T E N D E R S P E C I F I C A T I O N

NO: BHE/PW/PUR/MANUT-CVL AHP/1490

(CIVIL AND ARCHITECTURAL WORK OF CHP AREA)

All civil and Architectural works required for Ash Handling Plant

AT

4X270 MW Thermal Power Station, Manuguru, Distt-Khammam, Telangana

Volume 1 E – Technical Specification TSGENCO

Bharat Heavy Electricals Limited
(*A Government of India Undertaking*)
Power Sector - Western Region
345-Kingsway, Nagpur-440001

Date
Seal and Signature
Place

TELANGANA STATE POWER GENERATION CORPORATION LIMITED [TSGENCO]

KOTHAGUDEM THERMAL POWER STATION
STAGE-VII, UNIT#12, [1 x 800 MW]

KOTHAGUDEM, TELANGANA, INDIA

EPC BID DOCUMENT

DOCUMENT NO.: e-PCT/TS/K/02/2014-15

VOLUME-VII

TECHNICAL SPECIFICATION
FOR
CIVIL, STRUCTURAL & ARCHITECTURAL WORK
INCLUDING NDCT

OCTOBER 2014

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
CONSULTING ENGINEERS
24B PARK STREET, KOLKATA – 700 016, INDIA

TELANGANA STATE POWER GENERATION CORPORATION LIMITED

KOTHAGUDEM, TELANGANA , INDIA

1x800 MW KOTHAGUDEM THERMAL POWER STATION

STAGE-VII, UNIT#12

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GENERAL SPECIFICATION AND DESIGN CRITERIA FOR CIVIL AND STRUCTURAL WORKS

1.00.00 GENERAL

This specification is intended to cover general as well as technical specification required for design, supply, execution & erection of complete Civil, Structural and miscellaneous work required for completion of 1x800 MW Super Critical Thermal Power Plant to the satisfaction of the Owner.

The work shall include design, construction and erection activities of both underground and above ground civil and structural work and shall include all working drawing, labor, materials, plants, equipment, transportation and all incidental items not shown or specified explicitly but reasonably implied and necessary for proper completion of the project, all in strict compliance with this specification, including the revision and amendments thereto as may be required during the execution of the work.

The work shall be carried out according to the design/drawing to be developed by the Contractor and approved by the Owner/Owner's Consultant. For all building, structure, foundations, roads, drainage, necessary details and layout shall be prepared by the Contractor keeping in view the functional requirement of the plant and the facilities and providing enough space and access for operation use and maintenance. The drawings and specifications attached herewith do not provide complete description of each and every system but state the minimum functional requirement for the plant as a whole or certain individual components.

All the quality of work and standards pertaining to field and laboratory testing, excavation, concreting, fabrication, erection, welding and other technical requirements shall strictly conform to the Technical Specification for Civil, Structural and Architectural Work - Volume VII-C of this Bid Document. The specifications are intended for the general description of the work, quality and workmanship. The specifications are not, however, intended to cover the minutest details and the work shall be executed according to the spirit of the specification and in the absence thereof according to the relevant latest Indian Standard Codes. In absence of the later, the work shall be executed according to the local public work department practice or to the recommendation of relevant American & British Standards or to the instruction of the Owner. The IS Codes to be followed are mentioned in the relevant Technical specification for different items of work. All civil and structural work shall conform to approved Architectural drawing wherever applicable and General Specification and Design Criteria for Architectural Work - Volume VII-B of this bid document.

The bidder is expected to get clarified any doubts about the specification etc., before bidding through discussion with the Owner recorded in writing in respect of interpretation of any portion of this documents. The Owner reserves the right to alter/amend any part/criteria of this specification in the interest of the project without creating any financial implication whatsoever on the part of Owner.

Before bidding the contractor shall visit the site to get fully acquainted with site condition, approaches, transport facilities, off-site facilities, availability of materials, storage space, fabrication and bar bending yard, accommodation of workmen, site office, testing laboratory and other assorted facilities. The bidder or its consultants, if any, shall have well-equipped design office with modern drafting, validated civil/structural analysis and design soft-wares, computing and transmission facilities to comply with high rate of drawing/document production pertaining to civil & structural system to meet the stipulated time frame laid down in the specification. No extra claim shall be entertained for any unforeseen reason.

The contractor's offer shall cover the complete requirements as per the best prevailing practices and to complete satisfaction of owner.

2.00.00 SCOPE OF CIVIL AND STRUCTURAL WORK

The scope of civil and structural work comprises all necessary investigations, survey, foundations, buildings, substructures, superstructures and infrastructure required for the effective functioning of various systems of the power plant whether or not they are specifically mentioned.

The scope of work includes all the following work in conformity with approved Mechanical / Electrical layout drawings but not limited to the following.

A. Site preparation

In general, demolition of existing quarters, leveling and grading of the site will be taken up by TSGENCO. Any additional site preparation work required in detail engineering stage will be in bidder's scope.

- Detail Soil investigation including measurement of soil resistivity.
- Excavation, dewatering, shoring and strutting, backfilling ,disposal of surplus soil outside of plant boundary as per requirement
- Dewatering /slope protection work if required

B. **Power Block area**

- Power house building including Control room, Crane girder, Turbo Generator foundation and other equipment foundations. Crane capacity and crane rail level shall be fixed based on the equipment to be lifted and the method of lifting generator stator. At crane girder top flange level a crane walkway shall be provided in line with factory rules. Access shall be provided to crane walkway through staircase from operating floor in addition to cage ladders at two ends.

- Boiler area foundations including Boiler, ESP, Fan foundations, Duct supporting columns and other foundations (Equipment and structural steel work for boiler and auxiliaries will be covered under mechanical sections)

- Boiler area paving with drainage

- Mill Building including coal bunkers and mill foundations

- Mill reject loading hoppers

- ESP Control Room

- Chimney

C. **Transformer yard**

- Transformer yard foundations and substructure including Transformer foundations, Bus duct supporting structures and foundations, foundations for pylon and deluge valves for transformer fire detection and protection system, Rail track, fire wall, common oil pits, electrical trenches, pull pits and duct banks, drainage, gates, fencing, paving etc. all complete.

- RCC roads within switchyard, fire protection walls and chain link fencing for switchyard. RCC paving shall be provided in Transformer Yard.

- All other buildings structures and foundations as per approved electrical layout

D. **Switchyard**

- Switchyard structures, foundations, drains, pits, switchyard roads, RCC cable trench, gate, fencing, paving in yard using fly ash bricks in panels with pointing wherever required etc all complete.

For prevention of vegetation, the graded ground shall be covered with fly ash bricks pavement over 300 mm ash filling to be provided in the switchyard area. Each fly ash layer shall be compacted/consolidated by using ½ ton roller with 4 to 5 passes and suitable water sprinkling. The method of application of chemicals used for soil sterilization /anti-wed treatment shall be as per manufacturer's recommendation. Also, the RCC pathway shall be provided in switchyard as per the requirement. An approved system for draining the transformer oil collection and disposal system shall be provided.

- Switchyard control room
- All other buildings structures and foundations as per approved electrical layout

E. **Coal Handling system**

Separate marshalling yard of 6 lines and one additional line requirement from Gajulagudem to plant about 3 km will be provided to cater to the requirement of proposed unit as per RITE's report attached with the specification as annexure-2. EPC contractor to carry out any new or modification work in such a way that the existing structure and foundations are not disturbed and coal linkage to existing units can be continued un-interrupted.

- Wagon Tippler (2nos)
- Track Hopper
- Conveyor galleries with supporting trestles, and foundations
- In motion weigh bridge
- RCC tunnel
- Transfer points
- Pent house
- Crusher house
- Stacker/Re-claimer foundations
- Reclaim Hopper
- Crushed Coal stock pile yard for a storage of 30 days
- 1,00,000 MT Coal storage shed
- Control room / MCC room for coal handling plant

- Tanks / Reservoirs, Sumps, Pump Houses, Compressor House for Dust suppression and other utilities and fire fighting system
- All other buildings, structures and foundations as per approved mechanical layout

F. **Ash Handling system**

- Ash Slurry sump and pump house
- Bottom Ash overflow sump
- Ash water sump and pump house
- Coarse ash tank and pump house
- Fly ash equipment tower
- Ash blower/compressor building
- Vacuum pump House
- Ash handling plant switchgear cum control room
- Pipe rack for conveying the ash and water pipes
- Ash pipe corridor including providing proper drainage arrangements within the plant area.
- Fly Ash Storage Silo (2 nos.) with concrete approach road
- Silo utility building
- HCSD Pump shed
- Mill reject silo
- Foundations for clarifier and other equipments as per system requirement

- Ash pond by construction of earthen bund in extent of Ac.230.00 of land under acquisition including the construction of respective spillway, decantation well and RCC vent for relieving the water from ash pond in to the natural drain.

- Ash water recovery pump house.

- Civil foundations for 100 MT capacity weigh bridge for weighing the ash trucks as per site requirement during detailed engineering.

- All other buildings, structures and foundations as per approved mechanical layout

G. **Fuel oil System**

The HFO/LDO required for the proposed Unit will be pumped from Fuel Oil system to the day tanks.

EPC contractor to carry out any modification work for enhancement of capacities of existing system such that the existing structure and foundations are not disturbed.

- HFO/LDO Day Tank foundations and dykes with RCC pavement.

- HFO/LDO pipe supporting pedestals.

- HFO/LDO Forwarding Pump House

- HFO/LDO Pressurising Pump House

- All other buildings, structures and foundations as per approved mechanical layout.

H. **Raw water supply and pretreatment system including Intake**

- Re-routing of existing GRP pipe line passing through the new plant area using MS pipe line of 1200 mm dia.

- Raw Water Reservoir

- Raw Water Pump House

  EPC Contractor to carry out any modification work for enhancement of capacities of existing system such that the existing structure and foundations are not disturbed and water linkage to existing units can be continued un-interrupted.

- Clarified water storage tank
- Clarified water pump house
- Aerator
- Stilling Chamber
- Distribution Chambers
- Solid Contact Clarifier with approach stair cases to be provided diagonally at two sides of clarifiers.
- Rapid gravity filter
- Filtered water Reservoir and Pump House
- Sludge Sump & Pump House
- Filter Backwash Waste Sump & Pump House
- Chemical House cum RWPT Chlorination Building
- All other buildings, structures and foundations as per approved mechanical layout.

I. **Demineralised & Potable water supply system**

- DM Plant Building
- DM-Neutralizing pit and Pump House
- Potable water tank with the necessary pipe lines to all the buildings.
- All other buildings, structures , tanks and foundations as per approved mechanical layout

J. **Condensate Polishing System**

- CPU – Regeneration Building
- CPU- Neutralizing pit and Pump House
- All other buildings, structures , tanks and foundations as per approved mechanical layout

K. **CW system**

- Natural Draft cooling tower
- Cooling water pipes and return pipes upto inlet flange of cooling tower including their supports and foundations, thrust blocks etc. wherever required
- CW pump house and fore bay alongwith a walkway with handrails across the forebay adjacent to CW pumphouse, channel from NDCT to CW pump house
- Provision of gates to facilitate dewatering and cleaning of sump.
- CW Treatment Plant cum Chlorination Building
- All other buildings, structures and foundations as per approved mechanical layout

L. **Fire fighting system**

- Fire water tanks
- Fire water pump house
- Foundations for Pylon and deluge valves
- Deluge Valve canopy with RCC slab.
- All other buildings, structures and foundations as per approved mechanical layout.

M. **Waste Water Treatment System**

- Boiler Blow Down Drain Pit and P/H
- Backwash Waste Water from SSF Collection Pit and P/H
- Central Monitoring basin
- CMB Effluent Transfer P/H
- Flocculation Tank, Inclined Surface Settler
- Inclined Surface Settler Sludge Pit and P/H
- Coal Particle Settling Basin

- Coal Decanted Water Sump and P/H
- Sludge Thickener
- Centrifuge Building
- Chemical House for WWTS
- Retention Pit for Transformer Yard Oily Waste Pit and P/H
- Retention Pit for TG Building Area Oily Waste and P/H
- Retention Pit for Fuel Oil Storage Area Oily Waste and P/H
- Pre Oil Water Separator Retention Pit and P/H
- Retention Pit for Treated Effluent from OWS and P/H
- CPI Sludge Pit and P/H
- All other buildings, structures and foundations as per approved mechanical layout.

N. **Centralized Sewage Treatment System**

- Fixed Bar Screen Chamber
- Sewage Equalization Sump and P/H
- Extended Aeration Tank
- Settling Tank
- Clear Water Storage Tank
- Clear Water Transfer P/H
- Treated Water Storage Tank and P/H
- EPC Contractor will finalise required number and strategic locations of individual sewage lifting stations during detail engineering, subject to approval of the owner / owner's consultant.
- Finalising the location and size of centralized STP subject to approval of the owner / owner's consultant will also be in the scope of contractor.

- All civil and structural work associated with Sanitary sewer disposal system including inspection pits, manholes etc. for all buildings and facilities, providing sewerage pumps & pump houses, the pipelines connecting the individual sewage lifting stations with the central STP as per approved lay-out , will be within the scope of this contract.

O. **Other Utility services and Non-plant Building**

- Pipe and Cable racks
- Mill Reject handling compressor room and silo
- DG Building
- Air Washer Building and Compressor House
- Bulldozer shed and auto repair shop
- Ware house and chemical / hazardous stores
- AC Plant room
- VFD Building (if applicable)
- CPU Regeneration building
- Water Harvesting Well
- Guard pond
- Overhead storage water tank for potable water and service water
- Parking Sheds
- Service building including workshop
- Stores complex
- Chemical Lab room cum office with office furniture
- Maintenance Tool Room
- Dress change rooms and Locker rooms for workmen.
- Storage yard including storage sheds
- Canteen building

- Weigh Bridge Control Rooms
- Township
- Security gate and Watch towers in plant and Township
- Potable water system which shall be constructed in the plant at water treatment plant and pipe line shall be laid from PTP system up to 10 m beyond plant boundary as per the route shown during detailed engineering for supply of potable water to colony. Necessary pipeline network shall be provided in the plant by the bidder for supply of potable water in the plant to different locations.

P. **Plant roads and drainage**

- All internal roads, culverts & pavement within the battery limit of this specification.
- Some of the requirement for main roads is indicated on Plot Plan. However, additional roads and access to individual buildings/structures/facilities which are not specifically shown in layout but where access is necessary from inspection, operation & maintenance point of view, they shall be required with suitable designed pavement with RCC and shall be provided by the EPC Contractor.
- The scope shall also include modification and diversion of existing roads, where necessary. Approach road to ash dump area will be in EPC Contractor's scope of work.
- Complete storm water drainage system ~~for Stage 2 areas~~ with garland drains around building/structure/facilities, including providing drainage pumps (if required) along with pump house; storm water drains along both sides of the road, etc. The proposed drainage system with RCC in the plant area shall be suitably designed to discharge the effluents of the plant & storm water and to be connected to existing drains of KTPS-V & VI Stages. The scope shall also include modification and diversion of existing drains, where necessary.

Q. **Miscellaneous scope of work**

- Excavation for foundations and substructures, wherever necessary in all types of soil including shoring, dewatering, filling around foundations and to grade with compaction of fills and approaches.
- Extension of Raw Water Pump House near Godavari river at Burgampahad with additional Raw Water Pump .

- Construction of RCC room for installation of electrical panels for providing construction power supply.

- Laying of water supply lines for providing construction water from given point of source.

- Dismantling of existing structures/roads/culverts. Fouling structures are to be modified /re-laid/re-constructed/dismantled are in the scope of EPC Contractor only.

- Boundary walls, Chain link/barbed wire fencing & gates wherever required around any buildings/area. Any modification to the existing plant boundary wall to make it suitable for the requirement of proposed plant shall be carried out by the EPC contractor.

- Main plant paving including plinth protections around buildings and structures

- All foundations, grouting, embedment, inserts, bolts, etc. required for Ventilation, Dust Extraction, Water supply & Dust Suppression including drainage for the same.

- Civil and Structural work associated with all HVAC equipment and accessories as specified elsewhere in this specification including making of openings in floors / walls / roofs and building insulation as required.

- Civil and structural work associated with complete station lighting including area lighting, yard lighting, road (street) lighting, security lighting, etc. in all the areas.

- Providing High mast lighting in construction areas for illumination of construction works.

- Civil and structural work associated with Plant potable water supply, Potable water over-head tank of adequate capacity, associated pipe support trestles, pedestals & trenches within & outside buildings, all other civil work associated with service water system, etc.

- Slope protection for embankment including required filling work in plinth and plant area and RCC retaining wall along with pile wherever required.

- The scope shall also include all necessary civil work (mainly civil foundation) pertaining to erection of Generator Stator / Transformer including construction of Stator lifting portal foundations or any other equipment if required.

- Arrangement for unloading platform for TG Stator.

- Laying of required railway track necessary for shifting of Transformers/equipment /machinery.
- Construction of RCC pit and pedestals for Boiler Lift.
- Providing rails for electrical panels in HT Switchgear Room.
- All roofs shall be provided with access through M S staircase.
- Minimum 1.2m wide access path with tiles shall be provided on roofs.
- All roofs shall be provided with water proofing treatment.
- The scope shall also include setting up by the Contractor a complete testing laboratory in the field to carry out all relevant tests required for the civil work for the project.
- The land will be given to the Contractor by the Owner. All site investigations, surveys, grading, leveling and dressing and other additional work shall be carried out by the Contractor as per the approved drawing.
- During detail engineering the outfall structure for plant drainage shall be proposed by EPC contractor at a suitable location based on invert levels of existing plant drainage system as well as available contour drawings. The work shall be carried out based drawings to be developed by the Contractor and approved by the Owner.
- The work shall be carried out according to the design / drawings to be developed by the Contractor and approved by the Owner / Owner's authorised Consultant. For all building, structures, foundations, etc., necessary layout and details are to be developed by the Contractor keeping in view of the statutory & functional requirement of the plant & facilities and providing enough space & access for operation, use and maintenance.
- The layout and levels of all structures shall be made by the Contractor at his own cost from the general grid of the plot and the nearest GSI bench mark or other acceptable bench mark of Govt. Dept. The Contractor shall be solely responsible for the correctness of the layout and levels.
- All necessary statutory clearances shall be obtained by the Bidder prior to execution of work under scope of this specification.
- All the quality standards, tolerances, welding standards and other technical requirements shall be strictly adhered to by the Contractor

2.01.00 **List of Exclusions**

a) Bidder to refer to the plot plan for existing facilities excluded from EPC Contractor's scope of work. Demolition of existing quarters, leveling and grading of the site will be taken up by TSGENCO, however any civil/structural work required to make the existing facilities compatible to the new facilities of proposed plant, shall be within the bidder's scope.

2.02.00 **Terminal Points**

Storm and Plant drainage	As per plot plan
Plant Service Road	Existing Plant Road
Sanitary Facilities	As required
Site Grading	As per plot plan
Site Battery limit boundary/ fencing	As per plot plan
Ash pond	As per plot plan

2.03.00 **Notes**

a) This section shall be read in conjunction with Lead Specification and General conditions of contract.

b) For Architectural requirements of the plant General Specification and Design Criteria for Architectural Work - Volume VII-B and Technical Specification for Civil, Structural and Architectural Work - Volume VII-C of this Bid Document to be referred.

c) In the event, any contradictions, confusion arises for any statement / condition / terms pertaining to design of civil engineering systems, stated elsewhere in addition to this section, the statement furnished in this section shall prevail.

d) In the event, the bidder notice any inadvertent error / mistake published in the specification, the same shall be immediately brought to notice of the Owner.

3.00.00 **CODES AND STANDARDS**

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

3.01.00 **General**

a) Internationally accepted design Codes and Standards where Indian Codes are not available and which are equivalent to Indian Standards.

b) National Building Code of India.

c) "Accepted Standards" and "Good Practice" listed in the appendix to National Building Code of India.

d) IS-1200 : Method of measurement of Building and Civil Engineering Work.

e) IS-1256 : Code of Practice for Building Byelaws.

f) APDSS where ever a) to e) does not speak off.

3.01.01 **Earthwork**

a) IS-1498 : Classification and identification of soils for General Engineering purposes.

b) IS-3764 : Safety Code for excavation work.

c) IS-7293 : Safety Code for working with construction machinery.

3.01.02 **Concrete**

a) IS-269 : Ordinary and low heat portland cement.

b) IS-383 : Coarse and fine aggregate from natural sources for concrete.

c) IS-432 : Mild Steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.

d) IS-455 : Portland Slag Cement.

e) IS-456 : Code of Practice for Plain and reinforced concrete.

f) IS-460 : Test Sieves (all parts).

g) IS-516 : Methods of test for strength of concrete.

h) IS-1199 : Methods of sampling and analysis of concrete.

i) IS-1566 : Hard drawn steel wire fabric for concrete Reinforcement.

j) IS-1786 : High strength deformed steel bars and wires for concrete reinforcement.

k) IS-1834 : Hot applied sealing compounds for joints in concrete.

l) IS-2386 : Methods of test for aggregates for concrete (all parts).

m) IS-2502 : Code of practice for bending and fixing of bars for concrete reinforcement.

n) IS-3370 : Code of practice for concrete structures for storage of liquids (all parts).

o) IS-3414 : Code of practice for design and installation of joints in buildings.

p) IS-4948 : Welded steel wire fabrics for general use.

q) IS-6452 : High Alumina Cement for Structural use.

r) IS-7320 : Concrete slump test apparatus.

s) IS-7861 : Code of practice for extreme weather concreting (all parts).

t) IS-8041 : Rapid Hardening Portland Cement.

u) IS-8112 : High strength ordinary Portland Cement.

v) IS-10262 : Recommended guidelines for concrete mix design.

w) IS-12269 : 53 grade ordinary Portland Cement

3.01.03 **Foundations**

a) IS-1904 : Code of practice for structural safety of buildings : Shallow foundations.

b) IS-2950 : Code of practice for design and construction of raft foundations.

c) IS-2974 : Code of practice for design and construction of Machine foundations (all parts).

d) IS 2911 : Code of practice for Design and Construction of Pile Foundation.

3.01.04 **Loading**

a)	IS-875	:	Code of practice for Structural safety of buildings - loading standards.
b)		:	Bridge Rules of Government of India, Ministry of Railways (Railway Board).
C)	IS 4995	:	Criteria for design of RC bins for storage of granular and powdery materials.

3.01.05 **Masonry**

a)	IS-712	:	Building limes.
b)	IS-1077	:	Common Burnt Clay Building Bricks.
c)	IS-1127	:	Recommendations for dimensions and workmanship of natural building stones for masonry work.
d)	IS-1528	:	Methods of sampling and physical tests for refractory materials.
e)	IS-1597	:	Code of practice for construction of stone masonry (all parts).
f)	IS-2212	:	Code of practice for brickwork.
g)	IS-2116	:	Sand for masonry mortars
h)	IS-2185	:	Concrete masonry units. (all parts - Hollow and Solid concrete blocks).
i)	IS-2250	:	Code of practice for preparation and use of masonry mortars.
j)	IS-2572	:	Code of practice for construction of hollow concrete block masonry.
k)	IS-2691	:	Burnt clay facing bricks.
l)	IS-3414	:	Code of practice for design and installation of joints in buildings.
m)	IS-3495	:	Methods of tests of burnt clay building bricks.
n)	IS-4441	:	Code of practice for use of Silicate type chemical resistant mortars.
o)	IS-4860	:	Acid Resistant Bricks.

3.01.06 **Doors, Windows and Ventilators**

a)	IS-399	:	Classification of commercial timbers and their zonal distribution.
b)	IS-883	:	Code of practice for design of structural timber in building.
c)	IS-1003	:	Timber paneled and glazed shutters (all parts).
d)	IS-1038	:	Steel doors, windows and ventilators.
e)	IS-1081	:	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
f)	IS-1361	:	Steel windows for industrial buildings.
g)	IS-2835	:	Transparent sheet glass for glazing and framing purposes.
h)	IS-1948	:	Aluminium doors windows and ventilators.
i)	IS-1949	:	Aluminium windows for industrial building.
j)	IS-2191	:	Wooden flush door shutters (Cellular and hollow core type).
k)	IS-2202	:	Wooden flush door shutters (solid core type).
l)	IS-3103	:	Code of practice for Industrial ventilation.
m)	IS-3548	:	Code of practice for glazing in buildings.
n)	IS-3614	:	Fire check doors.
o)	IS-4021	:	Timber door, windows and ventilator frames.
p)	IS-4351	:	Steel door frames.
q)	IS-6248	:	Metal rolling shutters and rolling grills.

3.01.07 **Roof and Flooring**

a) IS-2204 : Code of practice for construction of reinforced concrete shell roof.

b) IS-3201 : Criteria for the design and construction of precast concrete trusses.

c) IS-2210 : Criteria for Design of R.C. shell structures and folded plates.

d) IS-809 : Rubber flooring materials for general purposes.

e) IS-1195 : Bitumen mastic for flooring.

f) IS-1196 : Code of practice for laying bitumen mastic flooring.

g) IS-1198 : Code of practice for laying, fixing and maintenance of linoleum floors.

h) IS-1237 : Cement concrete flooring tiles.

i) IS-1443 : Code of practice for laying and finishing of cement concrete flooring tiles.

j) IS-2114 : Code of practice for laying in situ terrazzo floor finish.

k) IS-2571 : Code of practice for laying in situ cement concrete flooring.

l) IS-5491 : Code of practice for laying in situ granolithic concrete floor topping.

m) IS-5766 : Code of practice for laying burnt clay brick flooring.

n) IS-1197 : Code of practice for laying of rubber floors.

o) IS-2441 : Code of practice for fixing ceiling coverings.

3.01.08 **Waterproofing**

a) IS-1322 : Bitumen felts for waterproofing and damp proofing.

b) IS-1346 : Code of practice for waterproofing of roofs with bitumen felts.

c) IS-1609 : Code of practice for laying damp proof treatment using bituminous felts.

d) IS-3036 : Code of practice for laying lime concrete for a waterproofed roof finish.

e) IS-3037 : Bitumen mastic for use in waterproofing of roofs.

f) IS-3067 : Code of practice for general design, details and preparatory work for damp proofing and water proofing of buildings.

g) IS-3384 : Bitumen primer for use in water proofing and damp proofing.

h) IS-4365 : Code of practice for application of bitumen mastic for waterproofing of roofs.

3.01.09 **Soil Engineering**

a) IS-1498 : Classification and identification of soils for general engineering purposes.

b) IS-1892 : Code of practice for sub-surface investigation for foundations.

c) IS-2131 : Method for standard penetration test for soils.

d) IS-2720 : Methods of test for soils (all parts).

