of investigation in an isotropic and homogeneous formation can be approximated to the distance between the consecutive two electrodes (s).

TEST RESULTS:

The overall mean resistivity values at each ERT locations are presented below.

APPARENT RESISTIVITY VALUES

Sl. No.	ERT Location	Co-ordinate (M)			Overall Mean Resistivity (Ohm-m)
		Easting	Northing	R.L.	
1.	ERT-01	672324.722	2479903.425	301.735	213.44
2.	ERT-02	672076.881	2479924.902	307.631	132.36
3.	ERT-03	671970.701	2479893.876	307.554	116.93
4.	ERT-04	671783.179	2479867.815	314.758	148.13
5.	ERT-05	672175.609	2479831.825	307.343	249.58
6.	ERT-06	672440.092	2479839.445	301.582	267.00
7.	ERT-07	672687.012	2479859.116	300.227	201.85
8.	ERT-08	672739.729	2479916.690	300.121	248.85
9.	ERT-09	672785.502	2479862.673	299.418	279.49
10.	ERT-10	672805.671	2479908.561	298.589	255.52
11.	ERT-11	672921.149	2479924.087	297.281	195.85
12.	ERT-12	672983.092	2479984.914	294.552	261.29
13.	ERT-13	673959.399	2479847.254	292.757	33.19
14.	ERT-14	673996.793	2479885.078	292.695	261.33
15.	ERT-15	672665.881	2479793.161	300.385	249.66

Sl. No.	ERT Location	Co-ordinate (M)			Overall Mean Resistivity (Ohm-m)
		Easting	Northing	R.L.	
16.	ERT-16	672607.072	2479749.033	303.215	221.59
17.	ERT-17	672577.013	2479809.071	300.592	213.90
18.	ERT-19	672015.808	2479704.775	308.694	203.91
19.	ERT-20	672141.376	2479664.620	306.981	201.01
20.	ERT-21	672322.633	2479703.028	304.525	277.91
21.	ERT-22	672424.982	2479667.755	303.891	232.99
22.	ERT-23	672482.535	2479689.513	302.625	172.69
23.	ERT-24	672505.895	2479666.010	303.170	242.01
24.	ERT-25	672473.481	2479622.318	303.680	262.19
25.	ERT-26	672516.562	2479630.253	303.620	342.08
26.	ERT-27	672554.174	2479651.932	303.215	246.54
27.	ERT-28	672619.309	2479649.894	302.412	315.62
28.	ERT-29	672677.953	2479623.798	302.238	413.71
29.	ERT-30	672720.729	2479602.179	302.120	265.95
30.	ERT-31	672828.030	2479593.264	299.005	222.36
31.	ERT-32	672669.141	2479557.393	302.121	260.84
32.	ERT-33	672642.668	2479603.414	302.318	240.00
33.	ERT-34	672607.489	2479591.859	302.820	216.06
34.	ERT-35	672594.036	2479539.579	303.262	497.13
35.	ERT-36	672550.691	2479591.223	304.180	140.35
36.	ERT-37	672529.362	2479550.111	303.610	239.72
37.	ERT-38	672449.404	2479525.142	304.435	194.51
38.	ERT-39	672395.971	2479566.630	304.518	191.47
39.	ERT-40	672302.345	2479600.290	305.934	147.90
40.	ERT-41	672227.085	2479551.326	306.113	248.64
41.	ERT-42	672133.927	2479415.777	308.335	188.94
42.	ERT-43	672188.508	2479391.502	308.388	211.07
43.	ERT-44	672238.810	2479380.796	308.120	265.11
44.	ERT-45	672314.613	2479456.836	305.583	218.28
45.	ERT-46	672311.620	2479368.584	308.822	160.69
46.	ERT-47	672344.926	2479384.586	304.215	151.92
47.	ERT-48	672310.880	2479326.832	310.100	154.34
48.	ERT-49	672340.164	2479307.538	308.123	163.07
49.	ERT-50	672383.285	2479321.366	307.695	232.32
50.	ERT-51	672414.149	2479413.233	304.590	178.44
51.	ERT-52	672511.748	2479446.424	303.792	283.20
52.	ERT-53	672623.392	2479489.012	302.803	119.18
53.	ERT-54	672640.858	2479476.362	303.185	225.29
54.	ERT-55	672637.037	2479430.321	303.370	197.42
55.	ERT-56	672702.130	2479434.257	302.795	131.99
56.	ERT-57	672695.468	2479373.950	303.631	249.69
57.	ERT-58	672558.759	2479368.296	303.801	127.04
58.	ERT-59	672475.910	2479343.941	304.775	156.53
59.	ERT-60	672558.215	2479336.900	304.143	129.97
60.	ERT-61	672482.186	2479291.156	305.097	169.41
61.	ERT-62	672439.600	2479277.309	306.325	249.10
62.	ERT-63	672551.383	2479246.887	304.528	175.73