3.01.10 **Water Supply, Drainage and Sewerage**

a) IS-404 : Lead pipes

b) IS-458 : Concrete pipes

c) IS-651 : Salt glazed stoneware pipes and fittings.

d) IS-771 : Glazed fire-clay sanitary appliances (all parts).

e) IS-774 : Flushing cisterns for water closets and urinals other than plastic cisterns.

f) IS-783 : Code of practice for laying of concrete pipes.

g) IS-1172 : Code of basic requirements for water supply, drainage and sanitation.

h) IS-1626 : Asbestos cement building pipes, gutters and fittings (all parts).

i)	IS-1742	:	Code of practice for building drainage.
j)	IS-2064	:	Code of practice for selection, installation and maintenance of sanitary appliances.
k)	IS-2065	:	Code of practice for water supply in buildings.
l)	IS-2470	:	Code of practice for installation of septic tanks (all parts).
m)	IS-3114	:	Code of practice for laying of Cast Iron pipes.
n)	IS-4127	:	Code of practice for laying of glazed stoneware pipes.
o)	IS-12251	:	Code of practice for Drainage of Building Basement.
p)	IS-1200	:	Method of measurement: Laying of water and [Part-XVI] sewer lines including appurtenant items.
q)	IS-1536	:	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
r)	IS-1537	:	Vertically cast iron pressure pipe for water, gas and sewage.
s)	IS-3486	:	Cast iron spigot and socket drain pipes.
t)	IS-5329	:	Code of practice for sanitary pipe work above ground for buildings.
u)	IS-3076	:	Low density polyethylene pipes for potable water supplies.
v)	IS-1538	:	Cast iron fittings for pressure pipes for water, gas and sewage.
w)	IS-1230	:	Cast iron rainwater pipes and fittings.
x)	IS-1729	:	Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
y)	IS-784	:	Prestressed concrete pipes.
z)	IS-1726	:	Cast iron manhole covers and frames.
aa)	IS-5961	:	Cast iron grating for drainage purposes.
bb)	IS-5219 [Part-I]	:	"P" and "S" traps.

cc) IS-772 : General requirements for enamelled cast iron sanitary appliances.

dd) IS-775 : Cast iron brackets and supports for wash basins and sinks.

ee) IS-777 : Glazed earthenware wall tiles.

ff) IS-2548 : Plastic water closet seats and covers (all parts).

gg) IS-2527 : Code of practice for fixing rainwater gutters and downpipes for roof drainage.

3.01.11 **Paving and Road work**

a) IS-73 : Paving bitumen

b) IS-702 : Industrial Bitumen

c) IS-1201 : Method of testing tar and bituminous materials. thru' 1220

d) Practice followed by Indian Road Congress (all parts).

3.01.12 **Earthquake Resistant Design**

a) IS-1893 : Criteria for earthquake resistant design of structures.

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

3.01.13 **Chimney**

a) IS-4998 : Criteria for Design of R.C. Chimneys (all parts).

3.01.14 **Structural Steelwork**

a) IS-800 : Code of practice for general construction in steel.

b) IS-802 : Code of practice for use of structural steel in Overhead Transmission Line.

Part-I : Load and permissible stresses.

Part-II : Fabrication, Galvanizing, Inspection & Packing.

c) IS-806 : Code of practice for use of steel tubes in general building construction.

d)	IS-808	:	Rolled steel beams, channels and angle sections.
e)	IS-813	:	Scheme of symbols for welding.
f)	IS-814	:	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.
g)	IS-816	:	Code of practice for use of metal arc welding for general construction in mild steel.
h)	IS-817	:	Code of practice for training and testing of metal arc welders.
i)	IS-818	:	Code of practice for safety and health requirements in electric and gas welding and cutting operation.
j)	IS-819	:	Code of practice for Resistance spot welding for light assemblies in Mild Steel.
k)	IS-919	:	Recommendations for limits and fits for engineering.
l)	IS-1024	:	Code of practice for use of welding in Bridges and Structures subjected to Dynamic loading.
m)	IS-1161	:	Steel tubes for structural purposes.
n)	IS-1182	:	Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
o)	IS-1200 [Part-VIII]	:	Method of measurement of steelwork and ironwork.
p)	IS-1239	:	Mild steel tubes, tubulars and other wrought steel fittings (all parts).
q)	IS-1363	:	Black hexagonal bolts, nuts and locknuts (dia. 6 to 39 mm) and black hexagon screws (dia.6 to 24 mm). [all parts]
r)	IS-1364	:	Precision and semi-precision hexagon bolts, screws, nuts and locknuts (dia. range 6 to 39 mm). [all parts]
s)	IS-1365	:	Slotted counter sunk head screws (dia. range 1.6 to 20 mm).
t)	IS-1367	:	Technical supply conditions for threaded steel fasteners.

u)	IS-1443	:	Code of practice for laying and finishing of cement concrete flooring tiles.
v)	IS-1608	:	Method for tensile testing of steel products.
w)	IS-1730	:	Dimensions for steel plate, sheet and strip for structural and general engineering purpose.
x)	IS-1731	:	Dimensions for steel flats for structural and general engineering purposes.
y)	IS-1852	:	Rolling and cutting tolerances for hot rolled steel products.
z)	IS-1977	:	Structural steel (Ordinary quality)
aa)	IS-2016	:	Plain Washers
bb)	IS-2062	:	Steel for General structural purposes.
cc)	IS-2074	:	Ready mixed paint, air drying, red oxide zinc-chrome, priming.
dd)	IS-2633	:	Methods of testing uniformity of coating of zinc coated articles.
ee)	IS-3613	:	Acceptance tests for wire-flux combinations for submerged-arc welding of structural steels.
ff)	IS-3664	:	Code of practice for Ultrasonic Pulse echo testing by contact and immersions methods.
gg)	IS-3757	:	High strength structural bolts.
hh)	IS-4000	:	High strength bolts in steel structures.
ii)	IS-4759	:	Hot dip zinc coatings on structural steel and other allied products.
jj)	IS-5334	:	Code of practice for Magnetic Particle Flaw detection of welds.
kk)	IS-7215	:	Tolerances for fabrication of steel structures.
ll)	IS-7280	:	Base-wire electrodes for sub-merged arc welding of structural steels.
mm)	IS-7318 [Part-I]	:	Approval test for welders when welding procedure approval is not required.

nn) IS-8500 : Structural steel – micro-alloyed (medium and high strength qualities).

oo) IS-9595 : Recommendation for metal arc welding of carbon and carbon manganese steels.

pp) AWS D.1.1 Structural Welding Code.

3.01.15 **Painting**

a) IS-348 : Specification for French Polish.

b) IS-427 : Specification for Distemper, dry colour as required.

c) IS-428 : Specification for Distemper, oil emulsion, colour as required.

d) IS-1477 [I & II] : Code of practice for painting of ferrous metal in buildings.

e) IS-2338 [I & II] : Code of practice for finishing of wood and wood based materials.

f) IS-2339 : Specification for Aluminium Paints for general purposes in dual containers.

g) IS-2395 : Code of practice for painting concrete, masonry and plaster surface.

h) IS-2932 : Specification for enamel, synthetic, exterior - a) undercoating, b) finishing.

i) IS-2933 : Specification for enamel, exterior - a) undercoating, b) finishing.

j) IS-5410 : Specification for cement paint.

3.01.16 a) Indian Road Congress (IRC) Bridge Codes

b) Indian Railway Standard Bridge Rules

3.01.17 **Environmental Protection**

Chapter on Corporate Responsibility for Environmental Protection (CREP) published in Gazette of India dated 27.08.2003.

4.00.00 UNITS AND LANGUAGE

4.01.00 Drawings

- All dimensions will be in SI Units - Metric (English)
- Scales
  - Planning Drawings: Site Layout & Elevations will be at 1:500, Section & Elevation of each building will be at 1:200.
  - Structural and architectural Plans, sections, and elevations will generally be at 1:100 and/or 1:50; for architectural and civil details; 1:1, 1:5, 1:10, 1:20 as required will be used.
  - Site work and yard piping plans will generally be at 1:200, 1:500
- Text will be in English language

4.02.00 Units for Calculations

All calculations will be in SI (English) units.

Length	mm, M
Area	mm^2, M^2
Volume (solids)	mm^3, M^3
Volume (liquids)	mm^3, M^3, liter
Density	kN/M^3
Force	N, kN
Pressure (piping)	Bar
Moment	kNM
Stress	Mpa, N/mm^2
Distributed loads, ground pressures, etc.	kN/M^2

English language will be used in calculations

5.00.00 GENERAL SITE INFORMATION

The site is located within the premises of existing Kothagudem Thermal Power Station which already accommodates 4x60+4x120+2x250+1x500 =1720 MW units. One 800 MW supercritical unit will be installed for augmentation of total plant capacity .

For the proposed 1x800 MW extension unit, main plant, equipments, facilities and green belt will be accommodated in existing 'D' colony of the thermal power station. 230 acres land will be acquired for expansion of existing ash pond for the proposed unit. The existing ground level of the plot is approximately varies from at 85-90 M above MSL.

Meteorological Data	
Site Conditions :	
Annual mean daily maximum temperature	44.7 degree C
Annual mean daily minimum temperature	13.5 degree C
Design Flood Level	Not known
Seismic Criteria	Zone -III
Wind Design	Basic Wind Speed, Vb = 44m/s
Average Annual Rainfall	1124 mm
Maximum Hourly Rainfall Intensity	102 mm

6.00.00 SITE DEVELOPMENT AND UTILITIES

6.01.00 Plant Coordinate System

- The site will be surveyed and coordinates for all points be determined.
- The surveying contractor will establish plant benchmarks and North/South and East/West control lines for control of construction on the plant site. The North/South and East/West control lines will be developed based on grid systems of the existing Plant.
- To facilitate design and construction, a plant grid system and plant north will be established. The plant coordinate system will be laid out based on this grid.
- The plant coordinate system will be indicated on the Plot Plan Drawing.

6.02.00 Grading

The plot of land for the proposed project is graded land with difference in ground level upto 7 meters. Different FGL for different blocks of the plant are shown in the plot plan. However, this is preliminary and contractor has to finalise the levels during detail engineering considering natural contours, successful operation of proposed and existing plants, proper drainage, roadways and other system and utility connectivity.

The existing ground level of the plot is approximately varies from at 85-90 M above MSL. All plant levels referred as RL will be with respect to Mean Sea Level (MSL) and all plant elevations referred as EL will be with respect to Power House Building Ground Floor elevation as 0.0M. The site bench mark will be established by the contractor accordingly.

- The road levels will generally be at 150 mm above FGL
- The finished floor level of ground floor of all the buildings will generally be at 500 mm above FGL
- The top of grout (under side of equipment base/base plate) for foundations and structures outside building at grade will generally be 200 mm above finished grade. The top of grout (under side of equipment base/base plate) for all equipment foundation at ground floor within the building will generally be 150mm above finished floor unless dictated otherwise by mechanical / electrical system layout.
- Base plates for structural steel building columns will generally be sufficiently below ground floor in order to keep enlarged portion of gusseted base below ground. This portion shall be encased in concrete for corrosion protection.

6.03.00 Drainage

6.03.01 General

Drains shall be designed as a network covering the plant area within the battery-limit of this specification. Attempts shall be made to convert construction drains into main drain as far as practicable. The invert of the in-plant peripheral drains shall be kept such that water can be discharged by gravity to the main/trunk drain under all condition.

The plant shall be provided with gravity drainage systems for the followings :

- Storm water Drainage
- Plant Drainage including Oily Water/ equipment process/chemical waste water
- Sanitary waste/ Foul water Drainage

6.03.02 Storm Water Drainage System

Storm water runoff is runoff from plant areas not subjected to contamination and will be discharged to terminal point via new lifting station if required any. Examples of such areas include building roofs, roads, paved areas, stone surfaced areas, grass surfaced areas, and other natural surfaced areas.

Storm water will be collected via a surface drainage system consisting of open drains, gulley pits or catch basins, manholes and below grade pipe system to terminal points

For buildings that have a gutter and downspout system, the downspouts will empty to gullies or inspection chambers with sand trap at ground level before discharge to the main drainage system. Drainage from Basements, Cable and pipe trenches will be routed to sumps and connected to the storm water drainage system by pumping system.

The storm water drainage system shall be designed with maximum hourly intensity of rainfall and its duration.

For pitched roof with metal sheeting a minimum slope of 1 (V) to 5 (H) and for flat roof a minimum slope of 1(V) to 50 (H) will be provided for efficient drainage of rain water. The maximum velocity for pipe drains and open drains will be limited to 2.4 M/sec and 1.8 M/sec respectively. However, minimum velocity for self cleansing of 0.6 M/sec will be ensured. Bed slope will not be milder than 1 in 500.

Cast iron pipes will be used below buildings and HDPE pipes will be used for below grade piping drainage system. Manhole will be provided at every 50 M interval, at connection points and at change of alignment.

Run-off coefficient for open ground area (unpaved) shall be minimum 0.80 and for paved area and other covered surface including roads the same shall be considered as 1.0.

Design considerations

i) Major drains will be of open type RCC construction with rectangular section and minor drains will be of brick masonry. R.C.C./brick drains shall be covered with perforated R.C.C. pre-cast slab (M-30) of minimum 50mm thickness with edge protection angles at all the side and with the provision of openable galvanized steel grating covers at every 4.0m intervals.

ii) In areas where vehicular loads would be coming, pre-cast RCC covers of suitable thickness with edge angles on all the corners without perforations and designed for the vehicular loads shall be provided.

iii) In Boiler and ESP area, drains shall be provided with galvanized steel gratings using 6 mm thick flat for both bearing and cross bars with class-1 galvanization. For areas covering vehicular movement, pre-cast covers shall be provided. The width of the pre-cast planks shall be so designed that it can be easily handled during maintenance period.

iv) Suitably designed underground storm water RCC piping on the basis of design loads specified elsewhere in this specification shall be limited to required areas where surface drainage ways are not desirable or practicable from other functional point of view.

v) RCC pipe culverts/box culverts shall carry drainage under intercepting roads and railway tracks.

vi) Class of RCC pipes shall be decided by Bidder as per design requirement. For pipe drains, concrete pipes of minimum grade – Class NP2 shall be used. However, for road concrete pipes of Class NP3 shall be used and for rail crossing, railway norms shall be followed.

vii) Surface drains shall normally have a slope of 1 IN 1000 along longitudinal direction and RCC pipes to have such slopes such as to have effective discharge.

viii) RCC or masonry structures shall be provided at drops/falls to prevent scouring. Drops/falls shall be provided on both sides of box/pipe culverts.

ix) Minimum self-cleansing velocity should be adopted as 0.7m/sec but the velocity of flow should not be more than 1.83 m/sec for brick drain and 2.4 m/sec for concrete drain, however, it is recommended to maintain the maximum velocity within 1.2 m/sec.

6.03.03 **Plant Drainage System**

Oily waste water will pass through oil water interceptor and then combined with storm water drainage system for ultimately discharged to terminal point. Oily waste water will include surface run off from transformer compounds, building floors and drains from other oil contaminated areas

Oily waste water will be collected via a surface drainage system consisting of open drains, gulley pits or catch basins and below grade pipe system to terminal points. In general, any surface drainage will be designed so that vehicles and equipment can drive over the finished surface.

The contaminated surface water runoff from rain will be designed for maximum hourly rainfall intensity.

The drainage from transformer pit will be stored in a collecting tank and subsequently passed through oil water interceptor before connecting to the storm water drainage system.

The maximum velocity for pipe drains and open drains will be limited to 2.4 M/sec and 1.8 M/sec respectively. However, minimum velocity for self cleansing of 0.6 M/sec will be ensured. Bed slope will not be milder than 1 in 500.

Cast iron oily pipes will be used below buildings and ductile iron cement lined oily line will be used outdoors. Manhole will be provided at every 50 M interval, at connection points and at change of alignment.

6.03.04 **Sanitary Waste Sewer / Foul Water Drainage System**

The sanitary waste/ foul water will be discharged to gravity fed foul manhole and then to a sewage treatment plant.

HDPE pipes shall be used for drainage. Sewers will be designed for a minimum self-cleansing velocity of 0.70 m/sec and the maximum velocity will not exceed 2.4 m/sec.

Manhole will be provided at every 50 meter along the length, at connection points and at every change of alignment, gradient or diameter of sewer pipeline.

The slope of sanitary pipe within the buildings will equal 20 mm per meter (1:50). Piping outside the buildings will be designed to maintain a minimum self-cleansing velocity with slopes not milder than 1 in 500.

Manual on Sewerage and Sewage treatment (published by Central Public Health Environment Engineering Organization, Government of India) shall be followed for design purpose.

6.04.00 **Roads**

All new roads, hardstands will be provided to have accessibility to the plant where required and to be connected with the existing road network at suitable points..

- Minimum carriageway and shoulder width shall be as listed below. Shoulders width shall be added to the carriageway widths to obtain minimum roadway widths.

Road Type	Classification	Carriageway Width (m)	Shoulder (m)	Roadway Width (m)
1.	Primary Road (Peripheral)	12.0	2.0	16.0
2.	Primary Road (internal Road)	7.0	1.5	10.0
3.	Accessways	4.0	-	4.0

- All internal roads in Power House area from Switch Yard to Chimney area including roads around Power House shall be Cement Concrete (CC) roads and all other roads within the battery limit of this package shall be water bound macadam with RCC topping on prepared sub grade with 300 mm minimum soling for heavy vehicles.

- All internal roads in Power House area from Switch Yard to Chimney area including roads around Power House shall be Cement Concrete (CC) roads with Vaccum Dewatered Flooring (VDF) concrete and other plant roads with bitumen macadam, water bound macadam base and sub-base shall be as per IRC standards with 300 mm minimum soling. Minimum total thickness of black topping (premix carpeting) shall be 50 mm in 2 layers of 25 mm each. Bituminous topping of all plant roads shall be done after completion of plant construction.

  For premix carpet, recommendation of IRC-14 shall generally be followed. Spreading of black topping work shall be carried out using mechanical paver / finisher.

- RCC pavement with Vaccum Dewatered Flooring (VDF) concrete shall be provided at areas requiring parking facilities.

- A detailed CBR test shall be carried out as per the procedure outlined in IS:2720 (Part XVI).

- For road crossing of pipelines supported on ground, the pipe top level generally shall not be more than 100mm above the top of the road. Suitable hump with slope not steeper than 1:30 shall be provided for the roads. Necessary modification shall be done by the Bidder for the roadside drains.

- Roads shall be designed as per IRC-37:1984 “Guidelines for the design of flexible pavements”. California Bearing Ratio (CBR) method shall be adopted for the design of roads.

  The geometric design of roads shall be done in accordance with IRC-73. Road widths, curves and parking areas shall have adequate space for maneuvering of vehicles. The ruling gradient for roads in longitudinal direction shall be 1 in 30. Normally the roads shall have much flatter gradient. Transverse camber of 1 in 60 shall be provided for the black topping of roads and a slope of 1 in 40 shall be provided on shoulders. Finished top (crest) of roads shall be 250 mm above the surrounding ground level.

  Shoulders shall be formed with gravel on par with the road level.

6.04.01 **Pavement/Footpaths in Other areas**

Paving as required will be provided using interlocking pre-cast concrete block.

Surface Treatment

a) **Main plant Area**

The entire area from Power House to Chimney shall be paved with reinforced cement concrete with Vaccum Dewatered Flooring (VDF) concrete and sloped to drains.

b) **Transformer Area & Switchyard**

Oil cooled equipment, such as transformers, shall be located within concrete basins filled with HBG metal. The individual basins shall be connected by pipeline to a separate chamber/oil pit for collection and further reclamation of oil through oil water separators, if necessary.

Drains shall be adequate to remove full discharge from deluge system used for fire control. Transformer Yard shall be paved with reinforced cement concrete with Vaccum Dewatered Flooring (VDF) concrete.

Switchyard area excluding the internal access roads shall be paved with ash bricks on edge over a layer of 100 mm thick lean concrete (M10) as specified elsewhere of this specification. Anti-weed chemical treatment as per specification to be done as required.

c) **Cooling Tower Area**

Paving in this area shall be as specified in Volume VII-D Technical Specification for Natural Draft Cooling Tower

d) Necessary pavement, surface treatment shall be done for Coal handling, DM plant and PT plant.

6.05.00 **Fencing**

6.05.01 Fencing with gates shall be provided around transformer yard, Switchyard, fuel oil area and other areas wherever necessary due to security, safety, and statutory requirements as per following specifications.

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 shall 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 shall 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 shall 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 shall 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 shall have two stay posts and every tenth post shall 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 75 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.

All gates shall be of structural steel of minimum 3.75 metres clear width for single lane access road and 7.75 m clear width for double lane access roads. The height of gate shall be same as that of the fence. 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.

6.06.00 **Electrical Conduit Protection**

All electrical conduits (duct bank) laid under ground will be encased in concrete. Reinforcements will be provided in the encased concrete at main traffic crossings and other areas requiring access during construction based on the final design and the Construction Sequence.

6.07.00 **Pipe and Electrical Concrete Trenches**

Generally pipe or electrical cables will be taken through concrete trenches with precast concrete covers. Suitable drainage and working arrangement inside trench shall be provided. The trench cover shall be provided with edge protection angles and lifting devices. Suitable inserts and opening shall also be provided as per service requirement. Precast covers for trenches shall be light weight and shall not weigh more than 65 Kg. each.

CW pipe line will be constructed by providing suitable supporting pedestals at 10 mts interval and burring the pipe in a trench after being rapid coated with bitumen bound approved coating. Pipe bed will be made of 500 mm thick, well compacted sand and sand fill will be packed at both sides upto 50% diameter of the pipe, followed by filling up rest of the portion by good selected earth so as to have min. 1.5m of earth cushion over the pipe. While crossing the road & railway suitable road/rail structure will be considered as per relevant IRC codes & loading specified elsewhere in this specification.

Generally all cableways outside building will be either through concrete underground duct banks housing PVC pipes or overhead on pipe rack except for HV cables which will be through trench. However, any trenches located outside buildings will project 150 mm above the finished formation level to avoid ingress of storm water. The bottom of trench will be sloped suitably for draining out the collected water into sump pit.

6.08.00 **Electrical Manholes**

Cast-in-place, reinforced concrete manholes will be provided as required to meet the electrical system construction requirements.

Drainage sumps will be included in all manholes to improve ability to remove water from manholes. The use of portable pumps to remove water from manholes will be considered.

7.00.00 GEO-TECHNICAL CRITERIA

7.01.00 General Description of Soils

Owner has carried out preliminary geotechnical investigation in the proposed power plant area. Representative borelog details along with the recommendations given in soil report shall be considered by the Contractor for reference only. Contractor shall make his own assessment for the type of foundations envisaged based on his site visit and data collected from site during the site visit. In any case, the contractor has to carry out detailed geo technical investigation after the award of contract, through approved/reputed agency and to submit geotechnical investigation report with recommendations for the Owner's review and approval. The recommendation given in approved final report becomes binding on the Contractor. The Contractor is not eligible to increase his cost or demand any extension of time if the final report is in variance from preliminary report furnished by the Owner. The preliminary geotechnical investigation report is available with the owner and will be furnished for reference on request.

7.02.00 Ground Water and Dewatering Requirements

GWT is located at about 2.5M to 3.5M below the existing ground level shown in contour map attached as Annexure 1 . HHFL is about 88M. However, the bidder has to determine the exact GWT during detailed engineering based on soil investigation at his scope.

7.03.00 Excavation Criteria including De-watering

Unless otherwise specifically mentioned in geo-technical report this shall be followed.

Excavation shall be carried out in all types of soil including soft soil, soft moorum, hard moorum, soft rock, hard rock etc.

After excavating to the founding level, the exposed sub-grade will be inspected and proof rolled, if required, prior to placing lean concrete for subsequent placing of rebar, setting forms and placing concrete. Soft or yielding areas will be excavated and replaced with compacted backfill. Bearing grades will be cleaned and kept dry prior to placing concrete.

Excavations will be maintained and protected against earth collapse from natural causes or subsequent construction work and will have stable slopes, as appropriate, to meet local soft conditions and safety codes.

Dewatering wherever is necessary has to be done at bidder's cost only.

7.04.00 **Backfill Criteria**

Site-excavated material free from unsuitable material or non-expansive bottom ash or pond ash may be used as backfill against pit and sump walls and as structural fill beneath foundations if suitable.

Off-site material if required to be used for backfill, it will be fully tested and installed as per the project specifications.

7.05.00 **Compaction Criteria**

Fill and backfill material will be as recommended in the Geo-technical Report and as required by project specification requirements.

Material used as structural fill (load bearing) beneath structures and roads will be compacted to a minimum of 95% of the maximum dry density (modified Proctor). Moisture content of material will not deviate more than 2 percent of optimum.

Material used as backfill (non load bearing) around structures will be compacted to a minimum of 90% proctor density. Natural moisture content of material will not deviate more than 3 percent of optimum.

8.00.00 **LOAD AND STABILITY CONSIDERATIONS**

8.01.00 Loads and their Combinations

All structures and portions thereof shall conform to the latest revision of relevant Indian Standard specifications and also to the various other technical requirements. Any structure which carries Indian Railway Loading or is situated in the vicinity of Railway Lines, the design has to conform to the Indian Railway Standard Specifications and approval must be obtained from Railway Authority including the clearance etc. All structures and foundations shall be designed for most critical combinations of dead load, live load, equipment load, pipe and cable tray loads, crane loads, wind loads, seismic loads, temperature loads and special loads as applicable as per requirement of relevant codes and standard.

A. **Dead Loads**

Dead load shall include the weight of all structural components and architectural appurtenances incorporated in the structures plus hung loads and any other permanent, externally applied load. This should also include equipment dead load. The content of tanks, silo, bins and hoppers shall be measured at full capacity for this purpose. Hung loads and the contents of tanks, silo, bins and hoppers shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing loads for uplift.

The following unit weight of material shall be considered for computation of loads. Loads given in IS:875 (part-I) shall be made use of for material not listed below.

Materials		**Unit weight**
Plain cement concrete	:	24.0 kN/cum
Reinforced cement concrete	:	25.0 kN /cum
Structural steel	:	78.5 kN /cum
Brick work	:	19.0 kN /cum
Cement plaster	:	21.0 kN /cum
Floor Finish, screed concrete, Plaster	:	24.0 kN /cum
Steel grating floor	:	0.5 kN/sq.m
Checkered plate cover	:	0.5 kN/sq.m
False floor	:	1.0 kN/sq.m
False ceiling in control and Electric rooms	:	0.4 kN/sq.m
Metal decking	:	0.15 kN/sq.m
Insulated metal siding	:	0.25 kN/sq.m
Non insulated metal siding	:	0.15 kN/sq.m
Masonry unit with plaster on Both sides :		
230 mm nominal thickness	:	4.95 kN/sq.m
115 mm nominal thickness	:	2.47 kN/sq.m
Coal	:	12.0 kN /cum
Fly Ash	:	16.0 kN /cum
Bottom Ash	:	16.0 kN /cum

B. **Live Loads**

Live loads in different areas shall include dust loads, minor equipment loads, cable trays, small pipe racks/hangers, operation/maintenance loads etc. The loads considered shall not be less than those specified in IS: 875 (Part II).

The loads listed hereunder are minimum loads for the areas involved. Special use areas shall be investigated and loading revised upward as necessary. Hung loads shall be based on minimum loading equivalents of 1.0 kN/Sq.m for piping and 0.5 kN/Sq.m for electrical, ventilation and air conditioning. Loadings resulting from concentrations of facilities in specific areas shall be substituted where listed base loading is excluded.

i) **All Buildings**

a) Roofs :

Inaccessible roof	:	0.075 kN/Sq.m + hung loads, if any + 0.5 kN/Sq.m (dust load).
Accessible roof where equipments are placed	:	5 kN/Sq.m + hung loads, if any + 0.5 kN/Sq.m (dust load).
Accessible roof without equipments	:	1.5 kN/Sq.m + hung loads, if any + 0.5 kN/Sq.m (dust load).

b) Stairs & Platforms : 5.0 kN/Sq.m

c) Corrridors : 5.0 kN/Sq.m

d) Removable gratings, chequered plates, walkways etc. : 5.0 kN/Sq.m (for supporting beams)

7.0 kN/Sq.m (for grating/ chequered plate)

e) Office, Laboratory, Conference rooms and other non-plant areas etc. : 5.0 kN/Sq.m

ii) **Power House Building**

a)	Ground Floor		
	Unloading Bay	:	35 kN/Sq.m
	Other areas	:	20 kN/Sq.m
b)	Mezzanine Floor	:	15 kN/Sq.m plus hung loads.
c)	Operating Floor		
	T.G. Lay-down Area	:	25 kN/Sq.m plus hung loads or actual load furnished by equipment supplier whichever is higher
	Other Areas in Turbine Hall	:	25 kN/Sq.m plus hung loads
	Rotor removal area beams shall also be checked for half the rotor load at the center of the beam		
	Other Areas in Operating Floor	:	15 kN/Sq.m plus hung loads
d)	Cable Spreader Floor	:	7.5 kN/Sq.m plus hung loads
e)	All other floors	:	15 kN/Sq.m plus hung loads
f)	Due to anchoring of conductors on "A" row column	:	2 x 20 = 40 kN (Twin ACSR Moose Conductor) and 10 kN (Sheilding Wires) OR actual load furnished by equipment supplier

iii) **Mill Building, Bunker and coal handling system**

a)	Ground Floor	:	25 kN/Sq.m
b)	Feeder Floor	:	15 kN/Sq.m + hung loads + 0.5 kN/Sq.m (dust load).
c)	Tripper Floor	:	10 kN/Sq.m + hung loads + 0.5 KN/Sq.m (dust load).

d)	Coal Weight	:	8.0 kN/Cu.M for storage volume calculation
		:	12.0 kN/Cu.M for load calculation

iv) **Auxiliary Buildings**

a)	Ground Floor	:	10 kN/Sq.m
b)	Cable Spreader Floor	:	7.5 kN/Sq.m
c)	Pump House Operating Floor	:	10 kN/Sq.m
d)	Office Floor	:	5 kN/Sq.m
e)	Switchgear room	:	15 kN/Sq.m
f)	All other Floors	:	10 kN/Sq.m

v) **Non Plant Buildings**

a)	Floors with equipment	:	10 kN/Sq.m
b)	All other floors	:	5 kN/Sq.m

vi) **Underground Structures/Trenches/pits**

Minimum surcharge shall be 10 kN/Sq.m. For structures in vicinity of roads and heavy vehicular movement, 20 kN/Sq.m surcharge shall be considered. Trenches/pits inside building shall be designed for a surcharge equal to Live Load intensity of Ground Floor or 10 kN/Sq.m whichever is greater. In Boiler area and other outdoor areas within Power Block, the minimum surcharge shall be 20 kN/Sqm.

vii) **Covers for Trenches**

Self-weight of top slab and a uniformly distributed load of 4.0 kN/Sqm on each panel or one 0.75 kN central point load, whichever is critical, shall be considered.

Trench cover at entry to buildings and at road crossings, shall be designed for class AA & Class A loadings as per IRC whichever is critical at centre. The trench cover at other location shall be designed with a surcharge of 1.0 T/Sq.M or a concentrated load of 1.0T at centre.

viii) **Roads**

Design of roads shall be in accordance with Indian Road Congress standard .

ix) **Road Culverts**

Road culverts shall be designed for Class `AA' loading (wheeled and tracked both) & to be checked for Class `A' loading as per IRC standards.

x) **Reduction in Live Load**

Reduction in Live load as per provision of IS:875 shall not be permitted.

The areas covered with equipment shall be designed on the basis of weight of equipment (flooded/operating) in addition to an uniform live load of 5.0 kN/Sqm or specifically defined live load whichever is greater.

Foundations and fixing arrangements for items of equipment, which generates vibration, shall be designed to prevent transfer of such vibrations to the adjoining structures.

For loads caused by moving equipment over the floor for installation, consideration shall be given to the shoring of beams and floor from floors below.

C. **Equipment Loads**

i) Loadings (both static and dynamic) of major equipments, including boiler, turbine-generator, boiler feed pumps, feed water heaters, de-aerator, PA, FD & ID fans, Coal Mill obtained from the manufacturer's certified drawings of the specified equipment to be furnished. Where design of structures supporting minor equipment other than those included above has to proceed, the loadings shall be estimated from similar jobs or catalog data.

ii) All equipment, tank and piping design loadings shall include Hydraulic Testing loads.

iii) Air & gas duct loadings shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads as applicable.

iv) Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as developed from the crane weights and wheel loads. Unless otherwise specified, the vertical and horizontal loadings shall conform to the applicable sections of the IS specifications.

v) Weight of equipments, ducts, tanks, pipes, conduits etc. supported by structure shall include maximum possible loading conditions i.e. flooded material contents and associated impacts, test loadings, anchorage and constraint effects.

vi) All structural components shall be designed to accommodate anticipated concentrated loads which shall or may be applied during the life of the plant.

Where both concentrated and uniform loads cannot act simultaneously, the structure or component shall be analyzed for both conditions of loading and shall be designed for most critical condition.

vii) Jet forces resulting from guillotine type pipe ruptures shall be considered in the design, if it is of high magnitude. Jet force to be considered shall be equal to the product of the pipe cross section and the internal design pressure applied on an area equal to the pipe cross section.

viii) Lay down areas in the Turbine Hall shall be investigated for concentrated loads resulting from equipment components to be stored during erection and maintenance operation. Where live load allowance is inadequate to permit storing of such equipment components, the design live load shall be increased to permit such use or the area shall be restricted by identifying lay down areas for specific components, each area to be identified by permanent marking.

D. **Wind Loading**

Wind loading shall be in accordance with Indian Standard Code IS:875 (Part 3):1987 for a basic wind speed of 44 m/s upto a height of 10 metres above mean ground level.

Terrain Category-4, Class-C shall be considered for all structures.

E. **Seismic Loading**

The site falls in Zone-III as identified in the map in IS:1893-2002. Analysis and design of structures to resist the seismic forces will be established in accordance with the recommendations of IS: 1893 (Part IV): 2005. Importance factor to be considered is 1.5 for all structures. Ductile detailing of RCC structures will be as per IS: 13920.

F. **Temperature Loads**

The structures shall be designed to withstand stresses due to fifty (50) percent of the total temperature variation. The total temperature variation for temperature loading should be taken as two thirds (2/3) of the average annual variation in temperature. The average maximum annual variation for this purpose shall be taken as the difference between the mean daily minimum temperature during the coldest month of the year and mean daily maximum temperature during the hottest month of the year.

Mean Daily minimum ambient temperature during coldest month of the year = 13.5° C

Mean Daily maximum ambient temperature during hottest month of the year = 44.7° C

Expansion and contraction due to changes of temperature of materials of a structure shall be considered and adequate provision shall be made for the effects produced as per provision in the relevant IS codes.

G. **Steam Piping Load**

Minimum intensity of steam piping load shall be 6.0 kN/Sqm for the areas at different levels through which steam piping is routed. However, the bidder shall check the loading as per static/dynamic analysis for steam piping or load data supplied by piping vendor and the worst loading shall be considered in design. Horizontal anchor loads, if any, shall also have to be considered in design.

H. **Earth Pressure Load**

Earth pressure for all underground structures shall be calculated using coefficients of earth pressure at rest, coefficient of active or passive earth pressure (whichever is applicable). However, for design of sub-structure of pump house, cold water basin of cooling water and under ground liquid storage tanks earth pressure at rest shall be considered.

In addition to earth pressure and ground water pressure, etc., surcharge load shall also be considered for the design of all underground structures including channels, sumps, cable & pipe trenches, etc., to take into account the vehicular traffic in the vicinity of the structure. Intensity of Surcharge Load shall be as described elsewhere in this specification.

I. **Crane, Monorail & Elevator Loads**

Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as per crane vendor's data. All lifting beams and monorails shall have their design loads increased for impact factor as mentioned hereinafter.

Impact Factor

Loads for cranes, hoists and elevators shall be taken as per IS:875. The minimum impact factor to be used in design shall be as follows:

Crane loads

a) For vertical force, an impact factor of 25% of the maximum crane wheel load

b) A lateral crane surge of 10% of the weight of the trolley plus lifted load applied at the top of each rail

c) A horizontal surge of 5% of the maximum static wheel loads of the crane applied at the top of the rail in longitudinal direction.

Monorail loads

a) Impact factor of 10% of lifted load of hoist for monorail and support design

b) Impact factor of 25% of the lifted load for electrical pulley and support design

Elevator

Elevator support systems shall be designed to accommodate the capacity load of the elevator plus the weight of the cab and accessories

J. **Construction Loads**

The integrity of the structures shall be maintained without use of temporary framing struts or ties and bracing so far as possible. However, construction or crane access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented by bidder to ensure stability and integrity of the structures during any periods involving use of temporary bracing systems.

K. **Other Loads**

Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance load, creep and shrinkage shall also be considered in design of all structures.

All Power House columns adjacent to first row of Boiler columns shall be designed for an additional load of 500 kN to account for piping/cable rack loads.

All structures situated in the vicinity of railway lines shall be designed conforming to the Indian Railway Standard Specification.

Dispersion of load in any direction through soil shall be as per IS:8009 (Relevant part).Dispersion of load through concrete shall be considered at an angle of 45 degree with horizontal from the edge of contact area.

L. **Thrust Load**

Thrust blocks shall be designed against the thrust load from pipe lines considering the test pressure in the pipe lines.

M. **Ash Silo**

The following densities shall be considered for design of Ash silo

a) For volume calculation of bottom ash silo : 6.5 kN/cum

b) For volume calculation of fly ash silo : 7.5 kN/cum

c) For load calculation of both types of silos : 16.0 kN/cum

The ash silo shall be designed generally as per the criteria laid down in IS:4995 (Part I&II). The static pressure calculated at rest shall be multiplied by an over pressure factor of 1.35 for the top 1/3 rd portion and by a factor of 1.75 for the bottom 2/3 rd portion. Special attention shall be given in assessing the effect of hot temperature of ash on the wall. Temperature of ash shall be considered in design.

8.01.01 **Load Combinations**

While designing consideration shall be given to the following load combinations:

i) DL + LL

ii) DL + LL + PL + Equip ± TL

iii) DL + LL + PL + Equip + Cb + CtLA± CS ± TL

iv) DL + LL + PL + Equip + Cb + CtLB± CS ± TL

v) 0.9*DL ± EL (for DL only) ± TL

vi) 0.9*DL ± WL1 ± TL

vii) 0.9*DL ± WL2 ± TL

viii) DL + LL + PL + Equip + Cb + Ct ± EL ± TL
(* Appropriate portion of LL which is considered for working out EL shall only be taken)

ix) DL + LL + PL + Equip + Cb + CtL1 ± (CS1+WL1) ± TL

x) DL + LL + PL + Equip + Cb + CtL1 ± (CS1+WL2) ± TL

Where the above loads are :

DL	=	Dead load of structures, floors, walls etc.
LL	=	General live load on floors
PL	=	Pipe Load
Equip	=	Equipment loads
Cb	=	Crane Bridge
Ct	=	Crane trolley positioned at middle of bridge
CtLA	=	Crane trolley + Load near one row
CtLB	=	Crane trolley + Load near other row
CtL1	=	Crane trolley + Half load lifted at centre of bridge
CS	=	Crane surge for full load

CS1 = Crane surge for half load lifted

WL1 = Wind load from left to right

WL2 = Wind load from right to left

EL = Earthquake load

TL = Temperature load

Appropriate impact factor shall be considered as per IS:875 (Part 2) - 1987 while calculating crane loads.

In calculating wind loads, appropriate internal thrust / suction shall be considered along with external pressures as per IS:875 (Part 3) - 1987. All possible load conditions considering external and internal pressures shall be considered in analysis and design for each combination number (vi), (vii), (ix) & (x) above to assess worst effect on whole structure as well as its components.

Appropriate allowable increase in permissible stresses as per IS codes, may be taken only under normal loads along with wind and seismic conditions. However, members which are designed primarily to resist wind, no increase in permissible stresses shall be permitted.

Applicable load factors to be used for design of RCC structures by Limit State Method as per IS:456.

8.01.02 **Load Combinations for Underground Structures**

Following loading conditions shall be considered in addition to the loading from super structure for the design of sub-structure of pump house, channels, sumps, tanks, reservoirs, trenches and other under ground structures.

Only liquid pressure from inside and no earth pressure and ground water pressure, and surcharge pressure from outside (applicable only to the structures which are liable to be filled with water or any other liquid).

Earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

Base slab of the pump house shall be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum ground water table. Intermediate dividing piers of pump sumps and partition walls in channel shall be designed considering water on one side only and the other side being empty for maintenance.

Design shall also be checked against buoyancy due to ground water during construction and operation stage. Minimum factor of safety as per IS:3370 against buoyancy shall be ensured considering empty condition ignoring superimposed loads.

8.01.03 **Other loading considerations**

Wind and seismic forces shall not be considered to act simultaneously.

For the design of main plant structures during seismic condition, the Deaerator Feed Water Tank shall be considered full up to operating level. However, for other load combinations, Deaerator Feed Water Tank in flooded condition shall be considered.

`Lifted Load' of crane shall not be considered during seismic condition.

For design of all underground structures/foundations, ground water table shall be considered at the Finished Ground Level.

If R.C.C. floors and roofs except those cast over metal decking are assumed to act as diaphragm transmitting lateral loads to braced bays then main beams/girders shall be provided with shear connectors. However, whenever large/more number of cutouts is 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. Shear connectors shall also be provided over beams having R.C.C. slab on one side and opening /chequered plate / grating on other side.

For R.C.C. roofs cast over metal decking, horizontal bracings must be provided below slab to transfer horizontal force to columns.

In Turbine Bay, horizontal wind girders between A-row and B-row columns must be provided below Mezzanine and Operating floor at gable ends to transmit wind load from gable columns.

PTFE bearing shall be provided where horizontal loads not to be transferred.

For calculation of seismic load, equipment load shall be considered as Dead Load.

Ultrasonic pulse velocity tests shall be carried out for the top decks of all machine foundations viz. TG deck and substructures, BFP Foundation, ID fan, FD fan, PA fan and Mill foundations to ascertain the homogeneity & integrity of concrete.

Whenever any structure under this contract shall carry or receive additional load from the work of any other contract, the structures under this contract shall be provided with sufficient margin to carry the above load (like Mill Bay structure, Trestles etc.) details of which shall be finalized during detail engineering.

Gratings / chequered plates shall not be considered as restraining members for compression flange of beams/girders. Diaphragm action shall also be not considered in design. Adequate horizontal bracings to be provided.

8.02.00 **Stability of Structures**

Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like under ground tanks, pits trenches, basements, etc. Minimum factor of safety of 1.25 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area shall be taken into consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS:456 and other relevant IS codes, subject to the following minimum values.

a) Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum.

b) Factor of safety against sliding shall be 1.5 minimum.

c) Factor of safety against uplift due to hydrostatic forces shall be 1.25 and due to any other loads shall be 1.5.

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In case where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

Ground water table shall be considered at Plant Finished Grade Level for design of foundations and all underground structures.

The design calculations and respective drawings in AUTOCAD format shall be submitted accordingly.

9.00.00 BUILDING DESIGN CONCEPT

9.01.00 Framing System and Method of Analysis

Analytical model of the building structure will be either two dimensional or a three dimensional space frame. Analysis of models shall be done using STAAD Pro Software.

For Steel frame structure, it will be either (1) Simple frames with vertical diagonal bracings at column lines in both directions and horizontal bracing at the roof and major floor levels or (2) Moment resisting frame in transverse direction with braced frames in longitudinal direction. For Concrete frame structure, it will be Moment resisting frame in both directions.

For composite framed building moment resisting frame will be provided in transverse and longitudinal direction with reinforced concrete columns and steel roof truss/girder framing members in transverse direction and reinforced concrete framing members in longitudinal direction.

9.02.00 Method of Design

The Strength design of Steel members will be done by working / allowable stress method using IS:800 (Latest Edition) where as the Strength design of Concrete members will be done by limit state method using IS:456 (Latest Edition).

Un-braced lengths for steel beams will be as per code or as determined from following criteria

- Beams supporting concrete slab with shear connectors / compression flange embedded in RCC slab will be considered continuously supported.
- Beams supporting metal roof deck attached with welding washers plug welded will be considered continuously supported.
- Beams supporting metal deck or concrete slabs formed with metal decking will have an un-braced length based on framing member locations.
- Beams supporting grating floor will not be considered continuously supported.
- Beams which are part of a truss will use the distance between panel points as their un-braced length or, if the panel has connecting major members, the un-braced length will be based on the distance between panel points or connecting members, whichever is the shorter distance.

- In grating floor, for two parallel, interconnected beams, the beam with greater load will be considered as un-braced and the other beam as braced at the points of interconnection

- In grating floor, for three or more parallel, interconnected beams with loads of same order or magnitude, all beams will be considered as braced at points of intersections. When the beams are loaded disproportionately, the un-braced lengths will be determined as stated above.

- **Acceptance Criteria for required depth**

  - For steel members, minimum depth equals to 1/24 of span unless clearance requirements will dictate lower depth in certain areas.

  - For Concrete members, minimum depth equals to 1/16 of span unless clearance requirements will dictate lower depth in certain areas.

  - Members will be framed into members of equal or greater depth

10.00.00 DESIGN OF REINFORCED CONCRETE STRUCTURES

a) The design of R.C. Structures shall be carried out by limit state or working stress method as per the provisions of IS-456.

Concrete tanks/water retaining structures shall be designed in accordance with the recommendation of IS-3370.

b) For reinforcement detailing IS:5525 and SP:34 shall be followed. Ductile detailing of RCC structures will be as per IS: 13920.

c) The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

d) **Liquid Retaining Structures**

RCC water retaining structure like storage tanks, reservoirs, etc. shall be leak proof and designed as uncracked section in accordance with IS:3370 (part I to IV) by working stress method.

Substructure of pump houses shall be designed as cracked section with limiting crack width of 0.1 mm and limiting steel stresses as per IS:3370 (Part I to IV) by working stress method for concrete face away from water/liquid. For faces in contact with water/liquid the structure shall be designed as uncracked section in accordance with IS: 3370 (part I to IV) by working stress method.

All water retaining / storage structures shall be designed assuming liquid up to the height of wall irrespective of provision of any over flow arrangement. No pressure relieving devices shall be permitted in underground structures.

In all liquid retaining structures leak-tightness shall be ensured and guaranteed. To achieve the same, methodology in design and construction in the way of providing PVC water bars at construction/expansion joints and/or injection grouting, usage of admixture in concrete or any such method should be adopted. The sequence of construction shall also be specified on drawings showing construction joints.

e) **Water reservoirs**

The in plant raw water reservoir will be compartmentalized to ensure de-sludging/maintenance of any section without affecting plant operation. With a view to conserve water LDPE of approved make of 500 microns lining as per IS 3370 will be provided on bed and sides.

Raw water reservoir will be provided with concrete slab. It is also to be attended with necessary methods of base preparation works for controlling the abnormal/uncontrollable seepage, if any.

Raw water storage Net capacity 1,50,000 M^3 with 1.2M free board is to be adopted.

Level gauge with approach steps shall be provided.

Outlet pipe with sludge valve shall be provided and stop gates at inlet may be provided.

The surface shall be provided with anti-weed treatment.

Hand railing shall be provided.

Floating matter trap gates at inlet shall be provided.

With a view to conserve water, the fire water reservoir will be provided with concrete slabs on top as protective cover, LDPE film lining will be provided on bed and sides to prevent seepage loss.

10.01.00 **Foundation design**

Foundations for Buildings and structures shall be designed to resist forces and moments, caused by vertical loads and by wind or seismic loads, based on static and dynamic analysis done for those structures. The foundation sections shall be sized and reinforced adequately for moments and shear stresses.

a) **Foundations resting on virgin soil**

All Major foundation shall rest either on pile or on virgin soil. Preliminary Geo-Technical investigation for the proposed site has been carried out by the owner and the report is available with the owner. The same will be furnished to bidder on request and for reference only.

Bidder however, shall carry out necessary geo-technical investigation at all relevant locations before deciding the type of foundations. Bidder shall decide the type of foundation based on the load from structure and the outcome of bidder's soil investigation.

b) **Foundations resting on fill material**

All grade slab, trenches, pits, electrical trenches & duct banks, manholes and other lightly loaded equipments & structures with bearing pressure not exceeding 50kN/Sq.M will be founded on this founding medium. A minimum of 0.5M below foundation will be of compacted sub-grade to a min. of 95% of the max. dry density (modified Proctor).

- **Minimum Founding Depth**

The bottom of foundations on virgin soil will not be less than 1.0 meter from finish grade level unless specified otherwise in geo-technical investigation and recommendation. Foundations for Misc. Skids and other minor supports will be kept minimum 300 mm below finished grade unless greater depth is required by site specific requirements.

For steel columns of Power House building, Boiler, Mill and Bunker building, ESP, etc., Top of RCC foundation shall generally be kept at a lower level so that the column base plates together with gussets and stiffeners remain below the finished floor level. Foundation levels of some columns shall have to be suitably lowered to accommodate underground services, pits, trenches, etc.

10.01.01 **Heavy Equipment Foundations for Turbine Generator, Coal mills, Turbine & Motor driven pump and large fans**

RCC design shall be done by working stress method for all machine foundations.

All block foundations supporting rotating equipment resting on hard strata shall be designed using the elastic half space theory.

Bidder's design scope of work shall consist of the following :

a) Finalization of the general arrangement layout and levels of foundation for Turbine Generator, Pulverizer, Turbine & Motor driven pump and large fans based on the equipment layout considering limitations of available space and any other layout constraints.

b) Submission of design criteria for approval

c) Submission of the following information as provided by equipment supplier and as applicable depending up on approved design criteria:

1. Loading diagram showing static and dynamic loads and points of application of loads.

2. Operating speed of m/c; Critical speed of m/c.

3. Weight of rotating parts; maximum eccentricity of rotating mass from the geometric axis of rotation.

4. Location of C.G. of machines in all three axes.

5. Mass Moment of Inertia.

6. Allowable amplitude/velocity of vibration at machine bearing points.

7. Temperatures in various areas during operation.

d) Analysis of the top deck, design and detailing of reinforcement.

e) Submission of all design calculation, all loading diagrams, General arrangement drawings, embedment drawings and reinforcement drawings for the foundations under the scope for the approval of the owner.

f) Carrying out revisions / alterations based on the comments of the owner. In addition to hard copies, the final soft copy of all drawings (in autocad and pdf format) and documents shall also to be submitted.

g) Submission of construction methodology / casting sequence and any special requirement. Concreting of STG columns shall be cast in single pour and methodology including temperature control shall be got approved by the Engineer.

A. Design considerations for major equipment foundations that supported on conventional machine foundations:

- Design of foundations shall be done in accordance with relevant parts of IS-2974. Unbalanced loads for normal operating condition as given by machine manufacturer and/or VDI 2060 whichever is more shall be used for calculating dynamic response. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. While designing following aspects shall also be taken care of.

- Foundations shall be isolated from adjacent structures for vibration control.

- Natural frequencies of structures and components shall be away from the running speed of equipment as per frequency separation criteria and amplitude criteria laid down in IS:2974 and/or DIN 4024 and/or VDI 2056 and/or as required by the machine manufacturer, whichever is more stringent shall also be satisfied. A fatigue factor of 2.0 shall be considered for dynamic forces / due to normal unbalance. For design of foundation of large fans etc. provision shall be kept in the foundation for addition of mass/area for retuning of the foundations, if required at a later date.

- All block foundations resting on pile shall be designed using the pile-soil interaction.

- The mass of the RCC block shall not be less than three times mass of the machine and the CG of the combined mass of foundation and equipment should pass through the CG of the base area with tolerance not more than 5%.

- Tension in piles shall not be allowed for any combination of loads. For Foundations of rotating major equipments, the natural frequency and allowable vibrating amplitude/velocity shall be as per criteria furnished by the Vendor. In absence of such criteria, the foundation shall satisfy the criteria set forth in IS 2974, DIN 4024 and VDI 2056.

B. Specific considerations for foundations where equipments are supported on vibration isolation system :

- **General Requirement**

  The vibration isolation system shall consist of steel helical spring units and viscous dampers supporting the RCC deck which would support the equipment. Complete Vibration Isolation System shall be provided for the foundations of Boiler Feed Pumps, Coal Mills, ID, Fan, FD Fan, PA Fan and all other rotating equipment except Turbo-generator.

  Steel helical springs and viscous dampers shall be provided by GERB or equivalent manufacturer with requisite experience and proven track record of similar installation in power plants of Unit capacity not less than 500 MW.

- **Material (Design & Supply)**

  Steel helical springs and viscous dampers shall consist of

  i) Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads etc.

  ii) Frames for pre-stressing of spring elements.

  iii) 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.

  iv) Any other items which may be required for the pre-stressing, erection, release of pre-stress, alignment and commissioning of the steel helical springs.

- The objective of designing the supporting arrangement for any rotating equipment shall be so that the vibration level is maintained as minimum as possible under all operating conditions. Accordingly, respective rotating equipment shall be supported on RCC deck slab which in turn shall rest on vibration isolation unit consisting of steel helical springs and viscous dampers, which in turn shall be supported on RCC supporting structure. The above design shall form part of this specification.

- The spring units shall have definite stiffness in both vertical and horizontal directions with the horizontal stiffness not less than 30% of vertical stiffness. The stiffness shall be such that the vertical natural frequency of any spring unit at its rated load carrying capacity is not more than 3 to 5 Hz.

- The damper units or spring-cum-damper units shall be of viscous type offering velocity proportional damping. The damper units shall be suitable for temperatures ranging from 0 to 50 deg. C. The damping resistance of individual damper units shall be such that the designed damping is provided using reasonable number of units. Damper shall have damping resistance ranging from 40 kN sec/m to 750 kN sec/m.

- The sizes of the spring units, damper units and spring-cum-damper units shall be such that groups of such units can be accommodated on column heads in case of elevated foundations and on pedestals/walls in case of foundations at ground level.

- The steel helical springs and viscous dampers shall be designed for ensuring “fit and forget” guarantee.

- It shall be ensured that not more than 5% of the dynamic loads are transmitted to the substructure. Necessary provisions of DIN 4024 shall be adhered to while designing the substructure. Substructure shall be designed for static loads.