Sl. No.	ERT Location	Co-ordinate (M)			Overall Mean Resistivity (Ohm-m)
		Easting	Northing	R.L.	
63.	ERT-64	672636.905	2479297.539	303.888	107.39
64.	ERT-65	672777.153	2479309.608	303.102	294.75
65.	ERT-66	672772.557	2479281.377	302.475	175.21
66.	ERT-67	672719.777	2479179.564	303.850	202.12
67.	ERT-68	672060.147	2479219.674	307.895	196.60
68.	ERT-69	671948.041	2479164.306	306.577	325.63
69.	ERT-70	671983.674	2479061.038	306.820	213.22
70.	ERT-71	671968.676	2478918.279	307.692	239.91
71.	ERT-72	672201.564	2479089.032	307.895	295.07
72.	ERT-73	672382.308	2479033.049	307.891	104.66
73.	ERT-74	672522.898	2479085.985	307.288	242.18
74.	ERT-75	675496.103	2478941.544	307.233	191.54
75.	ERT-76	672460.571	2478841.483	307.080	205.05
76.	ERT-77	673492.383	2479130.831	393.666	199.07
77.	ERT-78	673601.902	2479043.102	294.539	74.86
78.	ERT-79	673790.477	2479021.750	293.610	60.21
79.	ERT-80	672214.613	2479456.876	305.630	305.02
80.	ERT-81	672531.855	2479892.672	299.838	288.49

ERT No. 01

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	197.883	198.825	197.726	198.197	198.16
2	1.0	220.219	220.219	219.905	218.963	219.83
3	2.0	232.471	231.214	229.33	229.095	230.53
4	3.0	247.864	249.749	246.922	244.095	247.16
5	4.0	277.709	272.682	276.452	280.222	276.77
6	5.0	257.603	251.320	259.174	251.320	254.85
7	6.0	243.159	239.389	231.849	229.964	236.09
8	7.0	213.313	215.512	208.915	213.313	212.76
9	8.0	150.795	140.742	145.769	143.255	145.14
10	10.0	113.096	113.096	116.237	109.954	113.10

Mean Resistivity at ERT-01 is 213.44 Ohm - m.

ERT No. 02

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	120.771	120.929	120.929	121.400	121.01
2	1.0	125.974	124.089	124.089	124.403	124.64
3	2.0	180.322	180.950	182.835	187.233	182.84
4	3.0	154.562	159.274	149.850	153.619	154.33
5	4.0	144.509	147.022	144.509	149.535	146.39
6	5.0	128.802	131.943	131.943	139.797	133.12
7	6.0	126.292	137.601	130.062	133.831	131.95
8	7.0	109.955	120.951	116.552	125.349	118.20
9	8.0	105.557	128.176	105.557	115.610	113.73
10	10.0	97.388	103.671	94.246	94.240	97.39

Mean Resistivity at ERT-02 is 132.36 Ohm - m.

ERT No. 03

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	103.653	103.653	103.339	103.653	103.57
2	1.0	108.696	109.953	109.324	108.696	109.17
3	2.0	150.792	147.651	147.022	149.535	148.75
4	3.0	133.828	136.655	136.655	135.713	135.71
5	4.0	121.890	123.147	125.660	124.403	123.78
6	5.0	119.377	124.089	125.660	119.377	122.13
7	6.0	114.982	122.522	114.982	130.062	120.64
8	7.0	98.959	107.756	107.756	116.552	107.76
9	8.0	92.990	95.503	103.043	100.530	98.02
10	10.0	97.388	97.388	100.530	103.671	99.74

Mean Resistivity at ERT-03 is 116.93 Ohm - m.

ERT No. 04

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	126.592	126.268	125.797	126.582	126.31
2	1.0	128.802	128.802	128.802	129.116	128.88
3	2.0	141.368	139.483	139.483	139.483	139.95
4	3.0	150.792	151.734	152.677	159.274	153.62
5	4.0	150.792	147.022	150.792	144.509	148.28
6	5.0	171.212	171.212	164.929	160.217	166.89
7	6.0	162.106	163.991	162.106	162.106	162.58
8	7.0	153.937	156.136	147.340	160.534	154.49
9	8.0	148.282	148.282	140.742	148.282	146.40
10	10.0	160.219	160.219	144.511	150.794	153.94

Mean Resistivity at ERT-04 is 148.13 Ohm - m.

ERT No. 05

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	199.139	199.768	198.825	198.825	199.14
2	1.0	222.418	222.418	220.533	220.847	221.55
3	2.0	251.320	250.692	250.692	251.948	251.16
4	3.0	265.771	264.828	262.944	267.656	265.30
5	4.0	297.814	296.558	291.531	302.841	297.19
6	5.0	311.009	309.438	311.009	317.292	312.19
7	6.0	280.858	284.627	275.203	284.627	281.33
8	7.0	257.295	261.693	250.697	257.295	256.75
9	8.0	211.113	203.573	198.547	208.600	205.46
10	10.0	197.918	204.201	210.484	210.484	205.77

Mean Resistivity at ERT-05 is 249.58 Ohm - m.

ERT No. 06

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	262.274	263.844	262.902	263.844	263.22
2	1.0	251.320	253.519	252.262	251.634	252.18
3	2.0	340.539	340.539	341.167	341.795	341.01
4	3.0	316.663	318.548	316.663	315.721	316.90
5	4.0	307.867	310.380	301.584	307.867	306.92
6	5.0	295.301	296.872	292.160	292.160	294.12
7	6.0	286.512	286.512	280.858	280.858	283.69
8	7.0	248.498	257.295	241.901	259.494	251.80
9	8.0	213.626	218.653	208.600	206.087	211.74
10	10.0	141.370	153.936	147.653	150.794	148.44

Mean Resistivity at ERT-06 is 267.00 Ohm - m.