- For all equipment foundations supported on VIS system, the stiffness of the supporting substructure shall be at least ten (10) times that of spring elements as per DIN 4024.

- Tension in piles shall not be allowed for any combination of loads.

- **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 detail program for approval of engineer and take up the manufacturing/testing after approval of such program. The program shall include :

  i) Manufacturing schedule and quality check exercised during manufacturing.

ii) Detail of test to be carried out at the manufacturing shop with their schedule.

iii) Special requirements, if any, regarding concreting of top deck.

iv) Complete step-by-step procedure covering the installation and commissioning of the spring system.

v) Manuals for erection, commissioning, testing and maintenance of the steel helical springs and viscous dampers.

vi) A checklist for confirming the readiness of the civil fronts for erection of steel helical springs and viscous dampers.

vii) Checklist for equipment required at each stage of erection.

viii) Bill of materials (data sheet) of various elements such as spring units, viscous dampers, with their rating, stiffness etc. included in the supply.

ix) Bill of materials (data sheet) for frames for pre stressing, hydraulic jack including electric pump, high pressure tubes, hand operated pump etc. with their rating and numbers.

x) Any other details which may be necessary to facilitate design and construction of the foundations/structures.

- The springs shall conform to codes DIN 2089 and DIN 2096. The quality assurance and inspection procedures shall be finalized on the basis of the above codes and the quality plans be drawn accordingly.

- **Erection, Commissioning and Supervision**

  i) 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. all shall be done a specialist supervisor of supplier/sub vendor trained for this purpose.

ii) The scope of work shall be deemed to include all activities, which may not have been explicitly mentioned but are reasonably implied for the successful commissioning of steel helical springs and viscous dampers.

iii) 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".

- **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 Commercial Operation of the machine, the same shall be done by the contractor as and when asked for at no extra cost of the Owner.

- **Acceptance Criteria**

  Stiffness values shall be checked. The permissible deviations shall be as per DIN 2096. Following acceptance criteria shall be followed :

  i) General workmanship is being good and as recommended by the manufacturer are approved by the Engineer.

  ii) Tolerances are within the specified limit

  iii) Material test certificate (MTC) is in compliance with the applicable codes/standards.

  iv) Bought out material is from the approved manufacturer/vendor

  v) Bought out material is matching with the approved sample

- **Codes and Standards**

  Latest revision of following codes shall be used for the design of the spring supported foundations :

IS : 456 Code of practice for plain and reinforced concrete.

IS : 2974 Code of practice for design and construction of machine foundations.

IS : 1893 Criteria for earthquake resistant design of structures

DIN : 4024 Machine foundations; Flexible supporting structures for machine with rotating masses

DIN : 2089 Helical compression springs out of round wire and rod : calculation & design

DIN : 2096 Helical compression springs out of round wire and rod : quality requirements for hot formed compression springs.

VDI : 2056 Criteria for assessing mechanical vibrations of machine.

VDI : 2060 Criteria for assessing the state of balance of rotating rigid bodies .

C. **Steam Turbine Generator Foundation Design Criteria**

- The Steam Turbine Generator shall be rigid RCC frame structure supported on pile foundations wherever necessary. The concrete outline and embedments/inserts/pockets detail shall be supplied by machine manufacturer. The turbine generator pedestals shall be designed to meet the manufacturer's deflection criteria and other recommendations.

  Analysis and design of the Steam Turbine-Generator (STG) foundation shall be carried out in accordance with relevant codes IS: 2974 Part-3 and IS: 456 and/or manufacturer's requirements.

  The loads to be considered for static analysis and design shall consist of dead weight of the machine and foundation, machine power torque, condenser loads under normal operating condition, Equivalent static load due to machine unbalance, thermal elongation forces, forces due to one sided operation of the condenser, forces due to condensate pump failure, vacuum loads, forces due to piping, frictional forces at machine sole plate level for turbine, generator and condenser, temperature distribution under operating condition, failure loads of turbine (blade unbalance/loss of blade/bowed rotor), failure loads of generator (short circuit loads), seismic loads due to generator, turbine and condenser and erection loads.

Detailed static and dynamic analysis shall be performed both for normal operating condition & abnormal condition such as short-circuit, accidental loss of blades & earthquake. At any event of time any two transient loading (short circuit, seismic) need not be assumed to act in the same direction simultaneously. Seismic analysis shall be done by response spectrum method.

The dynamic analysis shall consist of free-vibration and forced vibration analysis. Frequency separation criteria and amplitude criteria as laid down in IS-2974 and or VDI 2056 and/or as required by machine manufacturer whichever is more stringent shall be satisfied.

Elaborate mathematical model shall be considered. Due regard shall be given to pile stiffness in lateral and vertical direction and pile-soil interaction.

Stress for thermal load, shrinkage and creep shall be properly accounted for. Minimum reinforcement shall be governed by IS-2974 as well as IS-456.

For appropriate load combinations or any other information, stipulations of IS-2974 shall be satisfied.

D. **Boiler Feed Pump Foundation**

TDBFP & MDBFP foundations shall consist of RCC top deck supported on steel helical springs and viscous dampers inside main power house. In case the top deck is located at operating floor/mezzanine floor or any other floor level based on bidder's approved layout, the springs / viscous dampers shall be supported on a group of structural steel columns-beams grid which shall be rigidly integrated with the Main Power House structural frame.

In case the TDBFP & MDBFP foundation is envisaged to be located at ground floor of Power House, these foundations shall consist of top deck supported on steel helical springs & viscous dampers which shall in turn be supported on RCC sub-structure. This is generally a RCC block foundation resting on either on piles or raft as per the design based on soil strata. Concrete outline and details of pipe sleeves/pockets/embedments shall conform to the data provided by machine manufacturer.

E. **PA, FD, ID Fan and Mill Foundations**

These foundations shall consist of top deck supported on steel helical springs & viscous dampers which shall in turn be supported on RCC sub-structure. RCC substructure shall be supported below ground level on pile or soil as per the design based on soil strata. (RCC foundation with provisions for pockets and cut-outs for bolts and electrical cables shall be as per vendor's outline drawing. The fan foundations shall be provided with detachable roof for protection of fans.

F. **Minor equipment Foundations**

For the foundations supporting minor 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 structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system (VIS) shall be designed suitably as specified elsewhere in this specification.

10.01.02 **Open Foundations**

a) In case open foundations are adopted, the following shall be adhered to :

Minimum width of foundation shall be 1.0 m.

Minimum depth of foundation shall be 1.0 m below NGL.

b) It shall be ensured that all foundations of a particular structure/ buildings/facility shall rest on one bearing stratum, i.e. either overburden or rock.

c) Wherever the intended bearing structure is weathered rock but the actual stratum encountered during foundation excavation consists of both overburden soil and weathered rock at founding level, under such cases either the foundation shall be lowered completely into the weathered rock or the overburden soil upto the weathered rock level shall be removed and built up through PCC up to designed foundation level.

The net allowable bearing pressure values to be adopted for design upon Owner's approval shall correspond to total permissible settlement as mentioned under para "permissible settlement of foundations" or the permissible settlement from functional requirement, whichever is more stringent.

d) Permissible settlement of foundations: The total permissible settlement and differential settlement shall be governed by IS: 1904 and IS: 13063 and from functional requirements, whichever is more stringent. However, total settlement shall be restricted to the following :

Item	**Settlement Criteria**
Steam Turbine Foundation	Maximum total long term vertical settlement after interconnecting systems are complete and the unit is placed in operation shall not exceed 25mm or limit specified by equipment manufacturer.
Boiler area foundations and Stack foundations	1. The allowable overall settlement of foundation shall not exceed 25mm/ vendor requirements
	2. Max allowable differential settlement of foundation shall not exceed 8.0 mm./ vendor requirements
Transformer foundation (including oil fill)	1. The allowable overall settlement of foundation shall not exceed 25mm / vendor requirements.
	2. Any additional long-term settlements after bus duct connections are made and transformer placed in service should not exceed 50mm
Turbine Building foundations	1. The allowable overall settlement of foundation shall not exceed 25mm. 2. Max allowable differential settlement of foundation shall not exceed 8 mm.
Other building and Structures foundations.	1. The allowable overall settlement of foundation shall not exceed 25mm. 2. Max allowable differential settlement of foundation shall not exceed 8 mm.
Miscellaneous Electrical Equipment foundations.	1. The allowable overall settlement of foundation shall not exceed 25mm.
Misc. Mechanical Equipment • Boiler Feed Pump • Lube Oil Skid • Other major equipments	The allowable overall settlement of foundation shall not exceed 25mm.

Item	Settlement Criteria
Flat Bottom above Ground Storage Tanks	Uniform Settlement : • Vertical settlement after filling, hydro-test shall not exceed 25mm.at perimeter unless flexible shell nozzle connections used. Differential Settlement of Center with respect to Edge • The center of the bottom plate floor shall not exceed the settlement of the edge by more than diameter/90.

In case the total permissible settlement is to be restricted to less than as above specified from functional requirements, then the net allowable bearing pressure shall be reduced / reviewed accordingly in consultation with Owner.

10.01.03 **Pile Foundations**

In case piles are adopted, following shall be adhered to :

a) The pile foundation shall be of RCC, Cast-in-situ bored, precast/cast-in-situ driven pile as per IS: 2911. Bored piles shall be installed by using rotary hydraulic rig. Three-stage flushing of pile bore shall be ensured, by airlift technique or any other internationally accepted method duly approved by the Owner.

b) The minimum diameter of pile shall be 450mm for cast-in-situ and 300mm for precast piles. The uplift and lateral load capacity shall be established by field test.

c) Only straight shaft piles shall be used. Minimum cast length of pile above cut-off level shall be 1.0 m.

d) The EPC 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 like (SPT & SCPT value, set criteria etc.), reinforcement for job as well as test piles, etc.) for Owner's approval.

e) 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 EPC Contractor for Owner's approval.

f) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be as under:

Vertical
Lateral
Uplift
} Minimum of 3 Nos. in each mode.

The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test the method of loading shall be cyclic as per IS: 2911 (relevant part).

g) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under:

i) Vertical - 1.0 % of the total number of piles provided.

ii) Lateral - 1.0 % of the total number of piles provided.

The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. The Owner shall approve piles for routine load tests. Routine load tests may be done by conventional method as per IS: 2911 (Part-4).

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 EPC Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required, without additional cost to the Owner.

h) Testing of piles and interpretation of pile load test results shall be carried out as per IS: 2911 (Part-4). The EPC Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory/ institute prior to their use. Additional measurement for pile movement shall also be done.

i) Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the piles for routine load test and not intended to replace the use of static load testing.

10.01.04 **Other Requirements**

i) In case of high ground water table, for excavations comprehensive dewatering arrangement shall be required. Scheme for dewatering and design with all computations and back-up data of dewatering and sheet pilling shall be submitted for Owner's information.

ii) The founding level for trenches/channels shall be decided as per functional requirement. The bottom of excavation shall be properly compacted prior to casting of bottom slab of trenches/channels.

iii) Excavation for open foundations shall be covered with PCC immediately after reaching the founding level. In case of any local loosening of soil at founding level during excavation, the same shall be removed and compensated by PCC. The foundation pits shall be maintained dry during the complete construction period by means of suitable dewatering systems.

iv) Backfilling, around foundations and bottom of pipes, thrust blocks, etc. shall be carried out with approved material in layers not exceeding 30 cm thickness and each layer shall be compacted to 90% standard proctor density for cohesive soil and to 75% of relative density for non-cohesive soils.

v) Excess/surplus excavated material shall be disposed off by the EPC Contractor as per the instructions of the Owner up to a lead of about 5 km crow fly distance from the plant site.

vi) CBR tests for flexible pavement design shall be carried out by the EPC Contractor after earth filling has been completed, if applicable.

vii) The storage tanks shall rest on flexible tank pad resting on an open/shallow foundation or pile foundation. The tank pad shall be made of two layers. The first layer shall be thoroughly compacted fill of gravel, coarse sand or other suitable material topped with minimum 75mm thick compacted crushed stone, screenings, fine gravel, clean sand or similar material mixed in hot asphalt (80 / 100 bitumen or equivalent 8 to 10% by volume), rolled and compacted. The second layer shall be with minimum 25 thick premix carpet with 12 mm and down broken stone chips and 80/100 grade hot bitumen. The tank pad shall be laid by an expert agency having wide experience in execution of similar work. The tank pad shall be made up from founding level to the required level by controlled compaction in layers of 200 mm to achieve a relative density of 85% using suitable compaction equipment approved by the Owner. In addition to the above, in case of an open/shallow foundation, a ring wall shall be provided adjacent to the tank wall for retaining the fill below tank. The foundation system shall be designed as per the provisions of IS: 803. The tank shall have a flexible bottom plate, which shall establish complete bearing with the foundation fill.

After the tanks have been erected, hydro testing shall be done. Subsequent upon hydro testing of tank, the differential settlement.

10.02.00 **General Requirements**

- **Minimum Thickness of Structural Elements**

The following minimum thickness shall be followed :

Pile caps	900 mm
Suspended floor / slab / walkways / canopy slabs, etc	150 mm
Ground floor slab (non-suspended)	150 mm
Water Retaining slabs / walls	200 mm
Cable / pipe trenches / underground pits / Launder walls and base slab	125 mm
All footings (including raft foundations)	300 mm
Width of beam	150mm
Parapets	125 mm
Sunshades at edge	75 mm
Pre-cast louvers / fins	50 mm
Pre-cast trench cover slabs / floor slabs / louvers	75 mm
Paving	150 mm
Basement walls and base slab	200 mm
Silo / bin walls	150 mm
Underground reservoir Below ground water table	200 mm
Above ground water table	150 mm

From fire resistance point of view minimum fire rating of 2 hours shall be considered where fire hazard is expected and minimum thickness of reinforced concrete members shall be as per fig 1 and table 16a of IS 456 or specified above, whichever is higher.

- **Concrete Cover**

  Following minimum clear concrete cover to steel reinforcement will be provided.

A.	**Substructure Work**	Bottom	Sides	Top	Ends
i)	Foundation	75	50	50	50
ii)	Columns, Pedestals, Grade Beams/Tie Beam	50	50	50	50
iii)	Trenches, Pits, Walls, Duct Bank etc. in contact with				
	Earth	50	50	50	50
	Water	50	50	50	50
	Others	25	25	25	40
iv)	Equipment Foundations	50	50	50	50
v)	Slab on Grade	25	50	25	50
B.	**Super structure Work**				
i)	Columns	-	40	-	-
ii)	Beams	35	35	35	50
iii)	Slabs/Walls	20	20	20	40
iv)	Lintel, Chajja, Bands etc.	20	20	20	25
v) vi)	Pre-cast Concrete Silo shell side cover	20	20 30	20	20

- **Minimum Heights For Pedestals/Encasements of Steel Columns**

  Pedestals to Steel Columns for building structures

  In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following.

  a) Open area : 300 mm above paved level

  b) Covered area : 300 mm above FFL

  Stair and ladder pedestal shall be kept 200 mm above the finished floor level.

  Pedestals to Steel Columns for Equipment structure :

  a) Equipment in open area : as required (300mm min)

  b) Equipment in covered area : as required (150 mm min)

c)	Structures and equipment supplied by vendor	:	as per vendor's data subject to minimum as specified above

Foundation levels for some columns may be changed suitable to accommodate underground services, pits, trenches etc.

- **Ground floor slab-on-grade**

  Ground floor slab-on-grade shall be RCC with Vaccum Dewatered Flooring (VDF) concrete construction laid over minimum 100mm thick lean concrete. Minimum 250mm thick graded stone (63 mm down size) soling with interstices filled with sand/gravel and compacted mechanically, shall be provided as sub-base below lean concrete. The sub-base shall be laid over rammed and well-compacted earth fill or hydraulically compacted sand fill as specified elsewhere in this specification.

- **Stairs, Platforms, Ladders and Handrails**

  All internal stairs, platforms and walkways shall either be of RCC or GI gratings construction. All outdoor stairs, platforms and walkways shall either be of RCC or minimum 40mm thick grating. Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 3.0 mm for a single flight. . All stairs shall have a maximum riser height of 125 mm and a minimum tread width of 250mm. Minimum width of stairs in all buildings shall be 1200 mm.

  Hand railing comprising of posts 1000 mm (min.) high not exceeding 1.5m (max) c/c, shall be provided around all floors/ roof openings, projections, balconies, walkways, platforms, steel stairs etc. All hand rails and posts shall be 32NB heavy duty GI pipes as per relevant IS Codes and shall be galvanized with class-1 galvanization (as per IS-277) shall be provided for all structural steel stair cases and external RCC stairs. Hand rail will be provided with one horizontal pipe at mid-height and continuous flat iron toe guard at bottom. For all internal RCC stair cases in buildings, stainless steel hand railing shall be provided. For stainless steel handrail refer relevant architectural specification.

  Steel cage ladder shall be hot dip galvanised. Stringers shall be of angles 90x90x10 with a minimum clear distance of 400 mm in-between. Rungs shall be of 20 mm diameter mild steel rods spaced at 300 mm centres. Ladder stringers shall be provided with suitable lateral stays. The ladder and its connection shall be designed for a minimum load of 200 kg at any location. Cage shall start from a height of 2.5 m above the base of ladder.

11.00.00 DESIGN OF STEEL STRUCTURES

a) Structural steel design shall be carried out as per the National Building Code with specific consultation to IS-800 working stress method unless noted otherwise. Design of structures in electrical substation shall be as per IS-802.

b) Lateral forces along the length of the building shall be resisted by bracings in horizontal and vertical frames. The transverse lateral load shall be resisted by stiff jointed frame action. Additional bracing or moment connection shall be used to assure stability of the structures.

c) Vertical bracing members which are connected to the beam shall be analyzed for all the vertical loads which the beam is subjected to along with lateral loads.

d) Shear force in steel columns shall be transferred to the pedestals/ foundations exclusively either through foundations bolts or through shear key arrangement.

Design of base plate shall be based on the design pressure on foundation which shall not exceed the following:

i) Pedestal in concrete grade M20 ……5.0 N/mm^2

ii) Pedestal in concrete grade M25 ……6.25 N/mm^2

iii) Pedestal in concrete grade M30 ……7.5 N/mm^2

e) Shop connections shall be all welded and field connections shall generally be bolted unless specified otherwise. Field bolts, wherever provided shall be high tensile of 20 mm dia. or of higher diameter and of property class 8.8 as per IS-1367 for all major connections. The bolted joints shall be designed for friction type connection and the H.T. bolts shall be tightened to develop the required pretension during their installation. However, the nominal connections in the field like purlins, stairs, wall beams etc. shall be done by 16 mm dia. M.S. black bolts (minimum 4.6 grade) conforming to IS-1363 unless specified otherwise.

f) Welding shall be in accordance with the recommendations of IS-816 - Code of Practice for use of metal arc welding for general construction in mild steel and IS-9595 - Recommendation for Metal Arc Welding of Carbon and Carbon Manganese Steels. Built-up members shall be fabricated using submerged arc welding procedure unless manual arc welding is specifically required. All butt welds in plate girders and columns shall be full penetration. All butt welds shall be radiographically or ultrasonically tested as per relevent IS codes and standard practice. The bare wire electrodes for submerged arc welding shall be as follows

Filler wire: AWS-A-5.17-EH14
Flux shall be agglomerated type of classification
AWS-A-5.17-F7A2EH14

g) All structural steel members for substation shall be hot dip galvanised in accordance with IS-4759. The fasteners shall also be galvanised in terms of IS-5358. Galvanizing of steel structure shall be done after all fabrication work is completed. Zinc coating of galvanized surface of structural members and threaded fasteners shall as recommended in IS:4759. However, fasteners may be tapped or re-run after galvanizing. Threads of bolts and nuts shall be capable of developing the full strength of the bolt. The spring washers shall be electro-galvanized as per IS-1573. All galvanizing shall be uniform and of standard quality and shall withstand tests in accordance with IS-2633.

h) Shop primer paint shall be single coat of epoxy resin based zinc rich primer (such as blast steel EZ1 of Shalimar Paints Ltd.). The surface preparation shall be done after sand blasting in accordance with IS: 1477 (Part I & II) – Code of Practice for Finishing of Ferrous Metals in Buildings. Second coat of primer shall be applied after erection and final alignment of the erected structures. Two or more coats of epoxy paint of approved shade and quality shall also be applied after erection. Total Dry film thickness of the finished paint shall not be less than 110 microns.

i) All welding electrodes shall be of Low Hydrogen type conforming to IS:814 and shall be EB5426H3JX type. All electrodes, flux, wire etc. shall be of ADOR Welding Ltd.,or ESAB India Ltd., or D & H Secheron Electrodes Pvt. Ltd or Modi electrodes or equivalent as approved by Owner.

If submerged arc welding is used, the bare wire electrodes shall be as follows :

Filler wire	:	AWS-A-5.17-EH14
Flux	:	agglomerated type of classification AWS-A-5.17-F7A2EH14

j) Minimum preheat & inter pass temperatures for welding over 40mm to 63mm (thickness of the thicker part at the point of welding) shall be 66°C and for over 63mm, it shall be 110°C. However, higher preheat & inter pass temperatures may be required due to joint restraint etc. and shall be followed as per approved welding procedure.

k) Minimum tests to be carried out during fabrication and erection of structural steel shall be as follows:

Steel

Ultrasonic Test: Plates above 25mm thick shall be subjected to ultrasonic test as per ASTM-A435 or equivalent to check the presence of lamination.

Fillet weld

Dye Penetration Test: 25% of the total length, Dye penetration shall be carried out to the root run.

Butt weld

Dye Penetration Test : 100% of the total length, Dye penetration shall be carried out to the root run after back gouging

Radiographic Test: Splicing should not be provided in tension flange of Bunker Girders and crane girders. Spot radiography shall be carried out on 100% joints in tension zone. Minimum 300mm length shall be spot radiographed. When radiograph is not possible ultrasonic test shall be carried out after grinding the surface.

100% radiography test shall be carried out for the plates of 32mm thick and above.

25% radiography test shall be carried out for the plates below 32mm thick.

100% radiography test shall be carried out of the crane girders and bunker girders irrespective of thickness of the plate.

Ultrasonic Test : 10% of all other Butt welds except crane girder and bunker girder shall be subject to spot radiographic test and the entire balance butt weld for ultrasonic test.

l) **Connections**

Connection of vertical bracings with connecting members and diagonal truss members shall be designed for full tensile capacity of the bracings.

Size of fillet weld for flange to web connection for built up column section shall be as follows:

Full shear capacity for box section.

80% of full shear capacity or actual shear (if indicated in drawings) or 0.5 times of the web thickness which ever is more for I section. Weld shall be double fillet.

All welds shall be continuous. The minimum size of fillet weld shall be as per relevant IS code. Shear connections shall be designed for 75% of section strength for rolled sections and 80% of section strength for built up section or rolled section with cover plates. Design shear force should be more than actual shear.

Moment connections between beam and column shall be designed for 100% of moment capacity of the beam section.

All butt welds shall be full penetration butt welds.

Connection of base plate & gusset members with the columns shall be done considering that total load gets transferred through weld.

Erection joints shall be provided with suitable splice plates as per design after conducting the relevant weld tests for the welded joints. All splicing work shall be of full strength. Shop splicing for all sections other than rolled sections shall be carried out by full penetration butt welds. Shop splicing of all rolled sections shall be carried out using web and flange cover plate.

Following connections shall be provided during erection :

Welded Connection

Connection of secondary beam to main beam

Connection of bracing to column

Connection of bracing to longitudinal tie beam

Connection of longitudinal tie beam to column

Connection of spandrel beam to column

Connection of other secondary structures

HSFG Connection (Grade 8.8 bolts)

Splicing of column/transverse frame beam/ longitudinal tie beam

Connection of frame beam to column

Connection of Crane Girder to column

Connection between crane girders

Other major connections

Bearing Type Connection (HT bolts Grade 8.8)

All removable type connections

M.S. bolts (Grade 4.6)

Purlins, stairs, wall beams etc.

11.01.00 **Other Specific Requirements**

All steel framed structures shall be either “rigid frame “or “simple space frames “or a combination of two.

Lateral forces shall be resisted by stiff jointed moment connections in rigid frame design. The column bases shall generally be fixed to concrete foundation pedestal by providing moment resistant base detail.

Simple space frame design utilises single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels.

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However, wherever large cut outs (area more than 1.0 m^2) are provided in the floor slabs horizontal floor bracing shall be provided. Grating/ chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support in the form of shear connector and horizontal bracing shall be provided as required.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimise vibration, avoid resonance and maintain alignment and level.

All indoor gratings shall be electro forged type and outdoor gratings shall be welded type. Minimum thickness of grating shall be 40mm for indoor installation and 32mm for outdoor installation. The opening size shall not be more than 30mm x 100mm. The minimum thickness of the main bearing bar shall be 4mm. All gratings shall be hot dip galvanized.

Where a steel beam or member is to be connected on RCC structure, it shall be connected using an insert plate and through shear connection.

For crane girders, welding between web and flange plates shall be carried out by submerged arc welding process. Full penetration of weld between web plate and top flange shall be ensured. Intermediate stiffeners shall be connected with top flange plate by full penetration butt weld. Welding across tension flange shall not be permitted. Bearing edges of crane girders shall be machined.

The pipe and cable rack structures shall accommodate the pipes/cables with proper access and adequate working space for erection and maintenance. These shall be designed to carry safely all the loads acting on them (DL, LL, WL, EQL, forces from pipe lines etc.). The structures shall be adequately rigid to carry the forces from the pipelines at anchor points without undue deflection so that the pipe lines are really anchored at the anchor points.

The working point of the bracing connection shall be the center of column and girder to which it connects, where practical. The connections of gusset plates to column and girders shall be made to include provisions for eccentricity in connection. The double angle back-to-back with gusset plate in between shall not be used in dust-laden areas. Where double angles are not adequate, beam sections with web in the plane of bracing are used.

Permissible stresses for different members shall be allowed to exceed up to 33.33% only under normal loads along with wind and seismic conditions. However, members which are designed primarily to resist wind such as bracing members, no increase in permissible stresses shall be permitted. However, permissible stresses in bolts and welds shall be allowed to exceed up to 25 % only under wind and seismic conditions.

11.02.00 **Permissible Deflections**

The permissible deflections of various steel members under normal load conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic load are acting concurrent with normal loading conditions.

Vertical Deflection

a)	For beams supporting dynamic equipment	:	Span / 500
b)	For beams supporting floors/masonry	:	Span / 325
c)	For beams supporting pipes (pipe racks)	:	Span / 400

d)	For roofing and cladding components	:	Span / 250
e)	For gratings and chequered plates	:	Span / 250 subject to a maximum of 6 mm
f)	Coal conveyor gallery bridges:		Span/450

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

a)	For manually operated cranes & monorails	:	Span / 500
b)	For electric overhead cranes :		
	i) up to 50 t capacity	:	Span / 750
	ii) over 50 t capacity	:	Span / 1000

Horizontal deflections

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	:	Height / 325
b)	Multistoried building (without crane load)	:	Height / 500
c)	Pipe rack columns	:	Height / 200
d)	Open Structures	:	Height / 200
e)	Crane gantry girder due to surge	:	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail level due to action of crane surge load only	:	Height / 2500 limited to maximum of 10 mm

g)	Open gantry columns at crane rail level due to action of crane surge load only	:	Height/4000 limited to maximum of 10 mm
h)	Coal Handling Trestles	:	Height/1000

Provisions of IS: 800 and relevant IS Code shall be followed for limiting deflections of structural elements not listed above.