ERT No. 07

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.293	229.293	229.136	229.764	229.37
2	1.0	214.564	214.25	213.622	214.250	214.17
3	2.0	228.701	228.701	228.073	228.701	228.54
4	3.0	231.843	233.728	226.188	228.073	229.96
5	4.0	209.852	212.365	207.339	208.596	209.54
6	5.0	201.056	202.627	201.056	202.627	201.84
7	6.0	192.265	192.265	188.495	194.150	191.79
8	7.0	189.123	202.317	189.123	191.322	192.97
9	8.0	158.335	160.848	155.822	155.822	157.71
10	10.0	166.502	166.502	157.078	160.219	162.58

Mean Resistivity at ERT-07 is 201.85 Ohm - m.

ERT No. 08

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	184.063	183.434	184.063	183.277	183.71
2	1.0	201.056	201.684	201.370	201.684	201.45
3	2.0	206.082	209.224	203.569	211.737	207.65
4	3.0	229.958	231.843	232.785	234.670	232.31
5	4.0	272.682	273.939	273.939	277.709	274.57
6	5.0	282.735	285.877	289.018	290.589	287.05
7	6.0	271.433	280.858	271.433	286.512	277.56
8	7.0	279.286	279.286	285.883	285.883	282.58
9	8.0	283.997	271.431	294.050	273.944	280.86
10	10.0	260.749	257.607	267.032	257.607	260.75

Mean Resistivity at ERT-08 is 248.85 Ohm - m.

ERT No. 09

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.136	229.450	228.979	228.822	229.10
2	1.0	242.524	244.095	245.351	245.037	244.25
3	2.0	245.665	247.550	248.807	248.807	247.71
4	3.0	264.828	265.771	269.541	269.541	267.42
5	4.0	295.301	302.841	297.814	306.610	300.64
6	5.0	307.867	317.292	314.150	307.867	311.79
7	6.0	301.592	301.592	295.937	299.707	299.71
8	7.0	301.277	307.874	301.277	301.277	302.93
9	8.0	309.130	319.183	306.617	321.696	314.16
10	10.0	276.456	279.598	282.740	270.173	277.24

Mean Resistivity at ERT-09 is 279.49 Ohm - m.

ERT No. 10

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	376.920	376.606	377.234	376.606	376.84
2	1.0	332.999	332.999	331.742	332.999	332.68
3	2.0	298.443	297.186	291.531	294.673	295.46
4	3.0	279.908	280.850	271.426	273.311	276.37
5	4.0	248.807	248.807	240.011	242.524	245.04
6	5.0	224.617	230.900	226.188	223.047	226.19
7	6.0	205.460	207.345	201.690	201.690	204.05
8	7.0	206.715	193.521	204.516	197.919	200.67
9	8.0	203.573	201.060	198.547	193.520	199.18
10	10.0	201.059	197.918	197.918	197.918	198.70

Mean Resistivity at ERT-10 is 255.52 Ohm - m.

ERT No. 11

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.764	229.764	229.293	229.293	229.53
2	1.0	200.114	199.171	201.056	201.370	200.43
3	2.0	188.490	189.747	189.118	188.490	188.96
4	3.0	208.684	208.281	198.857	199.799	203.91
5	4.0	208.596	214.879	207.339	217.392	212.05
6	5.0	229.330	237.183	221.476	230.900	229.72
7	6.0	197.920	196.035	194.150	192.265	195.09
8	7.0	173.729	182.525	182.525	175.928	178.68
9	8.0	168.388	178.441	158.335	153.308	164.62
10	10.0	157.078	160.219	153.936	150.794	155.51

Mean Resistivity at ERT-11 is 195.85 Ohm - m.

ERT No. 12

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	277.979	276.722	276.879	277.979	277.39
2	1.0	277.394	274.253	276.138	277.080	276.22
3	2.0	242.524	238.754	234.984	239.382	238.91
4	3.0	251.634	243.152	249.749	255.404	249.98
5	4.0	255.090	242.524	252.577	246.294	249.12
6	5.0	260.745	274.881	282.735	292.160	277.63
7	6.0	275.203	263.893	282.743	265.778	271.90
8	7.0	266.091	281.485	268.290	266.091	270.49
9	8.0	256.352	253.838	268.918	248.812	256.98
10	10.0	238.758	245.041	260.749	232.475	244.26

Mean Resistivity at ERT-12 is 261.29 Ohm - m.

ERT No. 13

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	38.006	39.105	39.733	40.676	39.38
2	1.0	45.551	44.923	46.808	47.122	46.10
3	2.0	34.556	36.441	38.954	35.813	36.44
4	3.0	30.158	34.870	35.813	35.184	34.01
5	4.0	26.388	30.158	32.671	37.698	31.73
6	5.0	25.132	32.985	29.844	36.127	31.02
7	6.0	24.504	35.814	28.274	32.044	30.16
8	7.0	21.991	37.384	28.588	28.588	29.14
9	8.0	22.116	36.190	23.624	23.121	26.26
10	10.0	23.247	36.442	25.760	25.132	27.65

Mean Resistivity at ERT-13 is 33.19 Ohm - m.

ERT No. 14

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	279.392	280.177	279.549	278.293	279.35
2	1.0	383.577	384.520	387.033	401.170	389.08
3	2.0	353.733	356.874	356.874	349.335	354.20
4	3.0	377.922	375.095	367.556	374.153	373.68
5	4.0	346.822	353.105	354.361	354.361	352.16
6	5.0	227.759	226.188	238.754	230.900	230.90
7	6.0	175.300	184.725	241.274	226.194	206.87
8	7.0	136.344	134.145	158.335	169.331	149.54
9	8.0	128.176	143.255	150.795	138.229	140.11
10	10.0	131.945	157.078	138.228	122.520	137.44

Mean Resistivity at ERT-14 is 261.33 Ohm - m.

ERT No. 15

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.293	229.293	228.979	229.764	229.33
2	1.0	251.320	250.378	252.262	251.948	251.48
3	2.0	272.054	272.682	272.054	277.080	273.47
4	3.0	265.771	263.886	265.771	266.713	265.54
5	4.0	276.452	278.965	282.735	283.992	280.54
6	5.0	256.603	260.745	259.174	262.315	259.71
7	6.0	231.849	233.734	239.389	239.389	236.09
8	7.0	233.105	239.702	237.503	241.901	238.05
9	8.0	221.166	231.219	221.166	221.166	223.68
10	10.0	229.333	235.616	248.182	241.899	238.76

Mean Resistivity at ERT-15 is 249.66 Ohm - m.

ERT No. 16

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	292.270	292.427	292.741	293.055	292.62
2	1.0	251.948	252.262	252.577	249.749	251.63
3	2.0	265.143	265.771	265.143	266.392	265.61
4	3.0	226.188	230.900	231.843	232.785	230.43
5	4.0	234.984	237.497	237.497	242.524	238.13
6	5.0	229.330	223.047	234.042	223.047	227.37
7	6.0	211.114	211.114	212.999	220.539	213.94
8	7.0	175.928	173.729	175.928	186.924	178.13
9	8.0	163.361	163.361	168.338	183.467	169.63
10	10.0	147.653	144.511	144.511	157.078	148.44

Mean Resistivity at ERT-16 is 221.59 Ohm - m.

ERT No. 17

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	260.389	260.860	260.703	260.860	260.70
2	1.0	253.205	252.577	253.519	251.320	252.66
3	2.0	285.877	285.877	286.505	289.646	286.98
4	3.0	266.713	264.828	263.886	263.886	264.83
5	4.0	260.116	261.373	257.603	256.346	258.86
6	5.0	227.759	223.047	224.617	227.759	225.80
7	6.0	186.610	179.070	175.300	173.415	178.60
8	7.0	153.937	156.136	158.335	164.933	158.34
9	8.0	138.229	130.689	130.689	125.663	131.32
10	10.0	125.662	125.662	113.096	119.379	120.95

Mean Resistivity at ERT-17 is 213.90 Ohm - m.

ERT No. 19

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	225.838	225.995	226.152	226.152	226.03
2	1.0	251.320	251.320	250.378	251.320	251.08
3	2.0	253.205	248.807	251.320	251.948	251.32
4	3.0	245.037	247.864	246.922	244.095	245.98
5	4.0	208.596	213.622	207.339	211.109	210.17
6	5.0	196.344	190.061	194.773	196.344	194.38
7	6.0	186.610	192.265	184.725	186.610	187.55
8	7.0	182.525	193.521	184.724	189.123	187.47
9	8.0	143.255	160.848	140.742	145.769	147.65
10	10.0	128.804	153.936	131.945	135.087	137.44

Mean Resistivity at ERT-19 is 203.91 Ohm - m.

ERT No. 20

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	194.742	194.742	195.213	195.841	195.13
2	1.0	189.118	189.432	189.432	187.548	188.88
3	2.0	217.393	219.277	216.135	214.879	216.92
4	3.0	228.073	229.958	229.015	234.670	230.43
5	4.0	211.109	213.622	216.135	214.879	213.94
6	5.0	205.768	212.051	212.051	210.481	210.09
7	6.0	197.920	192.265	192.265	194.805	194.31
8	7.0	173.729	217.711	175.928	173.729	185.27
9	8.0	173.414	183.467	183.467	168.388	177.18
10	10.0	191.635	207.342	204.201	188.493	197.92

Mean Resistivity at ERT-20 is 201.01 Ohm - m.

ERT No. 21

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	347.238	347.238	347.238	347.395	347.28
2	1.0	358.131	358.759	359.388	357.503	358.45
3	2.0	363.157	361.273	366.299	364.414	363.79
4	3.0	401.484	399.599	404.311	398.656	401.01
5	4.0	319.176	312.893	314.150	317.920	316.03
6	5.0	251.320	259.174	252.891	259.174	255.64
7	6.0	235.619	243.159	235.619	239.389	238.45
8	7.0	189.123	193.521	186.924	193.521	190.77
9	8.0	150.795	148.282	150.795	143.255	148.28
10	10.0	160.219	166.502	150.794	160.219	159.43

Mean Resistivity at ERT-21 is 277.91 Ohm - m.