11.03.00 **Minimum Thickness of steel elements**

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment (Exposed to open air i.e., to Rain; Contact with Soil, Coal, ash, Contact with drained liquid or contaminated water, acid/alkali etc.) shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgment in each instance.

a)	Trusses, purlins, girts and bracing	:	6 mm
b)	Columns and beams	:	8 mm
c)	Gussets	:	8 mm
d)	Stiffeners	:	8 mm
e)	Base plates	:	10 mm & above
f)	Chequered plates	:	6 mm o/p & above
g)	Grating flats	:	5 mm

Minimum thickness of structural members other than gratings and chequered plate directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

11.04.00 **Minimum Sizes of steel elements**

For Joists	:	I - 150
For Channels	:	MC - 100
For Angles	:	L 50 x 50 x 6
Gusset plates	:	8mm thick

The flange width of purlins supporting light weight concrete slab	:	65 mm
The flange width of purlins supporting roof sheeting and wall cladding	:	50 mm.
Width of steel rolled section connected to other member	:	50 mm.
The depth of beams for platform	:	125 mm.

11.05.00 **Slenderness and Depth Ratio**

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

a)	Truss	:	1 / 10
b)	Rolled beams and girders for Ordinary floors and rafters	:	1 / 24
c)	Supporting floor beams for vibrating Machinery / equipment	:	1 / 15
d)	Roof purlins and girts	:	1 / 45
e)	Gable column	:	1 / 30

12.00.00 **STRUCTURAL MATERIALS**

Following materials shall be used in design and construction of the structure and foundation:

12.01.00 **Structural Steel**

12.01.01 Structural steel shall conform to Grade A of IS: 2062 for rolled steel members or plates up to 20 mm thickness. For plates above 20 mm thickness and welded construction, steel conforming to Grade B (Killed and normalized) of IS: 2062 shall be used except for crane girders where Grade C (Killed and normalized) (IS: 2062) steel shall be used. All structural steel plates and sections shall be of Main producer such as “SAIL” or “TATA STEEL” or “RINL” or “JINDAL” make or vendor approved by owner.

12.01.02 Structural pipes conforming to IS 806 (YST 25)

12.01.03 Structural hollow sections (square & rectangular) conforming to IS:4923

12.01.04 Pipes of hand rail conforming to IS:1161 (Medium class Grade YST=240)

12.01.05 Plates, Flats, Ordinary steel washers conforming to IS:2062 (Grade A, B & C).

12.01.06 Steel Gratings – Carbon steel conforming to IS:2062.

12.01.07 Chequered plates (6 mm thick) – Carbon steel conforming to IS:3502.

12.01.08 Anchor Bolts, Studs or Threaded Bars – Mild Steel of grade 4.6 conforming to IS:5624.

12.01.09 Connection Bolts – All High strength connection Bolts shall be of grade 8.8 conforming to IS:1367 and shall be supplied conforming to IS:3757. All mild steel connection bolts shall be of grade 4.6 conforming to IS:1367.

12.01.10 All nuts shall be of heavy duty hexagonal type and shall be compatible with the bolts.

12.01.11 All nuts & washers for high strength bolts shall conform to IS:6623 & IS:6649 respectively.

12.01.12 Washers for mild steel bolts shall be of mild steel conforming to IS:5369/IS:5372 or IS:5374 as the case may be.

12.01.13 Welding Electrodes – Low Hydrogen electrodes conforming to IS:814.

12.02.00 **Concrete**

12.02.01 **Cement**

All cement shall be Fly ash based Portland pozzolana cement conforming to IS:1489 (Part-1).

Ordinary portland cement conforming to IS:8112 (43 grade) / IS 12269 (53 grade) shall necessarily be used for the following structures :

i) TG foundation top deck and sub-structure

ii) Major machine foundations such as PA/FD/ID Fans, Pulverizers, TDBFP AND MDBFP

iii) Chimney shell

iv) Shell and racker columns of NDCT

v) Structures requiring grade of concrete of M25 and above excluding water-retaining structures.

As an alternative to Fly ash based Portland pozzolana cement, Fly ash can be added to ordinary Portland cement (Grade 43/53). Batching plant shall have facility for mixing fly ash. Fly ash shall conform to IS: 3812 (Part I & Part II). Percentage of fly ash to be mixed in concrete shall be based on trial mix and subject to maximum of 25% replacement of cement. Detailed design mix shall be carried out by the bidder and approved by the consultant / owner.

PP Cement shall be used only for miscellaneous buildings like storage sheds, concrete pavements. For all other works OP Cement (grade 43/53) shall be used.

The cement procured from mini plants will not be acceptable.

12.02.02 **Grade of Concrete**

The following minimum grades of concrete as per IS-456 shall generally be used :

Sl. No.	Class	Grade of conc.
1.	i) Plain cement concrete used for screeds and mud-mat ii) Subgrade filling	M15 M7.5
2.	Paving in main plant area, Slab on grade, Duct bank	M20
3.	i) Reinforced concrete for super structure and foundation & Chimney raft	M25
	ii) Reinforced concrete for water retaining structure	M25
4.	Pre-cast concrete	M30
5.	Reinforced concrete for foundation of TG, Mill, BFP & Fan foundations	M30
6.	TG top deck, chimney foundation	M30
7.	chimney shell	M40
8.	Piles	M30

Detailed design mix shall be carried out by the contractor and approved by the Engineer.

All underground trenches, basement and water retaining/conveying system structures shall have plasticiser cum waterproofing cement additives such as 'SIKA', 'FOSROC' make or equivalent conforming to IS:9103. In addition, limits on permeability as given in IS:2645 shall also be met with. Addition of admixtures should not reduce the strength of the concrete below the specified strength in any case. In case of water leakage during hydro-test or otherwise, additional chemical injection grouting treatment shall be applied for repairing the leakage with no cost implication to the owner.

All concrete surface in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS:702 @ 1.7 kg/sqm (minimum) for water / damp proofing up to 400mm above finished grade level. Storm water drains shall not be provided with bituminous paint.

12.02.03 **Concrete Reinforcing Steel**

Reinforcing bars shall be TMT bars of grade Fe415 or Fe500 conforming to IS-1786 and Mild Steel bars conforming to IS : 432 (Grade I) of either of “SAIL”, “TATA STEEL” and “RINL”. However, for TMT re-bars above 25mm diameter shall be of ‘SAIL’, ‘TATA’ or ‘RINL’ only.

Furthur, vendor approval is required for additional vendors other than approved vendors of APGENCO.

13.00.00 **GENERAL DESCRIPTION**

Sl. No.	List of Structures/Buildings	Length (M)	Width (M)	Height (M)	No. Reqd.	No. of Storey	Remarks (Types of Building/Structure/Foundation)				
							Frame/ Structure	Foundation	Roof	Floors	Cladding
1.	Power House Building						Structural Steel	For details refer to cl.10.01.00 a) of this document	RCC (metal deck form over TG Hall)	RCC	For details refer Volume VII-B
2.	Mill Bunker Building						Structural Steel	For details refer to cl.10.01.00 a) of this document	RCC (metal deck form at feeder and tripper floor levels)	RCC	For details refer Volume VII-B
3.	Turbo Generator foundation, Boiler Feed Pump Foundation and all other major equipment foundations						RCC	-do-			
4.	Boiler Foundation						RCC	-do-			
5.	ESP & Duct Supporting Foundation						RCC	-do-			
6.	ESP Control Room						RCC	-do-	RCC	RCC	For details refer Volume VII-B
7.	Chimney & Foundation						RCC	-do-			
8.	Transformer Yard Foundations including Oil Pits						RCC	-do-			

Sl. No.	List of Structures/Buildings	Length (M)	Width (M)	Height (M)	No. Reqd.	No. of Storey	Remarks (Types of Building/Structure/Foundation)				
							Frame/ Structure	Foundation	Roof	Floors	Cladding
9.	Switchyard Structures, Foundation & Trenches						RCC/ Structural Steel	-do-			
10.	Switchyard Control Room Building						RCC	-do-	RCC	RCC	For details refer Volume VII-B
11.	DM Plant, DMW Storage Tanks, Chemical House etc.						RCC	-do-	RCC	RCC	-DO-
12.	CW Pump House						RCC Sump and structural steel super-structure	-do-	RCC	RCC	-DO-
13.	Chlorination Plant						RCC	-do-	RCC	RCC	-DO-
14.	B.A. Slurry Pit & Pump House						RCC	-do-	RCC	RCC	For details refer Volume VII-B
15.	Ash / MRHS Compressor Building						RCC	-do-	RCC	RCC	-DO-
16.	Ash Handling Plant Control Building						RCC	-do-	RCC	RCC	-DO-
17.	Ash Water Pump House						RCC	-do-	RCC	RCC	-DO-
18.	Ash Pipe Rack						Structural Steel	-do-			

Sl. No.	List of Structures/Buildings	Length (M)	Width (M)	Height (M)	No. Reqd.	No. of Storey	Remarks (Types of Building/Structure/Foundation)				
							Frame/ Structure	Foundation	Roof	Floors	Cladding
19.	Service & Technical Building						RCC	-do-	RCC	RCC	For details refer Volume VII-B
20.	Clarified Water Reservoir & Pump House						RCC	-do-	RCC	RCC	-DO-
21.	HSD/HFO Day Tank Foundation						RCC	RCC Ring Wall Foundation			
22.	FO Forwarding Pump House						RCC	For details refer to cl.10.01.00 a) of this document	RCC	RCC	For details refer Volume VII-B
23.	Diesel Generator & Compressor Building						RCC	-DO-	Colour coated galvanized sheeting	RCC	-DO-
24.	Side Stream Filter						RCC	-DO-			
25.	Store						RCC	RCC Spread	RCC	RCC	For details refer Volume VII-B
26.	Fly Ash Silo						RCC	For details refer to cl.10.01.00 a) of this document	RCC cast-in-situ		
27.	Mill Reject Silo						RCC/ Structural Steel	-DO-			

Sl. No.	List of Structures/Buildings	Length (M)	Width (M)	Height (M)	No. Reqd.	No. of Storey	Remarks (Types of Building/Structure/Foundation)				
							Frame/ Structure	Foundation	Roof	Floors	Cladding
28.	HSD/HFO Pipe Corridor						RCC/ Structural Steel	-DO-			
29.	Fire Water Sump						Structural Steel	RCC Ring Wall Foundation	RCC		
30.	Fire Water Pump House						RCC	For details refer to cl.10.01.00 a) of this document	RCC	RCC	For details refer Volume VII-B
31.	Wagon Tippler						Structural Steel	-DO-	Metal cladding		-DO-
32.	Transfer Point						Structural Steel	-DO-	Metal cladding		-DO-
33.	Pent House						RCC	-DO-	RCC	RCC	-DO-
34.	Crusher House						RCC	-DO-	RCC	RCC	-DO-
35.	Stacker/Reclaimer						RCC	-DO-			
36.	Equipment Laydown Space						RCC	RCC Paving			
37.	RCC Retaining Wall						RCC	-DO-			
38.	FO Pressurising Pump House						RCC	For details refer to cl.10.01.00 a) of this document	RCC	RCC	For details refer Volume VII-B
39.	Pipe Rack						Structural Steel	-DO-			

Sl. No.	List of Structures/Buildings	Length (M)	Width (M)	Height (M)	No. Reqd.	No. of Storey	Remarks (Types of Building/Structure/Foundation)				
							Frame/ Structure	Foundation	Roof	Floors	Cladding
40.	HFO & HSD Main Storage Tank						Steel	RCC Ring Wall Foundation	Steel		

14.00.00 DESCRIPTION OF MAJOR PLANT STRUCTURES/COMPONENTS

The description of some of the major structures/components of this turn-key Package are given below:

14.01.00 Power House Building

The main power plant building comprising TG bay (A-B bay) and the adjacent electrical & deaerator bay (B-C bay) will be of steel framed construction upto the roof level. All floor slabs at intermediate level will be of RCC and will be supported on steel beams & columns. Transverse frames will be of framed type, bracings will be provided in longitudinal direction to resist horizontal forces. A-B bay will be equipped with EOT crane.

All cladding / glazing, roof material , drainage and treatment, all necessary flooring, finishing, painting, doors, windows, louvers and all other fixtures shall conform to General Specification and Design Criteria for Architectural Work - Volume II-G/2 of this bid document.

Within the building, the concrete pedestal for supporting the turbine generators and Boiler Feed Pumps/motors will be completely isolated from the building floors for vibration control. The Boiler Feed Pumps shall be located in the ground floor of Power House Building. The foundation for Turbo-generator and Boiler Feed Pumps/motors shall rest on conventional machine foundations. The concrete operating floor will be designed for construction and maintenance loadings of TG. Hatchways with removable chequered plates or grating floor covers will provide access to equipment on lower floor and will be within turbine hall crane access. The intermediate floors will be of concrete with hatchways as necessary.

The roof over Turbine Hall shall be flat with a gentle slope of about 1 in 100 towards the transformer yard. The roofing will be done by cast-in-situ RCC slab over permanently colour coated (on exposed face) galvanized M.S. troughed metal decking of approved profile supported by steel purlins which are spanning between two adjacent roof trusses. The thickness of sheet shall be as per the design requirement considering worst load combination subject to a minimum thickness of 0.8mm. The roof shall be insulated with rigid insulating board. For Roof water proofing treatment relevant section of the Architectural specification shall be referred. Roof will be provided with suitable drainage arrangement through rainwater down comers.

All structural components will be shop welded while the field connections will be made with high-tensile bolts or welding as determined in design stage. The transverse frames will be of moment resistant design. In the longitudinal direction, these transverse frames will be braced to resist horizontal forces.

Stairs and platforms shall be provided as required for maximum utility and safety. Stairs shall have to be provided as per TAC regulations and any other statutory requirements.

Structural steel platforms along with gratings, ladders and hand rails shall be provided to all equipment for operating the valves etc., as and where required. Bus duct support & structure shall be provided as required.

14.02.00 **Mill & Bunker Building**

Mill & bunker Building shall house coal pulverisers, coal bunkers, feeders, Tripper conveyor with its drives and monorails. All columns, main and secondary beams shall be made of structural steel.

The frame will be designed as a moment resisting sway frame in the transverse direction and braced frame in the longitudinal direction. The columns shall be braced in both the transverse and longitudinal direction. Bracings may be waived of in the transverse direction above the tripper floor and near the ground floor due to functional requirement. The bracings in the longitudinal direction shall be in two (2) planes through a pair of longitudinal members laced or battened together. Each bracing member shall be connected to column flange plate through gusset plate of minimum thickness of 12 mm.

Grillage type column base of minimum depth of 800 mm and consisting of bottom base plate, top plate and vertical stiffeners shall be provided for main columns. Base plates will generally be 1250 mm below ground floor in order to keep gusseted base below ground. This portion shall be encased in concrete for corrosion protection. The column and mill will be supported on pile/raft foundations.

The floors will be of reinforced concrete slab with hardened top with hatchways as required. Building roof and floor slabs at feeder and tripper floor levels will be of Cast-in-situ R.C.C. over permanently colour coated (on exposed face) galvanized M.S. troughed metal decking of approved profile, supported on steel beams/girders. Ground floor slab will have drainage trenches covered with steel grating. Rain water down take pipes of galvanized MS conforming to class medium of IS:1239 shall be provided along all the bunker supporting columns from roof level to drain at ground level.

Supporting structure for Mill maintenance arrangement will be connected to this structure. Handrails shall be provided on all sides of Feeder floor. Slit openings are to be provided in Tripper floor for entry of coal from Tripper into bunkers. Framing arrangement for structural steel platform at various levels around the bunkers shall be provided, as required, with proper access ladder for poking, striking and attending to air cannons. Mill building shall be designed considering load from connecting conveyor gallery and other Coal handling facilities. End columns to support the external gallery of the tripper conveyor shall be provided with structural steel brackets with PTFE bearings.

The building sides will be cladded with brick cladding to a height of 3.0 mts with a provision of openable windows above tripper floor and balance portion above brick wall up to roof level shall be cladded with single skin metal cladding. The remaining portion of the building below Tripper floor up to

ground floor shall generally be uncladded. However, brick cladding shall have to be provided, if required, as per TAC and any other statutory requirements.

Stairs and platforms shall be provided as required for maximum utility and safety as per TAC regulations and any other statutory requirements. Stair should be provided from ground up to roof. Minimum two (2) nos. of stairs shall be provided in each Mill Building. Structural steel approach bridge from boiler structure and walkway with MS grating and handrails around the bunkers shall be provided above the feeder floor to access bunker coal level monitoring strain gauges. Structural steel platforms along with gratings, ladders and hand rails shall be provided to all equipment for their successful operation as and where required.

Bidder has the option to provide the Mill-Bunker Building independent of the boiler supporting structure or to integrate this building with the boiler structure. In case the Mill-Building is independent of the boiler structure, all walkway bridges to connect the Boiler with the RCC floors of the Mill-Bunker Building shall be provided with PTFE bearings.

The Coal bunker shall be circular in plan and cylindrical at top portion and conical at sloped hopper portion with minimum 73 deg. Slope. 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 inner surface of hopper wall shall be 4 mm conforming to grade SS304.Stainless steel liner shall be provided for complete hopper portion and extends 1.0 M in to cylindrical portion. On sides of the bunker necessary openings shall have to be provided for bunker ventilation / dust extraction. A comprehensive flowability study shall be conducted by the Bidder for the coalbunker hopper to ensure smooth flow of coal in all seasons with different moisture contents and different percentage of fines. Geometric parameters of hopper shall be decided considering the findings of flowability study.

Fastening System

The edges of stainless steel plates shall be ground smooth after cutting. The liner plates should be plug welded to the mother plate. The plug welding shall be done by drilling 20 mm. Dia. Holes @ 300 mm c/c both ways without puncturing the mother plate. The welding is to be done by using specialized stainless steel electrodes such as 308L / 309L. Shielding gas shall be Argon + Oxygen mixture or Argon + Hydrogen mixture. C02 mixture shall be avoided.

Before commencing regular fabrication of the bunker, trial assembly of the bunker including hopper shall be made at least for one bunker.

14.03.00 **Auxiliary Plant Buildings**

CW Pump House or any other superstructure of structural steel construction will be having rigid joint in transverse direction and braced in longitudinal direction. Gable and side cladding of this building shall be of brick masonry supported on steel wall beams. Roof shall be of cast-in-situ RCC slab over permanently colour coated (on exposed face) galvanized M.S. troughed metal decking of approved profile or removable formwork supported on steel purlins.

Dimensions, sizes, depth of CW pump house, control building etc. if indicated in bid specification are indicative and bare minimum only. The bidder should note that the cost implication, if any, due to change in the dimension, sizing etc. as per the equipment supplier's requirement is deemed to be included in the offer.

R.C.C. channel from Cooling Tower basin to CW Pump House shall be minimum 500 mm above F.G.L and road crossing portion shall be designed for Class 'AA' traffic.

For RCC buildings of more than 15M span steel roof truss/girders will be provided to support the concrete roof on permanently colour coated (on exposed face) galvanized M.S. troughed metal decking over concrete columns. Gable and side cladding will be constructed with brick masonry.

14.04.00 **RCC Stack**

14.04.01 **General Arrangement**

The reinforced concrete single brick flue stack of 275 M height shall be comprising of a wind shield of reinforced concrete shell with insulated brick lining inside the wind shield from hopper level to top. The brick flue shall be vertically supported on RCC ring corbels projected from inside face of wind shield at certain vertical spacings described elsewhere in this specification. The external RCC platforms shall be supported on RCC wind shield. Access to the platforms shall be through caged ladders outside of chimney.

i) **General Parameters**

1)	Total height of stack above ground level.	275 M
2)	Number of Stack (wind shield)	One
3)	Number of flue per Stack	1 (one) brick flue
4)	Number of Boilers	1

5)	Particulate emission	50 mg/Nm^3(approx)
6)	Foundation level	To be decided by Bidder as per recommendation based on geotechnical investigation carried out by bidder and approved by Owner
7)	Allowable Soil Bearing Capacity	To be decided by Bidder as per recommendation based on geotechnical investigation carried out by bidder and approved by Owner
8)	Exit velocity of flue gas	15 m/s with partial load 29.2 m/sec. with full load
9)	Type of stack (wind shield)	RCC wind shield with brick flue

ii) The wind shield shall be of RCC construction. Insulated brick flue shall be housed within the windshield. Brick flue/lining shall be supported on RCC ring corbels projected from inside face of wind shield at a maximum vertical spacing of 10.0$^{m.}$ External RCC platforms shall be provided at regular intervals satisfying all functional as well as statutory requirements. The flue ducts shall be entering the wind shield at a particular level.

All external RCC platforms shall be supported on R.C. shell of the wind shield. External cage ladder for access to all platforms shall be provided. Access door at grade level and clean out door at hopper level shall be provided for access into the windshield and to the hopper. All doors like inspection/maintenance doors shall be as per IS code / environment regulation.

Natural Ventilation within the windshield shall be provided as required.

iii) **Elevator and Caged Ladder**

Elevator and caged ladder outside windshield shall be provided.

The travel of the elevator shall be up to the last platform level. Caged ladder shall be provided from ground up to top level of chimney with access to all external platforms. The maximum spacing between intermediate landings shall be restricted to 9.0 m at which locations the direction of ladder shall be changed.

Steel cage ladder shall be hot dip galvanised. Stringers shall be of angles 90x90x10 with a minimum clear distance of 600 mm in-between. Rungs shall be of 20 mm diameter galvanized iron rods spaced at 300 mm centres. Ladder stringers shall be provided with suitable lateral stays connected to the chimney wind shield. The ladder and its connection shall be designed for a minimum load of 200 kg at any location.

iv) **Paintings**

Entire external surface of the windshield shall be painted at least two coats over prime coat in alternate band of signal red and white colour starting with signal red colour at the top and in line with aviation requirements. External painting shall have acid, UV and heat resisting properties conforming to IS-158. Total dry film thickness (DFT) shall be at least 150 microns. The top of shell and top of acid resistant bricks at the roof level shall be painted with two coats of 'EXPILUX 5 COAL TAR EPOXY PAINT" over a thin coat of the same paint as manufactured by M/s. Berger Paints (India). The overall DFT shall be at least 230 microns.

The inner surface of wind shield from ground floor up to full height shall be painted with acid and heat resisting black bitumen paint (two coats) of approved make to give a paint DFT not less than 150 microns .

Surface preparation and paint application shall be in accordance with manufacturer's recommendation and as per specification.

v) **Flue Gas Sampling Ports on chimney**

a) Gas sampling ports fabricated from stainless steel with flanged ends shall be provided for liner at platform levels, including proper insulation, blank plates, nuts, bolts etc. The location, orientation and levels of ports shall be as per the regulations of Central Pollution Control Board & Andhra Pradesh State Pollution Control Board.

b) Flue gas sampling ports for on line Emission monitoring instruments & Test Ports for local sampling & testing, fabricated from MS pipes of standard schedule shall be provided on the liner at access platform level.

c) The contractor shall provide one (1) nozzle made of 200 NB MS pipe and projected approximately 200 mm outside the flue wall with an upward inclination of 5 Degree with the horizontal plane of flue can for mounting of SOx, NOx & CO analyzer.

d) The contractor shall provide two (2) nozzles in diametrically opposite position made of 200NB MS pipe and projected approximately 200 mm outside the flue wall for mounting of Opacity monitor.

e) Location of the Sampling & Test ports, on the stack, shall be at least at a distance of 8D (D= Stack diameter) downstream along the direction of flue gas flow from ID fan duct connection to stack. Further the selected position shall be at least 2D before stack exit. The height of the test ports shall not be less than 82.5 metre from FGL, fulfilling all above the criteria.

f) Temperature Test pockets with a stub of size M33X2 for installing thermo-well shall be provided by Bidder for flue gas temperature measurement & correction for opacity measurement.

g) In addition to the above sampling ports for instrumentation purpose there shall be four (4) gas sampling ports on the flue can at 90 degree apart with flanged ends for local sampling & testing. Contractor shall provide required counter flange, nuts, bolts and gaskets. The size of each nozzle shall be 100 NB and provided with blind flanges.

h) Access platforms shall be provided for maintenance of the above analyzers and for local sampling.

i) Power connection with 240V, 15A AC plug socket arrangement shall be installed at this platform level for operating the Test Instruments.

j) Dimensions indicated above are tentative, which shall be finalized during detail engineering upon receipt of vendor data. The exact details of pipe & flange and their elevations will be furnished during detail engineering on receipt of data from analyzer supplier.

Bidder shall furnish the arrangement drawings for the sampling and test points for Owner's approval during detail Engineering.

vi) **Ash Hopper**

i) Hopper shall be of reinforced concrete and lined with 75 mm thick acid resistant brickwork laid over 75 mm vermiculite concrete. Only shaped acid resistant bricks shall be used in the hopper portion. The bricks, mortar and details of laying and joining shall conform to the requirements laid down for acid resistant brick lining as per latest IS codes.

Hopper shall be supported on continuous RCC corbel projected from wind shield. A ring beam shall be provided at end of hopper at top which will rest on RCC corbel over 12 mm thick asbestos board.

Hopper shall be properly sloped to enable accumulation of dust towards the central opening at bottom.

At the bottom of the hopper, Cast Iron (CI) flanged pipe with puddle flange of required diameter and length shall be provided. Inside of this pipe sleeve shall be coated with sodium silicate.

Adequately designed RCC baffle wall shall be provided at flue-duct level above hopper. Baffle wall shall be placed at the centre of the wind shield perpendicular to the incoming flue-duct and the same shall be supported from RCC wind shield. Acid resistant brick lining shall be provided on all surfaces of the baffle wall.

ii) **Maintenance Provisions**

The outer face of the chimney wind shield shall be provided with adequate number of stainless steel insert plates of grade 316 L at the top to enable fixing and supporting painter's trolleys and other accessories. The insert plates shall be provided with suitable number of threaded holes and nuts welded at the rear end to enable bolting of the assembly when desired.

Similar arrangement shall be made at each platform level but to fix the painting trolley arrangement directly on the platforms for the purpose of painting the chimney.

A lifting beam shall be provided to cater for lifting of materials during maintenance and painting. The size and capacity of the lifting beams shall be as per requirements.

iii) **Louvres**

Air outlet louvres shall be provided as per requirement. The louvre fins shall be of Z-shape in cross section and made from anodised aluminium plates of a minimum thickness of 4 mm. The frame work supporting the louvre fins shall be made from extruded aluminium sections of minimum thickness 6 mm. The louvres shall be mounted in the form of panels. The fins shall be closely spaced to cut off any driving rain entering the chimney wind shield. All panels must be approved by the Owner before installation.