ERT No. 22

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.764	229.607	229.293	229.293	229.49
2	1.0	229.330	230.272	228.701	228.701	229.25
3	2.0	213.622	212.365	214.250	216.135	214.09
4	3.0	246.922	240.325	247.864	250.692	246.45
5	4.0	256.346	253.833	256.346	265.143	257.92
6	5.0	251.320	251.320	254.462	254.462	252.89
7	6.0	243.159	250.698	241.274	243.159	244.57
8	7.0	222.109	222.109	219.910	217.711	220.46
9	8.0	221.166	231.219	216.140	216.140	221.17
10	10.0	213.625	216.767	210.484	213.625	213.63

Mean Resistivity at ERT-22 is 232.99 Ohm - m.

ERT No. 23

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.293	229.293	229.293	229.136	229.25
2	1.0	213.622	214.564	215.193	214.879	214.56
3	2.0	177.181	179.066	177.181	177.809	177.81
4	3.0	186.605	189.432	191.317	186.605	188.49
5	4.0	172.154	174.667	172.154	174.667	173.41
6	5.0	160.217	160.217	168.070	164.929	163.36
7	6.0	154.566	158.336	152.681	163.991	157.39
8	7.0	142.942	147.340	147.340	145.141	145.69
9	8.0	138.229	148.282	143.255	153.308	145.77
10	10.0	135.087	141.370	125.662	122.520	131.16

Mean Resistivity at ERT-23 is 172.69 Ohm - m.

ERT No. 24

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	379.904	380.061	381.003	379.904	380.22
2	1.0	327.973	328.287	327.973	329.543	328.44
3	2.0	254.462	255.090	254.462	256.975	255.25
4	3.0	229.958	233.728	233.728	234.670	233.02
5	4.0	218.648	221.162	219.905	223.675	220.85
6	5.0	204.198	202.627	202.627	201.056	202.63
7	6.0	199.805	196.035	199.805	201.069	199.18
8	7.0	200.118	189.123	206.715	186.924	195.72
9	8.0	198.547	193.520	208.600	198.547	199.80
10	10.0	207.342	207.342	210.484	194.776	204.99

Mean Resistivity at ERT-24 is 242.01 Ohm - m.

ERT No. 25

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	355.718	354.776	354.776	354.933	355.05
2	1.0	359.388	359.702	358.759	359.078	359.23
3	2.0	280.850	275.824	277.709	278.965	278.34
4	3.0	285.562	287.447	290.275	293.102	289.10
5	4.0	285.248	291.531	280.222	287.761	286.19
6	5.0	249.749	252.891	245.037	248.179	248.96
7	6.0	239.389	237.504	228.079	235.619	235.15
8	7.0	202.317	193.521	193.521	193.521	195.72
9	8.0	188.494	178.441	188.494	180.954	184.10
10	10.0	188.493	197.918	188.493	185.351	190.06

Mean Resistivity at ERT-25 is 262.19 Ohm - m.

ERT No. 26

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	314.571	314.728	314.414	314.571	314.57
2	1.0	333.313	333.941	332.999	333.313	333.39
3	2.0	378.237	378.237	378.237	375.723	377.61
4	3.0	429.757	426.930	422.218	425.987	426.22
5	4.0	407.138	413.421	403.369	404.625	407.14
6	5.0	389.546	405.254	387.975	397.400	395.04
7	6.0	367.565	369.450	354.371	363.795	363.80
8	7.0	327.666	321.069	316.670	323.268	322.17
9	8.0	251.325	256.352	236.246	246.299	247.56
10	10.0	232.475	248.182	226.192	226.192	233.26

Mean Resistivity at ERT-26 is 342.08 Ohm - m.

ERT No. 27

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	251.280	251.594	251.280	251.280	251.36
2	1.0	267.028	267.970	266.399	267.342	267.18
3	2.0	278.965	280.850	277.080	281.478	279.59
4	3.0	281.793	281.793	279.908	278.965	280.61
5	4.0	268.912	267.656	262.629	267.656	266.71
6	5.0	257.603	256.032	249.749	254.462	254.46
7	6.0	252.583	243.159	241.274	241.274	244.57
8	7.0	246.299	239.702	248.498	239.702	243.55
9	8.0	211.113	206.087	208.600	211.113	209.23
10	10.0	179.068	169.644	160.219	163.361	168.07

Mean Resistivity at ERT-27 is 246.54 Ohm - m.

ERT No. 28

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	289.286	289.443	288.658	290.071	289.36
2	1.0	314.778	314.150	313.208	312.579	313.68
3	2.0	351.848	353.105	353.105	353.105	352.79
4	3.0	374.153	372.268	371.325	375.095	373.21
5	4.0	351.848	354.361	346.822	356.874	352.48
6	5.0	331.428	336.141	329.858	331.428	332.21
7	6.0	322.326	316.672	318.557	318.557	319.03
8	7.0	301.277	299.078	301.277	303.476	301.28
9	8.0	301.590	294.050	301.590	299.077	299.08
10	10.0	229.333	226.192	219.909	216.767	223.05

Mean Resistivity at ERT-28 is 315.62 Ohm - m.

ERT No. 29

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	376.763	377.077	377.548	376.920	377.08
2	1.0	515.206	514.892	517.091	515.206	515.60
3	2.0	627.043	627.043	628.928	624.530	626.89
4	3.0	517.405	511.750	517.405	510.808	514.34
5	4.0	515.206	510.180	515.206	507.666	512.06
6	5.0	464.942	468.084	466.513	464.942	466.12
7	6.0	418.459	399.609	414.689	407.149	409.98
8	7.0	321.069	327.666	318.870	316.670	321.07
9	8.0	218.653	218.653	218.653	216.140	218.02
10	10.0	185.351	172.785	175.927	169.644	175.93

Mean Resistivity at ERT-29 is 413.71 Ohm - m.

ERT No. 30

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	417.753	417.753	418.852	417.910	418.07
2	1.0	374.153	378.237	378.237	378.237	377.22
3	2.0	402.112	402.112	401.484	402.740	402.11
4	3.0	224.303	222.418	219.591	224.303	222.65
5	4.0	209.852	214.879	201.056	209.852	208.91
6	5.0	204.198	212.051	205.768	207.339	207.34
7	6.0	194.150	192.265	199.805	192.265	194.62
8	7.0	208.915	204.516	204.516	202.318	205.07
9	8.0	218.653	203.573	211.113	206.087	209.86
10	10.0	210.484	204.201	219.909	219.909	213.63

Mean Resistivity at ERT-30 is 265.95 Ohm - m.

ERT No. 31

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.293	229.136	229.764	229.764	229.49
2	1.0	254.147	255.090	251.948	250.692	252.97
3	2.0	270.797	272.054	270.169	270.169	270.80
4	3.0	253.519	260.116	245.037	260.116	254.70
5	4.0	272.682	278.965	272.682	278.965	275.82
6	5.0	232.471	237.183	243.466	238.754	237.97
7	6.0	224.309	224.309	229.964	226.194	226.19
8	7.0	189.123	169.123	182.525	178.127	179.72
9	8.0	155.822	155.822	148.282	133.202	148.28
10	10.0	147.653	153.936	144.511	144.511	147.65

Mean Resistivity at ERT-31 is 222.36 Ohm - m.

ERT No. 32

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	293.998	294.469	293.684	294.155	294.08
2	1.0	295.615	295.301	297.5	296.243	296.16
3	2.0	310.380	317.292	315.407	314.778	314.46
4	3.0	308.181	313.836	311.009	312.893	311.48
5	4.0	277.709	278.965	278.965	278.965	278.65
6	5.0	265.457	270.169	263.886	268.598	267.03
7	6.0	216.769	237.504	226.194	235.619	229.02
8	7.0	202.317	202.315	204.516	208.915	204.52
9	8.0	203.573	206.087	196.034	201.060	201.69
10	10.0	213.625	197.918	216.767	216.767	211.27

Mean Resistivity at ERT-32 is 260.84 Ohm - m.

ERT No. 33

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	377.548	377.548	376.292	377.077	377.12
2	1.0	319.176	320.433	320.433	320.747	320.20
3	2.0	252.577	251.948	254.462	250.063	252.26
4	3.0	244.095	247.864	246.922	251.634	247.63
5	4.0	222.418	217.392	217.392	217.392	218.65
6	5.0	251.193	204.198	215.193	194.773	216.34
7	6.0	188.495	184.725	186.610	179.070	184.73
8	7.0	180.326	180.326	184.724	175.928	180.33
9	8.0	196.034	188.494	193.520	191.007	192.26
10	10.0	213.625	213.625	213.625	201.059	210.48

Mean Resistivity at ERT-33 is 240.00 Ohm - m.

ERT No. 34

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	471.307	470.679	471.150	471.150	471.07
2	1.0	301.898	305.040	303.469	302.526	303.23
3	2.0	195.401	199.799	194.773	196.030	196.50
4	3.0	169.641	174.353	167.756	172.468	171.05
5	4.0	163.358	160.845	157.075	157.075	159.59
6	5.0	160.217	161.787	157.075	162.217	160.32
7	6.0	167.761	177.185	162.106	173.415	170.12
8	7.0	160.534	175.928	162.733	173.729	168.23
9	8.0	163.361	178.441	170.901	178.441	172.79
10	10.0	188.493	191.635	185.351	185.351	187.71

Mean Resistivity at ERT-34 is 216.06 Ohm - m.

ERT No. 35

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	471.621	473.977	473.035	473.820	473.11
2	1.0	871.452	837.337	872.709	873.651	863.79
3	2.0	1068.740	1067.480	1068.110	1069.990	1068.58
4	3.0	640.866	648.406	649.348	649.348	646.99
5	4.0	449.863	431.014	442.323	436.040	439.81
6	5.0	435.098	435.098	424.103	424.103	429.60
7	6.0	329.866	326.096	327.981	326.096	327.51
8	7.0	299.078	314.471	305.675	307.874	306.77
9	8.0	206.087	203.573	218.653	218.653	211.74
10	10.0	207.342	201.059	213.625	191.633	203.41

Mean Resistivity at ERT-35 is 497.13 Ohm - m.