14.04.02 **Design Criteria**

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 IS, 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.

A. **Loading**

a) **Dead Load**

i) All permanent loads due to the weight of chimney shell, external platforms, insulated brick linings supported on corbels, ladders, other accessories etc.

b) **Imposed Loads**

i) Imposed load on service platform around Chimney shell, shall be taken as 500 Kg/m^2. Design live load during construction / erection shall be considered as 1000 Kg/m^2.

ii) Imposed loads from duct joining the Chimney shall be considered.

c) **Wind Load**

The wind loading shall conform to IS: 875 (Part-3). Following parameters shall be considered for assessing wind loads:

Basic wind speed = 44 m/s at 10m above mean retarding surface

k_1 = 1.08 as per Table 1 of IS: 875 corresponding to 100 years return period

k_3 = 1.0

k_2 = As per Table 2 of IS: 875 (Part – 3) corresponding to terrain (category 4)

k_2 (bar) = As per Table 33 of IS: 875 (Part – 3) corresponding to terrain (category 4)

Aerodynamic Interference Effect (proximity effect) due to presence of other tall structures and stacks in the vicinity shall be assessed based on wind tunnel test to be carried by specialized agency in this field acceptable to Owner and shall be incorporated in design.

Profile (diameter, thickness etc.) as well as wind forces (moment/shear etc.) at different sections/levels of chimney shall be calculated as per structural analysis conforming to requirements of IS:4998 and Contract Specification. Wind Tunnel study shall be carried out based on the profile of the chimney determined. Worst of the forces calculated as per structural analysis and obtained from wind tunnel study shall be considered as design forces for final design of shell and foundation.

d) **Seismic / Earthquake Load**

Calculation of earthquake forces acting on the Chimney and analysis for the same shall be carried out as per IS: 1893 (Part 4) [Zone – III] using the Response Spectrum Method. Material damping factor and number of modes to be considered for the analysis shall be as per recommendation in the code referred above.

e) **Thermal Effect**

Thermal effect due to established thermal gradient shall be duly considered as per provisions in relevant IS code.

The temperature gradient Δ T across the shell thickness of wind shield shall be calculated as per IS : 4998 but subject to a minimum of 30^{o}C. The temperature stresses shall be calculated according to the procedures given in ACI – 307 and IS : 4998.

f) **Local Loads**

The effect of following local loads shall be considered.

i) Local moment produced by corbels (if any).

ii) Local moment due to platforms.

iii) Local moment due to occurrence of ovalling oscillation.

iv) Local moment produced by thermal gradient.

B. **Load Combination**

Various load combination for calculation of stresses shall be as under.

i) Dead load + Wind load.

ii) Dead load + Earthquake effect.

iii) Dead load + Temperature effect.

iv) Dead load + Wind load + Temperature effect.

v) Dead load + Earthquake force + Temperature effect.

vi) Circumferential stresses due to temperature effect.

vii) Circumferential tensile stresses due to wind induced ring moment.

viii) Circumferential compressive stress due to wind induced ring moment combined with temperature.

In load combinations (i) to (viii) above, dead load considered with or without the weight of insulated brick lining, whichever condition is more critical shall be adopted for design. Across wind loads shall be combined with co-exiting along wind loads. The combined design moment at any section shall be taken as SRSS of the moments due to across wind loads and co-exiting along wind loads.

C. **Permissible Stresses For Chimney Shell**

The Stress in Steel reinforcement and Concrete shall not exceed the limits as prescribed in clause 7.0 of IS: 4998 (Part-2) for various combination of loads. Except for case of dead load + wind load, the maximum permissible stress in concrete in this case shall not exceed 0.28 Fc, where Fc = Characteristic compressive strength of concrete.

D. **Analysis**

- **Free Vibration Characteristics of Wind Shield**

  Assessment of Natural Frequencies and mode shapes shall be carried out. For this purpose the Chimney shell shall be idealized as a vertical cantilever with Lumped masses at different nodes. The nodes shall also be provided at each platform level.

  The number of modes to be considered in the analysis shall be such that at least 90% of the modal mass is excited.

- **Wind Analysis**

  a) **Along Wind Load**

  Along wind load shall be assessed based on methods specified in IS: 4998 (Part-I) – 1992. For design, higher of the wind loads obtained from simplified method in A-4.1 and random response method in A-5.1 shall be used. Dynamic modulus of Elasticity of concrete as recommended in IS: 4998 (Part-1) – 1992 shall be used for evaluating the natural frequencies.

Drag coefficient `$C_D$' or Force coefficient `C_f' shall be taken as 0.8 (minimum) based on Fig 5 of IS: 875 for the concrete shell in general. It will be increased as required as per IS: 4998 over the portion covered with strakes, if required. It is to be noted that provision of steel strakes may not be feasible considering the elevator and caged ladder up to top of chimney. Requirement of strakes shall be determined as per wind tunnel study.

b) **Across Wind Load**

The across wind response of the Chimney shall be evaluated as per the method given in Section A-4 as well as A-5 of IS: 4998 (Part-I) – 1992. Peak Oscillatory Lift Coefficient C_L shall be taken as 0.16 and Strouhal Number S_n as 0.2. Higher of the two moments shall be considered for design of the Chimney.

c) **Ring Moments due to Wind**

The circumferential ring moment due to wind shall be calculated in accordance with clause 5.4 of IS: 4998 (Part-I) – 1992. The wind induced stresses in concrete and steel shall be checked in accordance IS: 4998 (Part-2).

- **Seismic Analysis**

The Seismic Analysis shall be carried out using the Response Spectrum Method according to IS: 1893 taking the first 5 modes (minimum) of vibration in to account. 5% damping shall be considered for the analysis.

14.04.03 **Component Design Criteria**

A. **Wind Shield**

The design conditions for the concrete shell shall be as follows :

1. The concrete shell shall be designed for loads and load combinations as specified. Working stress method shall be used for design of shell. The modular ratio shall be calculated as per Annexure – B of IS – 456.

2. The concrete shell shall support all platforms as well as corbels, which in turn supports the brick flue.

3. The permissible stress in concrete and reinforcement shall be limited to as specified in clause 8 of IS 4998 (Part 2) and as per Cl. No. 10.02.00 of this section, whichever is critical.

4. The maximum deflection at the top of the chimney for both static and dynamic cases shall not be more than H/500 where `H' is the total height of the windshield above top of the foundation.

5. The static modulus of elasticity of concrete for various concrete grades shall be taken as specified in IS: 456.

6. The dynamic modulus of elasticity of concrete for various concrete grades shall be taken as lower values in the range of values specified in IS : 4998 (Part-I) – 1992.

7. Reinforcement in the shell shall be provided as per IS: 4998 (Part-2). However, the maximum spacing or reinforcement shall not be more than 250 mm both ways in the shell and 300 mm for foundation raft.

   Minimum 0.12% reinforcement shall be provided on either side of stack wind shield.

   While providing vertical reinforcement steel in the shell, the total number of vertical bars shall be continued till such height when alternative bars can be discontinued. However, reduction of bar diameter along the height is permissible. At any section of the shell vertical bars shall be uniformly spaced. Non-uniform spacing of vertical bars is not acceptable.
   One third of the vertical bars can only be lapped at one section.

8. Openings in the shell shall be provided for ductwork, access doors, ash channel and ventilation system etc. The maximum width of opening shall be limited to an angle of not more than 30^0 subtended at the center of the concrete shell. Openings for ventilation shall be provided along periphery of the wind shield just below top of ash hopper.

   The total plan area of the openings at a particular section shall not be more than 15% of the plan area of concrete shell at that location. The opening size for the purpose of stress calculations shall be taken as 1.1 times the actual width of the opening. The extra reinforcement around opening shall satisfy the requirements given in the following documents and the highest shall be provided.

   a) IS: 4998

   b) ACI 307

   c) Reinforced concrete chimney and tower by G.M. Pinfold.

9. Embedment to support the caged ladder shall be provided as required.

10. Caged ladder and elevator enclosures shall be provided keeping provision for a rack and pinion type electrically operated elevator.

11. Minimum thickness of wind-shield at top of base raft level shall be 1000 mm. Minimum thickness of wind-shield at top of chimney shall be 400 mm. However, uniform thickness of shell shall be maintained from top of raft to 3.0 m above top of flue duct entry.

12. Uniform Grade of concrete shall be adopted throughout the height of chimney shell.

B. **Brick Flue**

- **General**

a) The flue diameter shall be so sized to ensure that the flue gas exit velocity is approximately 20 meters/second at all loading conditions. It should be ensured that the flue gas exit velocity at the lowest continuous unit load is high enough (of the order of 15 meters/second) to enable adequate dispersion of the flue gases. For this purpose, 60% turbine MCR condition with design coal / worst coal firing (whichever yields lesser flue gas quantity) shall be considered as the lowest continuous load condition.

b) The number, size and location of flue opening in the shell shall be as per the requirement of boiler supplier. The Contractor shall make arrangement for the proper support of ducting on the shell and support arrangement as required.

c) Access doors shall be provided for the ducting where required for inspection and cleaning.

- **Brick Lining**

a) The chimney shall be lined with 230 thick acid resistant bricks for at least first 55 metres above top of hopper and 115 thick acid resistant bricks for the rest height of the chimney except for top 10.0 m where 230 thick acid resistant brick lining shall be provided. The lining shall be supported on RCC corbels (projected from inside face of wind shield) at intervals of not more than 10.0 metres vertically.

b) Lining bricks shall be hard, uniformly well burnt, uniform in colour, of correct shape and size, homogenous in texture and free from cracks, voids and other flaws and shall be of material suitable to withstand the service conditions. No broken bricks shall be allowed to use except for closing the course. Each brick shall be clearly marked with the manufacturer's name and trade mark.

c) The acid resistant bricks shall conform to Class I of IS:4860 and the mortar for this brickwork shall conform to IS:4832 (Part 1) - Silica type with potassium silicate liquid binder. Provision shall be made for differential vertical expansion at the lining support. The Contractor shall furnish test certificates confirming the acid resisting properties for acid resisting bricks from an approved laboratory for Owner's approval before bringing them to site. Properties of the acid resistant bricks of Class-I shall be as per Table-1 of IS:4860.

d) In the case of Acid resistant Brick lining, the mortar joints shall be cured with 25% dilute HCl for a minimum period of 3 days and as per Manufacturer's specification after which exposed face shall be thoroughly cleaned with water.

e) The value of the coefficient of thermal conductivity for acid resistant lining bricks shall not exceed K = 1.25 Kcal/m/hr/°C and shall be considered as K = 1.25 Kcal/m/hr/°C for the purpose of design of shell for temperature effects.

f) Prior to despatch of bricks from Manufacturer at least six (6) samples of the lot to be despatched shall be tested for K-value at an approved laboratory and test reports submitted to Owner for approval and permission for despatch of material. While testing, the hot-face temperature of the bricks shall be 300°C.

g) The thickness of lining shall be as per item no. (a) of this clause. The radial joints shall be broken in each course. Lining shall be strapped with circumferential and vertical double hot dip galvanised mild steel bands having a minimum dimension of 75x6 mm and 50x5 mm respectively, both spaced at one metre centres, on the exterior of the brickwork throughout the full height of the lining.

h) The vertical and horizontal bands shall be joined together by either (a) suitable spot welding and all weld joints painted with two (2) coats of zinc rich aluminium paint over a coat of compatible primer as per the requirement of the Manufacturer, or (b) fixed by bolting arrangement, with counter sunk bolts and slotted holes.

i) Mortar for lining shall be used within the initial setting time and no retempering shall be permitted. Joints shall be properly filled and at a given cross section, the thickness of the joint shall not be more than 3 mm. For this purpose, the bricks shall be of necessary curvature and taper.

- **Insulation**

a) The flue shall be insulated externally. The slag/mineral wool shall be of resin bonded type conforming to IS:8183 in the form of slabs. The material shall have a minimum density of 1.75 kN/cu.m. Maximum coefficient of thermal conductivity shall conform to requirements of IS:3677 at a mean temperature of 150°C.

b) The insulation thickness shall be chosen based on the maximum ambient temperature, insulation surface emissivity of 0.3 and the insulation cold face maximum temperature not exceeding 60°C. However minimum 100 mm thickness of insulation shall be provided.

c) The insulation shall be tightly secured to the exterior surface of the liner by impaling them on studs fixed to the bricks at 450 mm c/c both horizontally and vertically. The studs shall be plated and be of a minimum thickness of 10 gauge. The studs shall extend a minimum of 25 mm beyond the thickness of insulation and 63 mm. Circular or square metal plate speed washers of standard thickness shall be placed on the extended portion of the studs to hold the impaled insulation material well in place. Further, 20 gauge galvanised wire mesh with a 25 mm hexagonal pattern conforming to IS:3150 shall be wrapped around. Where the wire mesh is jointed, a minimum 150 mm overlap shall be provided. The mesh shall be bound and tied in place with a 16 gauge GI wire at 300 mm centres. Any form of lacing the mesh fibres together shall not be permitted.

d) The diameter of the asbestos rope conforming to grade 1 of IS: 4687 shall be 25 mm.

e) Asbestos mill board shall be 12 mm thick, unless otherwise specified. It shall be plain, dense and have a homogeneous texture, without cracks, flaws or any other manufacturing defects. It shall be laid directly over the concrete after removing all loose materials but without any mortar / plaster bedding.

f) The base for acid resisting brick lining in hopper portion shall be 75 mm thick vermiculite concrete.

g) No air gap shall be provided between insulation and brick lining. Accordingly, openings/cut-out in RCC corbels (for blowing of hot air) and openings in RCC wind shield at top (for venting out of hot air) shall not be provided. The insulation shall be packed properly between wind shield and brick lining.

- **Chimney Cap Over Brick Flue**

  In order to prevent gas-entrained matter from falling into the space between the liner and the shell and also to prevent the chimney top from chemical attack of flue gases, a sectional stainless steel cap of minimum 6 mm thickness over 25 mm thick asbestos mill board shall be provided. The cap shall cover the concrete shell, brick lining and insulation between them. The cap shall have slope towards the inside of the chimney at approximately 30° to the horizontal. All segments and sections of the cap shall be anchored in place with stainless bolts and stainless rag bolts respectively. The cap shall have a minimum overlapping length of 200 mm with 230 thick acid resistant brick lining with a clear gap of 6 mm between them.

C. **Foundation**

- Please refer provisions of Cl. No. 10.01.00 of this Section.

- The chimney foundation shall be designed 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.

- Ground water table shall be considered at finished grade level for foundation design. The foundation shall be checked for overturning for minimum and maximum vertical loads. Loss of contact of foundation shall also not be allowed in any combination of loads.

- Increase in allowable bearing capacity of soil under wind/seismic loading/combinations shall not be permitted.

- Base raft of chimney shall be designed as continuous considering uniform thickness without tapering. Annular raft with hollow inside is not permitted. Thickness of raft shall not be less than 0.1 times the diameter of the raft nor 0.4 times the overhang of raft from the face of the shell.

- The foundation diameter to depth ratio shall be maintained to around 10 and should preferably not exceed 12.

- Minimum 0.12% reinforcement shall be provided on either face of foundation.

- One intermediate layer of reinforcement in raft shall be provided where the thickness exceeds 2000 mm. Two such intermediate layers of reinforcement shall be provided where the thickness of raft exceeds 4000 mm. Such reinforcement in each direction shall not be less than 0.06% of cross-sectional area of raft.

- Concrete pouring sequence shall be such that no cold joints occur. Pouring for raft concrete shall not be more than 3 segments.

- The shrinkage reinforcement shall not be less than 16mm deformed bars at 600 m centres. In addition, vertical chair bars at 600 mm centres shall be provided to support these bars.

D. **Outer Platforms**

Outer platforms, shall be provided as per Directorate of Air Routes & Aerodromes (DARA) Circular for locating Aviation Warning Lights. The platforms shall be equally spaced at a spacing of 40 m (maximum). Top most platform shall be provided preferably 2.0 mts below the top of chimney.Additional platforms for sampling ports, access doors, clean out doors etc. shall have to be provided as per requirements.

The minimum clear width of the platforms shall be 1200 mm and a live load of 500 Kg/m^2 shall be considered for design in addition to the dead loads and other incidental loads, if any, including construction loads.

Hand railing shall be provided all around external platforms using 32 NB (medium duty) G.I. pipes. The spacing of railing posts shall not be more than 1500 mm center to center. The height of hand railing shall not be less than 1250 mm. There shall be three handrails at about 450 mm and 850 mm & 1250 mm respectively above platform level. The posts shall be embedded in RCC curb (150 x 200 high) at outside face of platforms.

150 mm dia GI pipe shall be provided to carry rainwater from all platforms to discharge point at ground level. The number of down take pipe shall be decided as per design.

E. **Doors**

i) **Access Doors**

Two access doors of size 3000 mm x 3500 mm (high) or allowable maximum size and 2000 mm x 2100 mm (high) shall be provided at ground floor level for truck and personnel access. Electrically operated roll up shutter of suitable size for truck entry access and hollow type

pressed steel doors for personal access shall be provided. These doors shall be provided with minimum two coats of acid and alkali resistant paint conforming to IS:158 type-I to give a DFT of 100 microns on inside surface. The outside surface shall be provided with 2 coats of resin based zinc rich primer and two final coats of epoxy paint. The personal access door shall be hinged and provided with positive locking device. The hinges required for connecting the doors with door frames shall be heavy duty butt hinges conforming to IS : 1341 (latest).

ii) **Clean Out Doors**

One number each clean out door having clear dimension of 1000 mm x 2100 mm (high) shall be provided just above hopper level at appropriate location on either side of baffle wall with proper access for operating the door. The edges of the doors shall be properly sealed to prevent leakage of hot flue gases. The doors shall be of hollow pressed steel construction with inner plate of 10 mm and outer plate of 8 mm thickness with suitable infill of stiffeners. The hollow space shall be filled up with insulation of the type used around flue. In addition, around the door openings, removable type of insulation similar to the insulation provided around flue shall be provided. The door shall be of hinged type and provided with locking device in addition to Swivel studs with wing nuts on the remaining 3 edges. The door shall be openable from outside only. Proper sealing arrangement shall be provided in the doors to ensure leak tightness.

F. **Miscellaneous**

i) **Ground floor slab and drainage**

150 mm thick slab-on-grade over 100mm thick PCC laid over 250mm thick (compacted) boulder soling with interstices filled with sand shall be provided at ground floor. Proper slope towards internal periphery shall be provided in ground floor. RCC drain shall be provided around internal periphery of shell which shall be connected to drainage outside.

ii) **Temporary Lightning Protection**

During construction, temporary lightning protection should be maintained by connecting the concrete reinforcement to two (2) permanent electrical earthing conductors. After top lift of the chimney shell has been completed, temporary air terminations, which may consist of reinforcing bars, should be installed at the top to serve as temporary protection until the lining and cap are completed and permanent air terminations, conductors etc. are complete.

iii) **Temperature of concrete**

Temperature of concrete for base raft shall not exceed 23^{o} C at the time of pouring.

G. **Electrical Items**

For electrical equipment and accessories as required for Chimney refer to Section XV, Volume V-B under Electrical Equipment & Accessories in this bid document.

14.05.00 **Coal handling plant structures**

14.05.01 **General arrangement**

The descriptions of some major structures/components covered under this package are given below:

i) **Track Hopper**

The sub-structure (below ground level), it's supporting enclosure structures/basement shall be provided with base raft & the cross beams for supporting rail beams along with counter-forts at an interval of 3.0 m (maximum) in longitudinal side wall. The top edges of the cross beams shall be chamfered for smooth coal flow and provided with removable abrasion resistant steel liner plates (Min. 16 mm thick) e.g. TISCRAL/SAILMA. The overall depth of the above cross beams shall be restricted as per system requirement.

All faces of the beams coming in contact with coal shall be provided with removable abrasion resistant steel liner plates (Min. 16 mm thick) e.g. TISCRAL/SAILMA. Paddle feeder table shall be provided with abrasion resistant steel liner plates (Min. 16 mm thick) e.g., TISCRAL/SAILMA of suitable size fitted with C/S bolts through slab from bottom instead of inserts for easy replacement and repair.

The internal surface of coal hopper shall be provided with 10 mm thick SS-409M liner plates.. Gratings shall be provided as per system requirement specified elsewhere.

The walkway floor shall have non-skid finish. Water proofing for sub structures shall be done as per specification. The hopper wall in no case shall be in contact with earth/backfill.

The super structure of track hopper shall have structural framing with provision for electric traction wire for electric locomotive.

Continuous gutter (same as roof sheet of adequate thickness) with 150 dia. GI/ MS pipe rain water down comers conforming to IS:1239 / IS:3589 shall be provided. The number and size of down comers shall be governed by IS:1742 & IS:2527. Suitable monorails and stair shall be provided at two ends of track hopper from track level to tunnel level where machine hatches are provided. In addition, one staircase at the centre of the track hopper shall also be provided. The hopper shall be provided with M.S. grating as stated elsewhere in this specification. Standard G.I. hand railings on sides to be provided, as per system requirement.

The complete track hopper complex shall be enclosed by side and roof cladding and all needed doors, window, louvers, ventilators, glazing etc. as per specifications elsewhere or as directed by the Engineer.

The vertical walls (4 sides) of track hopper over gratings shall be protected by providing 3 mm thick metal rail guards of 300 mm approx. wide, up to 1500 mm above grating level for complete hopper length and needed access from access walkway to hopper grating level at interval of 20 meter for both sides. The opening shall be minimum 1.5 meter wide. The manual Labour can enter hopper area from staircase and or removable gratings provided at track hopper floor at every 20 meters.

Electric hoist facility/equipment hatch/removable grating covers, hand railing etc shall be provided in each maintenance bay. Access Stair/maintenance platform with sufficient space around the equipment for O&M shall be provided. Clear width of stair shall be 1500 mm (minimum), landing to landing height shall not exceed 3.2 M.

All structures of Track Hopper under influence of railway loads shall be designed for static/moving loads of locomotive and wagons. The number of locomotives and wagons with capacity, design axle load, braking force, impact factors etc. shall be considered for design as per latest Indian Railway Code of Practice. Indian Railway Code of Practices shall be strictly adhered to for design. It shall be the responsibility of the contractor to get the designs and drawings of structures under railway loads approved by Railway authorities. For portion of structures without Railway loads the structure shall be designed for Earth & Water Pressure., Surcharge Pressure, uplift, material load, seismic and wind force.

Top level & Pockets for inserts on the beam supporting Track hopper rail shall be strictly as per Rail drawings with minimum tolerance of ($\pm$) 5mm.

All edges of concrete shall be provided with edge protection steel members and thickness of such members shall not be less than 8.0mm. Floor shall be provided cross slope towards side drains. Cross slope shall not be flatter than 1:50. Side drain shall be sloped towards sump where sump pump shall be provided. The slope of the side drain shall not be flatter than 1:400. Concrete surface in contact with soil shall have water proofing treatment as per specification.

Water-tightness shall be ensured and guaranteed. To achieve the same, methodology in design and construction in the way of providing water bars at construction/expansion joints and/or injection grouting, usage of admixture in concrete should be adopted subjected to approval from owner/owner's consultant.

The inside of the Maintenance house shall be free from any columns.

ii) **Wagon Tippler**

The sub-structure (below ground level), its supporting enclosure structures/basement shall be of reinforced cement concrete (RCC). Cross beams supporting the railway track may be provided at suitable spacing considering easy flow of coal. Suitable supporting RCC Foundation system for Side Arm Charger shall be provided as per design requirements

The top edges of the cross beams shall be chamfered for smooth coal flow. The overall depth of the above cross beams shall be restricted as per system requirement. All faces of the beams coming in contact with coal shall be provided with removable abrasion resistant steel liner plates (Min. 16 mm thick) e.g. TISCRAL/SAILMA. The internal hopper surface shall be finished with 10 mm thick SS lining. The walkway floor shall have non-skid finish. Water proofing for sub structures shall be done as per specification. The hopper wall in no case shall be in bare contact with earth/backfill irrespective of whatever shown in tender drawings. Gratings shall be provided as per system requirement specified elsewhere.

The super structure of wagon tippler shall have structural framing with provision of electric traction wire for electric locomotive.

Continuous gutter (same as roof sheet of adequate thickness) with 150 dia. GI/ MS pipe rain water down comers conforming to IS:1239 / IS:3589 shall be provided. The number and size of down comers shall be governed by IS:1742 & IS:2527. The hopper shall be provided with M.S. grating as stated elsewhere in this specification. Provide continuous standard G.I. hand railings on one side covering the entire length of the hopper fulfilling requirement of railway clearance to prevent any person falling inside. Stairs shall be provided at each end of wagon tippler hopper as well as at transfer points.

All structures of Wagon Tippler complex under influence of railway loads shall be designed for static/moving loads of locomotive and wagons. The number of locomotives and wagons with capacity, design axle load, braking force, impact factors etc. shall be considered for design as per latest system requirements. Indian Railway Code of Practices shall be strictly adhered to for design. It shall be the responsibility of the contractor to get the designs and drawings of structures under railway loads approved by Railway authorities. For portion of structures without Railway loads the structure shall be designed for Earth & Water Pressure, Surcharge Pressure, uplift, material load, seismic and wind force. All edges of concrete shall be provided with edge protection steel members and thickness of such members shall not be less than 8.0mm. Floor shall be provided cross slope towards side drains. Cross slope shall not be flatter than 1:50. Side drain shall be sloped towards sump where sump pump shall be provided. The slope of the side drain shall not be flatter than 1:400. Concrete surface in contact with soil shall have water proofing treatment as per specification.

iii) **Underground Transfer Points**

All underground transfer points shall be of RCC construction with waterproofing as per specification. The intermediate floor and basement floor shall be provided with floor finish as per specification. Other requirement for design loading and internal drainage etc. shall be alike underground tunnels described below. In all underground structures the drain shall be minimum 250mm depth. All internal drains shall be provided with min 40mm deep M.S. galvanized grating above.

All underground TPs shall be provided with minimum 1.2m wide RCC stair with hand railings as per specification.

iv) Over Ground Transfer Points, Pent Houses & Pump Houses including Boiler, ESP, Bunker columns, STG etc:

All over ground TPs shall have R.C. foundations resting on firm strata. The super structure for TPs shall be structural steel framed with adequate bracing arrangement. All intermediate floors and roof shall be of RCC. The ground floors for buildings shall be of RCC over PCC sub base over min. 230 thick compacted boulder/stone soling. Height of plinth shall be 500mm from ground level and RCC pedestals for column shall be 300mm above floor level. In all the floors steel column shall be encased with R.C.C. of min. grade M-20 with reinforcement up to minimum height of 500mm from respective FFL. Adequate windows and doors shall be provided as per specification.

TPs shall be provided with independent steel stair block with steps of M.S. grating from ground to roof with access to roof. The width of the stair shall be minimum 1.2 m. The tread shall be minimum 250mm and riser shall be uniform throughout the height and not exceeding 180mm. Continuous hand rails shall be provided in stair. For Pent House continuous GI handrail shall be provided on roof over R.C.C. kerb. For other structures RCC parapet of 900 mm height shall be provided. Adequate provision shall be made for roof drainage.