ERT No. 36

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	166.473	167.258	166.159	166.630	166.63
2	1.0	168.699	169.955	168.384	168.070	168.78
3	2.0	138.854	140.739	138.226	138.854	139.17
4	3.0	150.792	157.389	150.792	154.562	153.38
5	4.0	167.128	169.641	164.615	167.128	167.13
6	5.0	152.363	155.504	157.075	157.075	155.50
7	6.0	139.486	150.796	139.486	148.911	144.67
8	7.0	116.552	116.552	112.154	114.353	114.90
9	8.0	103.043	100.530	95.503	100.530	99.90
10	10.0	91.105	94.246	87.963	100.530	93.46

Mean Resistivity at ERT-36 is 140.35 Ohm - m.

ERT No. 37

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	166.787	166.944	166.159	166.159	166.51
2	1.0	172.468	176.238	172.783	174.353	173.96
3	2.0	214.250	214.879	214.879	214.897	214.73
4	3.0	245.979	250.692	245.979	245.979	247.16
5	4.0	261.373	265.143	260.116	261.373	262.00
6	5.0	303.155	311.009	296.872	303.155	303.55
7	6.0	284.627	280.858	278.973	278.973	280.86
8	7.0	263.892	277.087	263.892	270.489	268.84
9	8.0	233.732	238.759	231.219	231.219	233.73
10	10.0	245.041	254.466	235.616	248.182	245.83

Mean Resistivity at ERT-37 is 239.72 Ohm - m.

ERT No. 38

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	229.293	229.136	228.665	229.764	229.21
2	1.0	225.246	224.931	224.303	224.617	224.77
3	2.0	213.622	213.622	215.507	215.507	214.56
4	3.0	210.166	208.281	205.454	209.224	208.28
5	4.0	191.003	188.49	187.233	188.49	188.80
6	5.0	190.061	190.061	183.778	188.49	188.10
7	6.0	190.38	192.265	186.61	194.15	190.85
8	7.0	178.127	180.326	167.132	175.928	175.38
9	8.0	165.875	168.388	155.822	163.361	163.36
10	10.0	163.361	169.644	157.078	157.078	161.79

Mean Resistivity at ERT-38 is 194.51 Ohm - m.

ERT No. 39

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	103.81	103.653	103.653	103.653	103.69
2	1.0	109.324	109.638	109.638	110.895	109.87
3	2.0	150.792	150.792	152.049	152.049	151.42
4	3.0	188.49	185.663	192.260	195.087	190.38
5	4.0	216.135	212.365	217.392	219.905	216.45
6	5.0	229.33	230.900	226.188	235.613	230.51
7	6.0	220.539	222.424	231.849	229.964	226.19
8	7.0	291.91	213.313	224.308	226.507	239.01
9	8.0	208.6	216.140	218.653	218.653	215.51
10	10.0	223.05	226.192	235.616	241.899	231.69

Mean Resistivity at ERT-39 is 191.47 Ohm - m.

ERT No. 40

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	166.316	165.688	166.473	166.473	166.24
2	1.0	172.154	174.039	173.097	172.468	172.94
3	2.0	185.349	187.233	188.490	186.605	186.92
4	3.0	173.411	166.814	171.526	172.468	171.05
5	4.0	183.464	185.977	182.207	183.464	183.78
6	5.0	161.787	144.509	160.217	152.363	154.72
7	6.0	141.371	133.831	139.486	135.716	137.60
8	7.0	116.552	138.543	118.751	129.747	125.90
9	8.0	95.503	87.963	95.503	85.450	91.10
10	10.0	87.963	91.105	87.963	87.963	88.75

Mean Resistivity at ERT-40 is 147.90 Ohm - m.

ERT No. 41

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	251.908	252.065	251.908	252.536	252.10
2	1.0	368.498	369.755	370.697	371.639	370.15
3	2.0	327.973	326.716	305.982	324.831	321.38
4	3.0	356.246	359.078	360.958	359.073	358.84
5	4.0	314.150	315.407	314.150	312.893	314.15
6	5.0	202.627	204.198	210.481	199.485	204.20
7	6.0	190.380	190.380	190.380	188.495	189.91
8	7.0	160.534	156.136	156.136	160.534	158.34
9	8.0	153.308	165.875	163.361	158.335	160.22
10	10.0	153.936	157.078	157.078	160.219	157.08

Mean Resistivity at ERT-41 is 248.64 Ohm - m.

ERT No. 42

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	236.674	236.831	237.146	236.831	236.87
2	1.0	207.653	206.397	208.281	207.967	207.57
3	2.0	315.407	315.407	316.035	318.548	316.35
4	3.0	160.217	162.101	163.986	162.101	162.10
5	4.0	169.641	162.101	168.384	165.871	166.50
6	5.0	161.787	160.217	161.787	160.876	161.17
7	6.0	160.221	162.106	160.221	165.876	162.11
8	7.0	167.132	175.928	167.132	175.928	171.53
9	8.0	145.769	150.795	148.282	150.795	148.91
10	10.0	153.936	157.078	157.078	157.078	156.29

Mean Resistivity at ERT-42 is 188.94 Ohm - m.