The transfer point structures shall be so designed that the transverse deflection at places where conveyor galleries meet, should be equal to the respective transverse deflection of the conveyor supporting trestle. 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.

For pent houses and pump houses similar specifications shall be adopted except that the structural arrangement shall be of RC framed instead of structural steel frame.

v) **Crusher House & Crusher Foundations**

The Specification for Crusher house is similar to over ground TPs mentioned above.

The crusher house shall have an independent stair with access to roof for general use like other TPs. In addition, it shall have a separate stair block for fire escape suitably located complying with fire fighting norms of TAC. 250mm thick brick wall to be placed in suitable structural frames for stability and safety between two crushers in full height with a provision of a door.

The crusher shall be supported on RCC deck which in turn will rest on suitable vibration isolation system consisting of springs and dampers. This RCC deck slab shall be isolated from the building frame work / floor by a clear design gap. However, the vibration isolation system consisting of springs and dampers may rest on main building frame work. The design shall be as per recommendations of approved manufacturer of vibration isolation system e.g. GERB or equivalent.

VIS shall be designed with 90% isolation efficiency or manufacturer's recommendation whichever is more stringent. Stiffness of supporting structure shall be 10 times more than that of spring element. Deflection of beams supporting the crusher shall be limited to the permissible value as specified by the spring manufacturer.

The transverse deflection of the frames and deflection of the beams (other than vibration isolation supporting structures) shall be same as transfer point structures.

The Dynamic analysis will consist of free vibration analysis and forced vibration analysis. Frequency separation criteria and amplitude criteria as laid down in IS: 2974 and/or DIN 4024/ VDI 2056 and/or ISO 10816-2:2001(E) or as required by the machine manufacturer, whichever is more stringent shall be satisfied. R.C.C design will be done by Working stress method for all machine foundations. A fatigue factor of 2.0 will be considered for Dynamic forces. Minimum reinforcement shall be governed by IS: 2974 as well as IS : 456.

The spring units shall conform to DIN 2089 and DIN 2096 and the normal spring capacity will be 35 % higher for crusher foundation. The horizontal spring stiffness shall not be less than 50 % of vertical stiffness.

vi) **Under Ground Tunnels for Conveyors**

All under ground tunnels shall be of RCC considering box sections. The roof of the tunnel shall be straight. The profile of the tunnels shall match with profile of conveyor. The tunnels shall have side and/or central walkways of required width as per Mechanical system requirement. The tunnel shall have water proofing as per specification. Floor shall be non skid type and shall be provided with proper slope to drain out water by means of drains, running along the length of tunnel and connected to sumps. Arrangement shall be made for disposal of this water upto the inlet of coal slurry settling basin. The drain shall be provided with M.S. pressure locked type (preferably electro forged) galvanized grating manufactured in accordance with applicable Indian Standard. RCC (M-20) steps shall be provided where the inclination is more than 8 degree inside portion of tunnel. The risers for walkway steps shall not exceed 150mm. Continuous Hand rails of 32 NB GI pipes shall be provided along both side walls. Sufficient insert plate shall be provided at the side walls & roof soffit of the tunnel for Mechanical/Electrical requirements.

The tunnel shall be designed for Earth & Water pressure, surcharge load or load due to Coal pile/Bulldozer/Railway loads (as applicable) whichever is higher, over burden etc. Tunnels below roads shall be designed for Bulldozer or Class A/Class-AA loading (as per IRC) whichever is critical. Necessary approval for designs of tunnels under influence of Railway loads shall be obtained by the Contractor from Railway authorities. Tunnels for Conveyor in coal stock pile area shall be designed for additional loads due to coal pile of 5.0m high, bulldozer loads or a combination of above whichever is critical.

vii) **Over Ground & On Ground Galleries & Trestles**

Over ground and on ground galleries shall be of enclosed type. The gallery shall have walkways and the width and height shall be as per system requirement. A continuous slit opening of 500 mm height shall be provided on both sides of gallery just below roof sheeting. The gallery shall be made of structural steel.

The floor for on-ground galleries shall be raised at least 500 mm above finished ground level and paved with min. 150 thick RCC (M-25) over 100 mm thick lean concrete (M10) over 230 thick boulder/stone pitching interstices filled with sand. The raised floor shall be retained by continuous brick walls at both sides of enclosures running along length of the conveyor and the surface of the wall shall be plastered and finished with cement based paints externally as per specification. Conveyor Gallery structures shall be designed considering both conveyors operating simultaneously. All gallery supporting trestle shall be so proportioned that the transverse deflection of gallery due to wind/seismic load should not be exceeded height/1000 as stipulated in IS:11592. Overhead conveyor will be located in a suitable enclosed gallery of structural steel and will consist of two latticed girders having rigid jointed portal frames at both ends. The latticed girder will be braced together in plan at top and bottom. Roof truss will be provided at upper node points of latticed girder to form an enclosure.The maximum span of gallery will not exceed 25 m unless higher span is required due to site condition subject to the approval of Owner. Sliding PTFE bearing supports shall be provided at one end of the gallery for relieving forces due to temperature variation. Accordingly for the purpose of analysis one end of the gallery shall be taken as hinged and other on roller. End of conveyor gallery which will be supported over transfer point, shall be so detailed that no horizontal force in longitudinal direction is transferred from conveyor gallery and vice versa. This side of the gallery shall therefore be supported on sliding PTFE support. The top of pedestal for the foundations shall project minimum 300 mm above the grade level.

For ground conveyor, all portals will be placed at a maximum spacing of 6.0 m.

For Conveyor Galleries washing water down comer shall be provided at every Trestle location.

The conveyor trestle legs in CHP area shall be encased with R.C.C. (M-20) upto 1.5 m from finished ground level.

All trestles having height more than 20.0 m will be 4 legged. Adequate 4 legged trestles shall be provided to take care longitudinal forces in conveyor. Four legged trestles will be placed at a maximum interval of 90.0 metres and an emergency caged ladder up to ground level at every 4-legged trestle except at stair locations shall be provided.

Walkway portion of over ground conveyor galleries shall be of chequered plate construction with anti-skid steel bars (10 mm) @ 500 mm along the length of gallery below 8 degree inclination of conveyor gallery. However, for inclination more than 8 degree chequered plate steps shall be provided with toe guard. For both sides & Central walkway continuous hand rail shall be provided as specified elsewhere. The floor of conveyor gallery all along the gallery length, shall be provided with minimum 3 mm thick seal plates and the same is to be provided under the conveyor galleries in such a way that complete gallery bottom shall form a leak proof floor. The seal plates shall conform to IS : 1079 (semi-killed quality).

Roof, side sheeting and slit opening on walls for over ground conveyor galleries shall be similar to ground conveyor explained above. The area for natural light shall not be less than 15% of floor area. Crossover shall be provided at intervals not exceeding 100m c/c & stair upto the ground floor level shall be provided at every location of crossover. Crossovers shall preferably be located over four-legged rigid trestle location. Platforms for cross over shall be provided with chequered plate flooring and hand railing as per specification. The foundations & structures for gravity take up with platform and hand railing shall be provided by the bidder's drawing and specification. Fencing with lockable gate shall be provided around Gravity take ups. Trestles shall be of structural steel braced adequately and provided at suitable locations. Location of trestles adjacent to boiler house and railway lines shall have to be decided carefully so that there is no interference (both underground and over ground) with other buildings, equipment/equipment structures foundations nearby as well as railway lines, ducting, trenches, drains etc. Adequate clearance required by Railway authorities shall be maintained. Execution and erection sequence of foundation for trestles and galleries or any other coal handling plant equipment and structures has to match erection sequence of boiler, ESP or other adjoining structures.

In Tripper floor, necessary pockets, inserts, bolts etc. for conveyor and equipment supporting structures will be kept at floor level based on the requirements of conveyors.

viii) **Stacker-Cum-Reclaimer**

Stacker-Reclaimer foundation shall be in RCC and shall be designed as a continuous wall or RCC framed structure (in longitudinal direction) with lateral tie-beams between two rails supporting elements at a regular interval of approx.3.0 m center. The foundation shall rest on firm strata through open foundation or through piles only. Foundation shall be designed in such a way that the differential settlement in rail do not exceed recommended value as per machine manufacturer or as per IS whichever is critical. (The contractor shall assess such requirement and decide foundation system to be adopted, prior to submission of his bid). The walkway and portion below conveyor shall be paved with min. 150 thick RCC (M-25) over 100 mm thick lean concrete over 230 thick boulder/stone pitching interstices filled with sand.

Dozer access over drain to be provided for stock pile area. Remaining portion of Conv. (other zones excluding RCC foundation portion for stacker & reclaimer) shall be raised and retained by continuous brick wall on both side and walkway floor shall be as described earlier.

ix) **Reclaim Hoppers**

Underground Reclaim Hopper shall be of RCC construction with waterproofing as per specification. Reclaim hoppers shall be designed for 4.0m high coal pile and Bulldozer loads also. The intermediate floor and basement floor shall be provided with floor finish as per specification.

The super structure of Reclaim hopper shall have structural framing. The roof and side sheeting shall be single skin metal cladding system of specification as specified for Track Hopper.

All faces of the beams coming in contact with coal shall be provided with removable abrasion resistant steel liner plates (Min. 16 mm thick) e.g. TISCRAL/SAILMA. The internal hopper surface shall be finished with 10 mm thick SS lining. Gratings shall be provided as per system requirement specified elsewhere.

Other requirement for design loading and internal drainage etc. shall be alike underground tunnels described above.

x) **Coal Stock Yard**

Entire area shall be excavated to average 250 mm depth and given slope of 1 in 100 in suitable directions as approved. Entire excavated area shall be watered and rammed and compacted with 10 tonne roller. 100 mm thick river sand cushion layer shall be placed over compacted sub grade and consolidated by flooding 150 mm thick boulder soling shall be laid over sand cushion, joints filled with river sand. Over boulder soling, 75 mm thick lean concrete (1:4:8) shall be spread. Final layer shall be minimum 150 mm thick RCC slab. M20 with double layer reinforcement. Slope is to be maintained through all layers.

The coal stack area shall be graded with suitable slope for draining the surface.

Retaining wall of minimum 1m depth to be provided around the crushed coal pile to prevent coal spillage into the drain. Necessary control joints in the grade slab shall be considered to avoid temperature and shrinkage cracks in the slab. The design of coal stack area should take care of loads arising due to dozer movement and shall be designed to sustain coal water pressure.

xi) **Coal Stock shed**

Coal storage area to accommodate one lakh metric tonne (1.00.000MT) of crushed coal shall be covered with a shed constructed of structural steel. A large intermediate column-free area to accommodate coal stock piles and an operating Stacker- cum-Reclaimer with highest boom position shall be considered in the design of this structure. Rails for stacker –cum- Reclaimer shall run on concrete foundation throughout the length of this area. Drainage at ground level below coal bed shall be considered by providing a network of perforated pipes which would discharge the water to the trenches running parallel to two sides of rails . The roof shall be covered with pre-coated coloured and transparent sheeting as per requirement. The specification for structural steel work shall satisfy the Technical Specifications for fabrication and erection of Structural steel work. All necessary provisions for ventilation, illumination, dust suppression and safety shall be incorporated. Bidder shall provide an arrangement drawing along with his bid.

xiv) **Area Drainage**

The entire Coal Handling Plant area shall be suitably graded for easy drainage of water. Suitable storm water drainage arrangement on either side of rail with graded filter at about 1.5 m intervals on the

sides to trap coal dust shall be provided. The drain shall be of RCC with precast perforated RC cover. Weepholes shall be provided in the trench walls at the locations of filter pockets for collecting surface water in the longitudinal drains for discharging into the main surface drains by the side of the road.The stock yard & CHP drains carrying coal dust shall be connected to coal slurry Settling Pond.

14.05.02 **Design requirement**

a) For design, Bulk density and angle of repose for coal shall be considered as 1.20 MT/Cu.M, 34 deg for (crushed coal) and 35 deg for (uncrushed coal) respectively. However for storage volume consideration, density 0.8 MT/CuM shall be considered.

b) Loads as defined under clause 8.00.00 shall be applicable. All hoppers shall be designed under the following load conditions.

i) The hopper is full upto it's full capacity with top surface horizontal at grating level.

ii) The hopper is partially empty with the highest level of coal at grating level and making an angle as specified in clause a above.

The above conditions are to be analysed for the case where the whole content of coal within the hopper is supported by the hopper only without taking support from any other structures below.

The hopper shall also be designed for lateral coal pressure, frictional forces during filling and emptying and forces due to impact and failing of arches of coal within the hopper, etc.

c) Wagon Tippler structure shall be analyzed and designed for the worst load combinations. However, it shall be analyzed for the following load combination also.

Combination – 1

i) Hopper full.

ii) Maximum load from railway track.

iii) Earth pressure without surcharge and sub-soil water pressure.

iv) Maximum load from steel column for shed.

v) Maximum load from paddle feeder support.

vi) Maximum load from coal tray.

Combination – 2

i) Hopper full.

ii) Maximum load from railway track.

iii) Earth pressure with surcharge and sub-soil water pressure.

iv) Maximum load from steel column for shed.

v) Maximum load from paddle feeder support.

vi) Maximum load from coal tray.

Combination – 3

i) Hopper full.

ii) No load from railway track.

iii) Earth pressure with surcharge and sub-soil water pressure.

iv) No load from steel column for shed.

v) DL only from paddle feeder supporting structure.

vi) DL only from coal tray.

Wagon Tippler Hopper / Reclaim Hopper shall have removable type steel grating cover. The opening size for grating shall be as per mechanical requirement. Bar grid shall be fabricated and made of rolled sections and flats of minimum thickness of 20 mm.

d) Load considered for grating design

i) Wagon Tippler : 1.0 M hight of coal and wheel loader operating with bucket carrying boulders / oversize ROM coal

ii) Reclaim Hopper : Two bulldozer operating side by side.

Or

Two bulldozer operating side by side over coal heap of 4.0 M whichever is critical

Fire and Noise proofing shall be taken care as per applicable TAC and environmental regulations.

14.05.00 **Ash dyke**

14.05.01 **Design Criteria**

The ash dyke around the storage has been planned to be constructed in stages. The starter dyke construction shall be under the scope of the bidder. Maximum height of starter dyke shall be considered as 10M above existing grade level.

For defining the profile of the phreatic line across the dyke section, a comprehensive seepage analysis shall be done for the ultimate height of the dyke, with full water inside and tail water (if any due to H.F.L.), on outside of the dyke, before doing the stability analysis. The slope stability analysis of the dyke for ultimate stage shall be done for steady seepage condition both for static and dynamic (earthquake) cases as per IS: 7894 –Code of Practice for stability.

14.05.02 **Basic Guidelines**

- **Lagooning System**

  The ash disposal area shall consist of two storage lagoons in equal (approx.) compartments each having water recovery facilities. The storage lagoons shall be planned in such a way that when one lagoon is in the process of filling, the other lagoon can be evacuated/emptied before the other lagoon is filled up.

  The dykes of lagoons shall be constructed using earth as the main construction material to be arranged by contractor. Free board of 1.5 m shall be kept for dyke.

  The water from the storage lagoons shall escape through RCC water escape well type structures located in the storage lagoons and RCC hume pipes of suitable diameter. These hume pipes shall be lined with rectangular RCC section, with minimum lining thickness of 250 mm at bottom & 150 mm on all other sides and shall have suitable isolation gates. Collection well shall have approach for maintenance. Arrangement shall be such that recovery . of clean ash water would be possible at progressively higher levels at stages with water level rising along with gradual increase in ash level stored, closing the collection points at lower levels.

- **Design of Embankment**

  The design of embankment shall be done by a process of successive trials and refinements. The following steps may be followed. Select a trial embankment section incorporating the available materials, with the following parameters.

  Top width - 6 metre minimum having a WBM road of 4.0 m wide and suitable vehicular turn shall be provided at every 500 M with 100 mm and 150 mm of base & sub-base respectively. Higher top width shall be provided if pipelines are to be run over the dyke top.

  Free board - 1.5 metre minimum. Higher free board shall be provided if required from the anticipated wave height and from run up point of view.

  Side slopes - Minimum 2.5 Horizontal to 1 Vertical. 3m wide berms shall be provided for all slopes at about 6 metre height intervals.

Impervious lining – In order to arrest ground water contamination from ash water, provision of lining to make the ash dyke bed impervious by achieving permeability less than 1X 10^{-6} cm/sec shall be done by either providing impervious clay lining or by blending the soil with bentonite as per MOEF norms. In case of clay blanket a minimum thickness of 600 mm shall be maintained. In case of naturally existing soil blended of bentonite percentage of bentonite and layer thickness shall be decided by laboratory tests. Method of mixing of soil with bentonite shall be decided by Contractor.

Internal drainage arrangement should be provided as follows :

Sand chimney of minimum 1.0 metre thickness, up to 0.5 m below dyke top.

Sand blanket of minimum 1.0 m depth.

Rock toe at the downstream toe of embankment. Height of rock toe should be minimum 3.0 metre. With the above drainage arrangements, the phreatic line is expected to follow the drainage path.

The exit gradient of seepage flow near the downstream toe shall be checked by drawing flownets. The exit gradient shall not exceed about 0.14. If the gradient is more than this value, the dyke slope shall have to be flattened to reduce the gradient.

Contractor shall arrange necessary borrowed earth required for the ash dyke.

- **Slope Protection Work**

  On the downstream slopes no stone pitching is envisaged.

  Wherever, there are chances of water accumulation on the downstream side, the slope shall be protected by stone pitching of suitable thickness, depending upon the wave height likely to act on the slope, in the region from 1.5 metre above the maximum water level to 1.5 metre below the minimum water level.

  On the upstream slope, no stone pitching is envisaged.

  On the top of dyke, Water Bound Macadam surfacing shall be made for movement of vehicles, which shall also give protection to the earth surface against rain and wind erosion.

- **Cut-off Trench**

  As the foundation material is very impermeable, a nominal cut-off trench shall be provided in the portion upstream of sand chimney, to increase the drainage path of any seepage occurring at the junction between the embankment and its foundation. A minimum bottom width of 4m shall be provided for the cut-off trench to facilitate compaction with rollers. A depth of 1 to 1.5m may be adopted with 1:1 side slope in earth. If rock is available at a depth less than 1 metre, the cut-off trench may be stopped at the rock level itself. The effect of cut-off trench is not taken in the design and it is only provided as an additional precaution against piping failure in foundation.

- **Filters**

  Filters are to be provided below stone pitching and between rock toe and the embankment material.

- **Instrumentation**

  In order to monitor the performance of ash dyke during construction and operation the following instruments should be installed at approximate distance of 500 metre along the alignment of dyke and at critical locations.

  Piezometers

  Surface settlement markers

14.05.03 **Other Requirements**

The contractor is expected to visit actual site conditions in order to assess its actual area, distance etc, and other conditions, which shall have bearing on the design and construction of the ash dyke as per specified requirements and the cost thereof.

The required borrow areas for dyke construction and clay blanket shall be identified and arranged by contractor. All costs associated to borrow material / borrow areas including any royalties, tax, cess, etc. to be paid, shall be borne by the contractor.

Depth of cuts in all parts of borrow areas shall be determined by the Engineer and shall be as uniform as possible. No earth shall be borrowed from inside the lagoons.

When the borrow area is located contiguous to the dyke alignment then it must be ensured that the borrow area shall not be opened within a distance of 5 times the height of embankment contiguous to the heel or the toe of the embankment or 25 metres whichever is more.

The required approach roads and haul roads shall be constructed and maintained by the contractor. The contractor shall divert the existing roads, if any, which are in the ash, dyke area at his own cost before the start of work. The foundations of the different stretches of the dykes may fall on different soil conditions depending on actual site conditions. It may be on virgin ground or may be on filled up area. However, for peripheral starter dyke, if filling is encountered in the alignment, the same shall be stripped to virgin ground before construction.

A cut-off trench with 4.0m base width, 1.0m deep and 1:1 side slopes shall be excavated at base of the dyke and shall be filled with impervious soil as per specifications.

The foundation shall be stripped for the full width of the dyke including the width of the toe drain plus 1.0 m more on both sides.

The slopes of divide bund between two storage lagoons shall be lined on both sides for top 3.0m vertical heights for protection against wave, with brick lining in brick masonry panel walls. This divide bund shall have sand chimney and sand blanket also to take care of any seepage water from the first lagoon when under use.

To ensure proper compaction of the shoulders, the WBM road on top of the dyke shall be constructed by making the dyke embankment up to the design top level of the dyke first and then cutting the box for accommodating the road construction. The width of road shall be 3.75m. The sub base shall be placed in two layers of 100 mm-compacted thicknesses each with 90-45 mm graded stone aggregates. The base shall be placed in two layers of 75 mm-compacted thicknesses each with 63-45 mm and 53-22.4 mm graded stone aggregates.

14.06.00 **Switchyard Structures**

14.06.01 **Basic design requirements**

a) All structures shall be latticed type with bolted connections.

b) Structural steel shall conform to Grade A of IS:2062 for rolled steel members or plates up to 20 mm thickness. For plates above 20 mm thickness and welded construction, steel conforming to Grade B (Killed and normalised) of IS:2062 shall be used. All structural steel plates and sections shall be either of “SAIL” or “TATA STEEL” or “RINL” make ~~or equivalent~~.

c) All connections shall be bolted unless specified otherwise. M.S. galvanized bolts (minimum 4.6 grade) of minimum 16mm diameter conforming to IS-1363 shall be used unless specified otherwise.

d) All structures shall be galvanized as described elsewhere in this specification.

e) All butt welds shall be full penetration butt welds.

f) Connection of base plate & gusset members with the columns shall be done considering that total load gets transferred through weld.

g) For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on IS: 802 Part-1/ Sec 1

h) For materials and permissible stresses IS: 802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

i) Minimum thickness of galvanized tower member shall be as follows:

Member	Minimum thickness (mm)
Leg members, Ground wire Peak members/Main members	6
Other members	6
Redundant members	6
Gussets	8
Stiffeners	8
Base plates	10 & above

j) Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per IS-802.

k) Minimum distance from hole center to edge and between center to center of holes shall be as per provisions in IS: 800.

l) In order to facilitate inspection and maintenance, the structures shall be provided with climbing- devices. Each tower shall be provided with step bolts not less than 16 mm diameter & 175mm long spaced at 300 mm apart, staggered on faces on one leg extending from about 0.5 meters above ground level to the top of the tower. The step bolt shall conform to IS: 10238.

14.06.02 **Design Criteria**

a) All towers & girder structures shall be designed for the worst combination of dead loads, live loads, wind loads as per IS-802, seismic forces as per code IS: 1893 (latest), importance factor of 1.5, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc.

Short circuit forces shall be calculated considering a fault level of 40.0 KA for 400kV switchyard. IEC-865 may be followed for evaluation of short circuit forces.

b) Switchyard girders structure shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.

Factor of safety of 2.0 under normal conditions and 1.5 under Short circuit condition shall be considered on all external loads for the design of switchyard structures, which are of lattice type.

c) Vertical load of half the span of conductors/string and the earth wires on either side *of* the beam shall be taken into account for the purpose *of* design. Weight of man with tools shall be considered as 150 kgs for the design *of* structures.

d) Terminal/line take off girders shall be designed for a minimum conductor tension of 1000Kg per sub conductor per phase for 400 kV. The distance between terminal girders and dead end tower shall be taken as 100 meters. The design *of* these terminal girders shall also be checked considering +/- 30 deg deviation *of* conductor in both vertical and horizontal planes. For other girders, conductor tension shall be worked as per requirement and shall be considered in design.

e) The girders shall be connected with lattice columns by bolted joints.

f) All support structures used for supporting equipment shall be designed for the worst combination *of* dead loads, erection load, wind load/seismic forces, short circuit forces.

Short circuit forces shall be calculated considering a fault level of 40.0 kA for 400kV switchyard. IEC-865 may be followed for evaluation of short circuit forces.

g) Foundation bolts shall be designed for the loads for which the structures are designed.

h) Lighting towers shall be designed for diagonal wind condition. Lighting towers shall be provided with a structural steel ladder within its base upto mounting height of fixtures.

Two platforms shall be provided one each around 10mtr and another at upper level for mounting of lighting fixtures. The platforms shall have protection railing.

14.06.03 **Fabrication**

The fabrication and erection work shall be carried out generally in accordance with IS 802. A reference however may be made to IS 800 in case of non-stipulation of some particular provision in IS 802. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.

- **Shop assembly**

  The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specific camber, if any, is maintained. In order to minimise distortion in member the component parts shall be positioned by using the clamps. clips, lugs. jigs and other suitable rneans and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.

  Sample towers, beams and lightning masts and equipment support structures shall be trial assembled in the fabrication shop and shall be inspected and cleared by Contractor based on the design approval accorded by purchaser before mass fabrication.

  Pursuant to above the B.O.Ms along with corrected fabrication drawing shall be prepared and submitted by the main vendor to Purchaser as document for information. Such BOM, which shall be duly certified by the main vendor for its conformity to the approved design, shall be the basis for Purchaser to carry out inspection.

- **Bolting**

  Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

  All steel items, bolts, nuts and washers shall be hot dip galvanised.

  2.0% extra nuts and bolts shall be supplied for erection.

- **Welding**

  The work shall be done as per approved fabrication drawings, which clearly indicate various details of joints to be welded, type of weld, length and size of weld. Symbols for welding on erection and shop drawings shall be according to IS: 813. Site welding shall not be permitted in general.

14.06.04 **Foundation bolt**

Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and shall utilize steel templates as required.

The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb.

All foundation bolts for lattice structure are to be supplied by the Contractor.

All foundation bolts shall be fully galvanised as per requirement of coastal environment and shall be as specified elsewhere in this specification.

All foundation bolts shall conform to IS 5624 but the steel material shall be MS conforming to IS: 2062.

14.06.05 **Galvanizing**

All structural steel work and supports shall be galvanized after fabrication. The galvanizing bath shall be long enough so as to reduce the number of splices in the long members. The galvanization bath should have controlled heating arrangements and the hot deep bath should remain clear and free from any foreign matter floating on the top.

Zinc required for galvanizing shall have to be arranged by the manufacturer. Purity of zinc to be used shall be 99.95% as per IS: 209.

The Contractor shall be required to make arrangement for frequent inspection by the Purchaser as well as continuous inspection by a resident representative of the Purchaser, if so desired for fabrication work.

14.06.06 **Touch-up painting**

The touch up primers and paints shall consist of Red Oxide / Zinc chromate conforming to the requirements of IS: 2074 with a pigment to be specified by the Purchaser.

14.07.00 **Natural Draft Cooling Tower**

All civil and structural work for Natural Draft Cooling Tower shall be as specified in Volume VII-D Technical Specification for Natural Draft Cooling Tower.

15.00.00 **MISCELLANEOUS REQUIREMENTS**

Further to all requirements described in the preceding clauses, the following criteria shall be strictly complied with pertaining to analysis, design, layout & construction of aforesaid power plant.