ERT No. 43

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	402.362	402.519	402.048	401.891	402.21
2	1.0	384.392	350.906	348.392	352.162	358.96
3	2.0	239.382	238.759	239.382	241.896	239.85
4	3.0	178.123	176.238	180.950	176.238	177.89
5	4.0	158.332	164.615	163.358	164.615	162.73
6	5.0	163.358	171.212	160.217	171.212	166.50
7	6.0	148.911	156.451	158.336	156.451	155.04
8	7.0	147.340	140.742	156.136	131.946	144.04
9	8.0	150.795	138.229	153.308	143.225	146.39
10	10.0	150.795	147.653	163.361	166.502	157.08

Mean Resistivity at ERT-43 is 211.07 Ohm - m.

ERT No. 44

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	291.956	291.956	292.113	292.13	292.04
2	1.0	313.522	314.778	314.464	312.893	313.91
3	2.0	358.759	358.759	358.759	1358.131	608.60
4	3.0	321.375	319.491	317.606	314.778	318.31
5	4.0	330.486	334.256	329.229	329.229	330.80
6	5.0	180.636	186.919	182.207	186.919	184.17
7	6.0	167.761	163.991	162.106	163.991	164.46
8	7.0	169.331	162.733	173.729	192.733	174.63
9	8.0	130.689	143.255	138.229	135.716	136.97
10	10.0	125.662	131.945	125.662	125.662	127.23

Mean Resistivity at ERT-44 is 265.11 Ohm - m.

ERT No. 45

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	197.726	198.354	197.726	198.354	198.04
2	1.0	218.334	219.905	218.963	219.277	219.12
3	2.0	200.428	197.915	201.056	197.915	199.33
4	3.0	228.073	229.015	223.361	228.073	227.13
5	4.0	206.082	202.313	201.056	202.313	202.94
6	5.0	216.764	221.476	224.617	226.188	222.26
7	6.0	233.734	233.734	228.079	233.734	232.32
8	7.0	224.308	215.512	224.308	217.711	220.46
9	8.0	251.325	258.865	251.325	253.838	253.84
10	10.0	207.342	216.767	197.918	207.342	207.34

Mean Resistivity at ERT-45 is 218.28 Ohm - m.

ERT No. 46

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	225.524	225.838	225.367	225.367	225.52
2	1.0	234.356	235.298	235.613	235.298	235.14
3	2.0	146.394	146.394	143.881	143.252	144.98
4	3.0	133.828	140.425	136.655	136.655	136.89
5	4.0	141.996	133.200	140.739	133.200	137.28
6	5.0	155.504	157.075	149.221	150.792	153.15
7	6.0	133.831	145.141	139.486	137.601	139.01
8	7.0	140.742	134.145	134.145	140.742	137.44
9	8.0	148.282	143.255	140.742	148.282	145.14
10	10.0	157.078	153.936	147.653	150.794	152.37

Mean Resistivity at ERT-46 is 160.69 Ohm - m.

ERT No. 47

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	91.403	91.560	91.246	91.089	91.32
2	1.0	125.974	125.660	127.231	127.231	126.52
3	2.0	189.118	194.145	191.003	192.260	191.63
4	3.0	192.260	200.742	195.087	197.915	196.50
5	4.0	179.694	187.233	173.411	184.720	181.26
6	5.0	146.080	141.368	144.509	139.797	142.94
7	6.0	156.451	156.451	148.911	150.796	153.15
8	7.0	151.738	142.942	145.141	131.946	142.94
9	8.0	153.308	153.308	140.742	143.255	147.65
10	10.0	150.794	153.936	138.228	138.228	145.30

Mean Resistivity at ERT-47 is 151.92 Ohm - m.

ERT No. 48

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	145.585	145.899	146.371	145.899	145.94
2	1.0	202.313	201.998	201.056	201.370	201.68
3	2.0	226.188	226.188	228.073	226.188	226.66
4	3.0	179.066	179.066	182.835	178.123	179.77
5	4.0	125.660	126.917	129.430	131.943	128.49
6	5.0	116.236	124.089	130.372	130.372	125.27
7	6.0	135.716	133.831	133.831	133.831	134.30
8	7.0	120.951	125.349	129.747	129.747	126.45
9	8.0	130.689	138.229	150.795	145.769	141.37
10	10.0	131.945	135.087	135.087	131.945	133.52

Mean Resistivity at ERT-48 is 154.34 Ohm - m.

ERT No. 49

Sl No.	S (M)	Apparent Electrical Resistivity (Ohm-m)				
		(N - S)	(E - W)	(NE - SW)	(NW - SE)	Mean
1	0.50	273.424	273.895	273.581	273.424	273.58
2	1.0	162.416	163.358	162.730	163.672	163.04
3	2.0	152.049	151.420	153.305	153.305	152.52
4	3.0	140.425	144.195	141.368	143.252	142.31
5	4.0	150.792	115.607	149.535	118.120	133.51
6	5.0	144.509	144.509	149.221	147.911	146.54
7	6.0	139.486	145.141	145.141	148.911	144.67
8	7.0	156.136	158.335	156.136	158.335	157.24
9	8.0	155.822	155.822	165.875	150.795	157.08
10	10.0	160.219	157.078	160.219	163.361	160.22

Mean Resistivity at ERT-49 is 163.07 Ohm - m.