15.01.00 Dense concrete with controlled water cement ratio preferably 0.45 shall be used for all underground concrete structure such as basement, pump houses, water-retaining structure, cable & pipe trenches etc., for achieving water tightness.

15.02.00 All joints, including construction and expansion joints for the water retaining structure shall be made watertight by using 230 mm (minimum) PVC ribbed water stops with central bulb. However, kicker type (Externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting.

15.03.00 Anti termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc., as per IS-6313 and other relevant standards.

15.04.00 Minimum 100 mm thick lean concrete shall be provided below all underground structure, trenches etc., to provide a base for construction.

15.05.00 All masonry walls from ground floor shall be placed on reinforced concrete grade beams. However, light internal partitions may be placed on ground floor slab.

15.06.00 Each building shall be provided with minimum 1.0m wide reinforced concrete paving all round unless specified otherwise. All buildings shall have a slab offset of 300 mm from the wall. Paving shall be sloped to provide a rapid run off of rainwater away from building.

15.07.00 The steel column base plate along with stiffening gusset plates shall not be protruded above floor level.

The steel columns below ground floors shall be encased in concrete up to minimum 250 mm above finished floor.

15.08.00 **Stability of structure**

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

15.09.00 **Grouting**

The method of grouting the column bases shall be subject to approval of Purchaser and shall be such as to ensure complete uniformity of contact over the whole area of the steel base. The Contractor shall be fully responsible for the grouting operations.

Grouting shall be done with 'SIKA' or Conbextra GPX-2 of `Fosroc' or equivalent for Equipment foundations and Conbextra GP-1 or equivalent for all structural column bases. For pipe-supports grouting shall be done with 1:1:2 cement-sand - 6mm down stone chips.

15.10.00 Steel chequered plates and gratings shall be hot double dip galvanised.

15.11.00 Angles 50 x 50 x 6 mm (min.) with lugs shall be provided for edge protection all round of cut-outs/opening in floors, edge of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, and any other places where breakage of corners of concrete is expected. Precast cover slabs shall have edge protection angles at top and bottom on all the four sides along with lugs.

15.12.00 All drains inside the building shall have minimum 40 mm thick grating covers and in areas where heavy equipment loads would be coming, pre-cast RCC covers shall be used in place of steel grating.

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

15.14.00 For all buildings suitable arrangements for draining out of water collected from equipment blow-downs, leakage, floor washing, fire-fighting etc., shall be provided for each floor and connect the drain pipes to drains at ground level..

15.15.00 Duct banks consisting of PVC/GI conduits for cables shall be provided with concrete filling conforming to IS-456. The minimum depth of top of duct bank from grade level shall be 500mm. Duct banks for cables shall be sealed using approved fire retardant sealing compound.

15.16.00 All sand filling shall be compacted to minimum 95% of the relative density.

15.17.00 All buildings shall have framed super structure. All walls shall be non-load bearing infilled panel walls.

15.18.00 Increased cover to reinforcement for all RCC structures as per IS-456 - 2000 shall be provided to withstand corrosive environment if there be any.

15.19.00 All gates and stop-logs shall be of structural steel, which shall be hot double dip galvanised.

15.20.00 All mild steel parts used in the water retaining structures shall be hot double dip galvanised. Galvanising shall be checked and tested in accordance with IS-2629.

15.21.00 A screed of concrete layer not less than 100 mm thick shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structure.

15.22.00 For steel pipes encased in concrete, concrete encasement to steel pipe shall be with M20 grade of concrete and shall be of minimum 150 mm thickness all around pipe.

15.23.00 Ramps for building entrance shall be cast- in-situ RCC slab designed as a slab spanning over supports or rigid pavement resting on subgrade provided that the thickness of slab and the property of subgrade shall be such to ensure of its being treated as rigid pavement. The slope of ramps shall not be more than 20°. Minimum thickness of slab shall be 150mm.

15.24.00 Only sewage and drainage pipe may run below road. Any other pipe like system water pipe may run beyond 1.0m from the edge of road along its longitudinal direction.

15.25.00 Provisions of safety, health & welfare according to factories Act shall be complied with. These shall include provision of continuous walkway of minimum 750 mm wide along the crane girder at crane girder level with side handrails on both sides of the building, access staircase at one end and cage ladders at two ends to EOT crane walkway from operating floor, railing, fire escape, locker room for workmen, pantry, toilets, rest room etc.

15.26.00 Trenches located outside building shall project at least 150mm above the finished formation level so that no storm water shall enter into the trench. The bottom of the trench shall be sloped suitably for draining out the collected water into the sump pit.

15.27.00 All cables & pipes in outlying area shall run above ground over steel trestle or other supporting structures for easy inspection and maintenance except in transformer yard area and some other local area where the same can run in RCC trenches or through duct-banks. However laying of cables shall be as per approved Electrical layout.

A minimum clearance (clear head room) of 8.0m shall be kept for all over ground pipe/cable trestles for all road/rail crossings. In case of rail crossings the above mentioned clearance shall be maintained from the top of rail level and not from the top of formation level. In other areas the clear height shall be 3.0m (minimum) from ground/grade level.

All trestles shall be provided with continuous walkway of minimum 750 mm width with handrail and toe-guards all along the length of the trestle along with approach ladder near roads, passageways etc.

A barrier of suitable height shall be constructed near rail/road crossing, so as to prevent the approach of cranes (having height more than 8.0m) etc. upto the pipe/cable rack trestles.

Four-legged trestles & foundations are to be provided for supporting the pipe/cables at suitable intervals or at corners as per layout. Crossover, operating platform & necessary thrust resisting arrangement at pipe bend shall be provided as required.

15.28.00 For all trench structures, the bottom slope perpendicular to the run of the trench shall be minimum 1 in 200 and shall be minimum 1 in 500 for slope along the length of the trench.

15.29.00 Top of CW pipes shall be minimum 1.50 m below grade level/ formation level.

15.30.00 For open horizontal drains, reservoirs concrete lining of minimum M15 grade on sides & bottom shall be provided. The thickness of lining shall be minimum 100mm or as per design consideration whichever is higher.

15.31.00 Provision for fire proof doors, nos. of staircases, fire separation walls etc., shall be made according to the recommendations of TAC /LPA regulation.

15.32.00 All roofs shall be provided with access through a staircase. All roofs shall be provided with water proofing treatment.

15.33.00 Fly ash bricks shall be used for masonry work. Bidder shall ascertain himself at site regarding the availability of fly ash bricks of minimum 75 Kg/sq.cm compressive strength before submitting his offer. Bidder shall take approval of APGENCO for usage of bricks other than fly ash bricks.

15.34.00 Ground floor slab for the buildings and paving shall be of minimum 150 mm thick VDF concrete laid over 100 mm PCC and 230 mm (minimum) soling unless specifically mentioned otherwise. The reinforcement shall consist of minimum 8 mm diameter bars at 200 mm c/c of grade Fe 415 at top and bottom in both direction.

15.35.00 Windows of ground floor of all buildings shall be provided with heavy duty MS grill for MS windows and Aluminium grill of 7.5mm thick weighing 3.58Kgs/1Sqm for aluminium windows.

16.00.00 **STATUTORY REQUIREMENTS**

The Civil Engineering and building work shall comply with all appropriate statutory requirements including all current Building Control regulations, and with all planning or other conditions as required by the relevant local, state, and National authorities.

16.01.00 The contractor shall provide full general arrangement drawing (Civil, Structural & Architectural) of all buildings, structures and facilities to the Owner for comment. The Contractor shall not proceed with these drawings further without such comment. Any work carried out by the Contractor using drawings unacceptable by the Owner shall be at the Contractor risk.

16.02.00 The Contractor shall seek and obtain all necessary approvals and detailed planning consents outstanding at the time of placing the contract and shall be responsible for all necessary liaison with such authorities to obtain the same and for the payment of due fees for such approvals.

16.03.00 The Contractor shall obtain approval from the appropriate authority regarding the safe means of escape in the event of fire or other hazard before relevant construction work proceeds. As a minimum, the Contractor is required to ensure that the work shall comply with all statutory requirements including:

i) Central Government/State Government - for all building control regulation

ii) State factories act - For Safety, health & welfare, use of hazardous substance

iii) Central and State Pollution Board - For limits on pollution levels.

iv) Central Water Authority/State Irrigation Department - For Water obstruction/supply for withdrawal of water from local source, location of Intake pump house / Jack well.

v) State Water & Disposal Department - for waste & Foul Water disposal.

vi) Ministry of Environment - for all matters relating to environment.

vii) Ministry of Railway - for all matters for railway line construction.

viii) Tariff Advisory Committee - for regulation concerning fire safety/means of escape.

ix) Aviation Authorities - for clearance of tall structure like stack etc.

x) State Public Work Department - for regulations on Civil work/road work.

xi) Ministry of Forestry - for deforestation, if any, for site development.

16.04.00 The Contractor shall make due allowance for all necessary negotiation/ administration required and the time needed to obtain these permission and approvals in his programme. Failure to obtain such approvals in a timely manner shall not be a reason for extension of the programme.

17.00.00 **DOCUMENTS TO BE SUBMITTED**

17.01.00 **Design Documents**

A. The Contractor shall be required to prepare a `Basis of Design' for each Elements/Structures of Civil Work expanding on the information given in the specification. The `Basis of Design' shall include the following:

i) A concise description of the form of Structure considered.

ii) A statement of salient assumptions made.

iii) Codes of practice and references used

iv) A description of the design approach

v) Detail Calculations including Computer inputs & results with conclusion.

vi) Design/working drawings showing necessary details

The design and drawings shall be addressed to Owner / consultant appointed by the Owner for scrutiny of the same at least 12 weeks prior to the commencement of the relevant construction activity. The comments of the consultants shall be considered for effecting further revision.

B. The submission shall be in accordance with dates set down in Contractors civil work design and construction programme.

C. The Contractor shall be required to carry out at his own cost, any rectification, alteration or replacement of work progressed within 12 weeks of submission of the design basis and drawings and resulting from engineers comments on the design submission.

D. Acceptance of the Contractor `Basis of Design' calculations or drawings by the Owner shall not relieve the Contractor of any of his obligations to meet all the requirements of the Contract or relieve the Contractor's responsibility for the correctness of design and safety of the structure for the design life of the plant. The Contractor shall make any changes in the design/drawing in the form of DCN without any financial implication, which are necessary to make the work comply with the contract.

E. The Contractor shall prepare detailed calculations for all structure / elements in accordance with cl. no.17.01.00 A. The Contractor shall also make available any additional calculations, other than routine structural calculation, as requested by the Owner during the period of Contract.

F. In addition to Geotechnical investigation report, the Contractor shall arrange and make available any other reports and investigations the Owner deems necessary for safety & stability of plant. The investigations shall be carried out in any standard laboratory of repute and as recommended by the Owner. All laboratory tests shall be carried out in the presence of Owner's engineer.

G. In the event, the Contractor adopts any patented method of design and Construction, not popular or practiced in this country; the Contractor shall sought prior approval of Owner in writing. The Contractor shall forward appropriate literatures, documents, certificates, case histories etc., to establish the viability of the method.

H. The bidder shall submit the tender with a schedule of proposed sub contractors for different construction packages (if necessary), structural consultants, (if any), any hired personnel for expertise, along with their name address, etc. and shall obtain approval of the Owner before fixing up of sub-contractor with required credentials for a particular work.

I. Each calculation document shall include the following

i) Contractor's name

ii) Package identification (if any)

iii) Designer's name/initials

iv) Checker's name/initials

v) Reference No.

vi) Index

vii) Date & Revision No.

viii) Revision identification mark

ix) Detail calculations including computer input data and output.

J. Calculation packages shall preferably be bound at A4 size sheets. All numerical analysis shall be done through computer. The bidder shall have either their own system or have access in other system outside their premises.

The Contractor shall be a bonafide license holder of any software package used in this project. Any in-house developed software may also be used subject to the approval of the Owner through validation with standard computer programme. Any pirated & unlawful use of software shall not be permitted. The Contractor shall furnish:

i) Name of Software

ii) Developing Agency

iii) A write-up/overview of the programme. As supplied by the copyrighter.

iv) Relevant documents verifying users right for using this software in this country.

K All construction drawings furnished by the contractor shall consist of total quantity of concrete (grade-wise), reinforcement steel (diameter-wise) and structural steel (section-wise).

17.02.00 **Construction Documents**

Based on approved design drawing, detailed drawings for construction will be prepared by the Contractor. For reinforced concrete structures and foundations detailed bar bending schedules in approved format shall accompany each detailed drawing. For structural steel work the Contractor will prepare detailed fabrication drawing along with bill of materials.

Six (6) copies each of selected or all detailed drawings/ fabrication drawings as decided by Engineer for all structures /bill of materials need be furnished to Owner/Consultants along with bar bending schedule.

17.03.00 All working & construction drawings shall be drawn by CAD system, and shall be issued in A0/A1 size. The drawing shall include:

i) Name of Project, Owner, Consultant & Contractor.

ii) Title of the Drawing

iii) Drawing No. Issue Date, Revision No.

iv) Statement for Revision

v) Revision Identification Mark

vi) Release Status

vii) Designer/Checker’s/Draughtsman's name/initial

17.04.00 The Contractor, who shall maintain an upto date drawing & document register, shall monitor drawing & document issue. This register shall list all drawings & documents used in the design and construction for civil and structural work. The drawing register shall be a controlled document and shall be kept updated/revised and shall be issued on A4 size sheets.

17.05.00 All drawings, design documents, reports, correspondence pertaining to civil structural work shall be in `English Language'. Documents in any other language shall be translated in English before submitting to Owner.

18.00.00 **LAYOUT**

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

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

19.00.00 **WORKMANSHIP**

Workmanship shall be of the best quality and all work shall be carried out by skilled workmen except for those which normally require unskilled persons. Welding shall be done by experienced and certified welders in proper sequence using necessary jigs and fixtures. Fabrication shall be done in shops having proper equipment for accurate edge lanning and milling of column shaft ends, base plate surfaces etc., and shaping and dimensioning of anchor bolt assembly, inserts and other misc. items. In addition to the requirement specified above, if the bye-laws of the local Govt., Municipal or other authorities require the employment of licensed or registered workmen for various trades, the Contractor shall arrange to have the work done by such registered or licensed personnel. In case of manufactured materials, the Contractor shall have, with no additional cost to the Owner, the services of the supervisors of the manufacturers to ensure that the work is being done according to the manufacturer’s specifications.

20.00.00 TEMPORARY WORK

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

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

21.00.00 INTERFACE WITH STRUCTURES UNDER OTHER'S SCOPE OR EXISTING STRUCTURES

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

22.00.00 SEQUENCE OF WORK AND PROGRESS REPORT

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

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

ANNEXURE-1

GROUND CONTOUR PLAN

ANNEXURE-2

FINAL FEASIBILITY STUDY REPORT BY RITES LIMITED

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GENERAL SPECIFICATION AND DESIGN CRITERIA FOR ARCHITECTURAL WORKS

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GENERAL SPECIFICATION AND DESIGN CRITERIA FOR ARCHITECTURAL WORKS

1.00.00 SCOPE

The architectural services shall cover finishing work of power house and all auxiliary buildings, Non-plant buildings included under the specification starting from brick work, partition walls, roof protection, finishing of walls, floors and ceilings, false ceiling, cladding, as required potable water system, service water, Plumbing and sanitation etc. as required for functional requirement. The contractor offer shall cover the complete requirements as per the best prevailing practices keeping in view the statutory and functional requirements of plants & facilities and providing enough space & access for operation, use & maintenance and to complete satisfaction of the owner.

Plant buildings under this scope of work :

- Power House Building including Electrical Bay, Switch Gear Room & Control Room
- Mill Building
- Switch Yard Control Building
- ESP Control Building
- CW & ACW Pump House & Electrical Building
- Ash Slurry Pump House
- Ash Handling Electrical / Control Room
- AHP Compressor Building
- DG & Compressor House
- HFO & LDO Forwarding Pump House
- DM Plant
- Clarified Water Pump House
- Chemical House
- CW Chemical Treatment Building
- CW Chlorination Building
- Crusher House & Transfer House
- CHP Control & MCC Building
- Ash Water Pump House
- Raw Water Pump House & Electrical Building
- HCSD & Silo Utility Pump House
- CPU Regeneration Building
- Vacuum Pump House
- Centrifuge Building
- Condensate Transfer Pump House

Non Plant buildings under this scope of work :

- Service Building & Workshop
- Canteen
- Fire Station
- Permanent Store & Yard
- Time and security office with Gates, watchman cabins.
- Weigh Bridge Control Room
- Bulldozer Shed
- Car Parking stand
- Cycle/ Scooter stand
- Watch Tower

Above list of Plant & Non Plant Buildings is not exhaustive. Buildings necessary for the smooth operation of the plant shall be within this scope of work.

1.01.00 **Prequalifying criteria for Architectural works**

a) The bidder should have registered architect(s), registered under Council of Architecture (COA), as his employee. An attested copy of COA of the lead Architect should be submitted as a part of Pre-qualification document. The lead Architect should have experience of rendering architectural services one complete 500 MW or above project and this includes BTG, BOP and Non-plant buildings.

b) The bidder may form consortium with an architectural firm. In that case MOU between the bidder and the architectural firm is to be produced. The COA registration certificate of the lead architect of the firm is to be submitted. The architectural firm should have experience of rendering architectural services for BTG, BOP & Non-plant buildings of one completed 500 MW or above TPP or STTP project.

c) In case of foreign collaboration/consortium registration certificate of the lead architect of that country, duly approved and attested by the Consulate of that country is to be produced as per-qualifying document. Successful completion certificate of one 500 MW TPP or STTP by the architectural firm is to be submitted.

d) The bidder shall obtain the approval from TSGENCO for the agency for architectural services.

2.00.00 DESIGN REQUIREMENTS

2.01.00 Architectural Concepts

a) Layout of the plant area shall have definite hierarchy of road network depending upon its usage, aesthetic, visual sensibilities for creating road vistas, focal points, building back drops, building frames. General layout shall be evolved taking over the basis of landform & local climate & due consideration shall be given to orientation and wind direction. The resulting built mass shall present a definite image width in distinct vocabulary in the form of landmarks, nodes & skyline.

b) Main plant building shall be architecturally treated in such a way that it retains a monumental scale, yet presents a pleasing composition of mass and void with suitable and functionally designed projections and recesses. The overall impact of the building shall be one of aesthetically unified architectural composition having a comprehendible scale, blending tonal values with the surroundings and taking full consideration of the climatic conditions, the building orientation and the existing structures nearby.

c) All other buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the main plant, surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to all buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

d) Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipments, exposed structural elements, piping, trestles, bus ducts and other service elements.

e) Overall emphasis shall be on developing an eco- friendly architecture, merging with the nature with its own sustainable energy management systems.

The scheme shall be conceptually finalized in totality including that of equipments so that the proper co-ordination with other agencies can be taken up at appropriate time.

Architectural Design

a) Natural light shall be used to the maximum extent especially in the form of north light/skylight. For adequate light and ventilation, National Building Code recommendation shall be followed. However all windows shall have minimum 1.0m sill height and bottom of lintel height shall be 2.5m from finished floor level. Minimum door height shall be 2.5m.

b) Entrance canopies, sunshade (projections, recesses) over openable windows and door openings on exterior facades shall be provided.

c) All the buildings shall be architecturally designed to meet the National Building Code.

d) Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect Statutory requirement and any clearances from local authority may be required to be met with, wherever essential. The Architect Consultant shall be of national/ international repute having experience in similar kind of works. The consultant shall evolve the design philosophy and shall present it in the form of presentation drawings, prospective views, 3-D Models & detail drawings. All architectural drawings shall be prepared under responsibility of an Architect. The Architect should be registered under Council of Architecture. The registration certificate of the architect should be produced by the bidder during bid submission.

e) 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.

f) At the inception of the detail engineering the bidder should submit the architectural concept of the overall plant with 3D views & colour scheme of Plant & Non-plant buildings for selection of the owner. The selected concept shall the vernacular of the project to bring harmony all over the plant site.

2.02.00 **Plant Buildings**

2.02.01 **Powerhouse Building**

Powerhouse shall be of structural steel framed with RCC floor and part Brick Wall and balance part double skin insulated colour coated galvalume sheets cladding construction. Operating floor being the heart centre of Powerhouse shall be designed as a very impressive floor having high quality finish, material and appropriate ambience.

External facade shall be with full brick thick wall up to approximately 3.0m high, plastered and painted. From 3.0m-upto roof external façade shall be clad with factory fabricated Rockwool / PU insulated metal cladding on A Row & Gable ends, on C Row and any other external exposed surfaces, single skin metal sheet cladding over brick work shall be installed where brick work is technically required. Fire Wall facing towards Transformer yard, shall be minimum 6.0M high and minimum 250mm thick RCC wall as per Fire Prevention regulation. Single skin metal cladding similar to the Top sheet of Insulated Metal Cladding used for other part of the facia shall be applied over the Fire wall to match the overall elevation treatment.

Sufficient natural light and ventilation has to be ensured for every part of the building unless prevented due to technical reasons. Operating floor may have large glazed area made with Structural glazing system. At Crane girder level windows on A Row, B Row and gable ends shall be provided. North Light system shall be provided on roof of power house building at suitable locations so that sufficient natural light can be obtained at TG Hall floor.

Rain-water pipes or sanitary pipes shall not be visible from outside. Provision of pipe ducts shall be made to ensure pipe routing.

Minimum one number Down comer shall be provided at each grid column.

All cable spreader floors shall have proper slopes and provision of fire emulsifying system for drainage.

Steel columns within fire hazardous areas like electrical room, Main control room and switch gear room shall be encased with brick work or concrete. All steel columns shall have 150mm high concrete base to ensure proper floor finishing work and to protect the column base.

Minimum 2.1m high headroom clearance has to be maintained at every part of the building.

Vertical Head room clearance shall be maintained as per industry factories Act.

Sufficient headroom shall be provided in cable galleries.

Where false ceiling is to be provided, provision of human access has to be made to maintain the HVAC, Electrical and other service lines above false ceiling. If the height between false ceiling and bottom of beam is more than 2.1M then steel grid system (1.2M X 1.2M span) with catwalk to be provided to support the false ceiling system and human access respectively.

Minimum 1.5M wide passage is to be marked on the floor as safety exit route. Such passages shall lead to Fire-escape staircases or fire-safe zones. Doors of fire-hazardous rooms or areas shall open towards safety exit passage. All external doors shall open towards outside. Fire escape staircases shall be located as per fire-code and TAC.

2.02.02 Mill & Bunker Building

This shall be of steel framed structure having single skin metal cladding to clad Tripper floor only. The colour and pattern of the sheeting should match the overall ambiance of Power Island. Sufficient natural light and ventilation should be provided for tripper floor. Provision of roof access through stair should be made.

2.02.03 Other Plant Buildings

Structures of Other plant buildings shall be as per description stated elsewhere in this Civil/Structural Specification. Architectural concepts of structures shall offer its own identity and will be aesthetically blended to give pleasing appearance maintaining harmony of the plant complex. Functional needs of each building shall be maintained.

3.00.00 ARCHITECTURAL REQUIREMENTS

3.01.01 Roof Insulation and Ventilation

The roof of buildings which are recommended by HVAC department for over deck insulation shall be insulated with rigid insulating board.

Extractor fans will be provided over roof of turbine hall for ventilation. For ventilation requirements relevant section of the specification shall be referred.

3.01.02 **Roof Waterproofing**

Roof water proofing treatment shall be as follows :

a) Roof water proofing treatment shall be as follows :

i) For roofs with structural slope :

The cleaning and preparation of the substrate to which the elastomeric membrane is applied must be carried out thoroughly to leave a sound base for the application. Any laitance present on the surface must be removed mechanically. Release oil and other contaminants which may impair adhesion must be removed.

Over the finished well prepared sloped surface of RCC slab, application of elastomeric membrane shall be a single component the liquid, cold applied, elastomeric polyurethane based, that cures by reaction with atmospheric moisture to form a tough but flexible waterproofing membrane. It is elastomeric, seamless waterproof membrane applied in 2 coats to a DFT of 1.2 mm thick having a elongation capacity of over 600% and average tensile strength of 1 MPa, tear resistance as per GBT 19250-2003 >20N/m. The material shall comply with – ASTM C 836 National Std. of Canada 37.58 – M86 by CGSB. over the entire surface of waterproofing membrane laying a separation layer of non-woven polypropylene geo-textile of 120 gsm followed by application of rigid insulation board expanded polystyrene BASF PERIPOR of BASF or similar approved for thermal insulation as per HVAC requirement shall be laid over the finished separation layer of geotextile. The insulation board shall have interlocking tongue-groove arrangement. The insulation board shall have the following specifications;

- Colour: Orange
- Thickness: 50 mm
- Compressive strength: 200-220 kN/m2
- Thermal Conductivity (K): 0.034 W/mK
- Thermal Transmittance (U): 0.5-0.6 W/m2 oC
- Water Absorption (% vol): <0.1% (by total immersion)

The top surface of the rigid polystyrene block of Peripore of BASF or similar approved shall be finished with pressed precast concrete tiles (size minimum 600 mm x 600 mm) of 20 mm thick on 15 mm thick cement plaster (1:4) which laid over 120 gsm non-woven polypropylene geo-textile separation layer. 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 under bed layer also.

ii) For roofs having no structural slope: The cleaning and preparation of the substrate to which the elastomeric membrane is applied must be carried out thoroughly to leave a sound base for the application. Any laitance present on the surface must be removed mechanically. Release oil and other contaminants which may impair adhesion must be removed.

Over the finished well prepared flat surface of RCC slab, application of elastomeric membrane shall be a single component the liquid, cold applied, elastomeric polyurethane based, that cures by reaction with atmospheric moisture to form a tough but flexible waterproofing membrane. It is elastomeric, seamless waterproof membrane applied in 2 coats to a DFT of 1.2 mm thick having a elongation capacity of over 600% and average tensile strength of 1 MPa, tear resistance as per GBT 19250-2003 >20N/m. The material shall comply with –
ASTM C 836 National Std. of Canada 37.58 – M86 by CGSB. over the entire surface of SONOSHIELD HLM 5000R waterproofing membrane laying a separation layer of non-woven polypropylene geo-textile of 120 gsm followed by application of rigid insulation board expanded polystyrene BASF PERIPOR for thermal insulation as per HVAC requirement shall be laid over the finished separation layer of geotextile. The insulation board shall have interlocking tongue-groove arrangement. The insulation board shall have the following specifications :

- Colour: Orange
- Thickness: 50 mm
- Compressive strength: 200-220 kN/m2
- Thermal Conductivity (K): 0.034 W/mK
- Thermal Transmittance (U): 0.5-0.6 W/m2 oC
- Water Absorption (% vol): <0.1% (by total immersion)

The top surface of the rigid polystyrene block of Peripore shall be finished with pressed precast concrete tiles (size minimum 600 mm x 600 mm) of 20 mm thick on screed concrete mix (1:2:4) grading having minimum 25 mm thickness at the lowest point of the slope over R.C.C. slab and shall be laid as per the slope laid over 120 gsm non-woven polypropylene geo-textile separation layer. 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 under bed layer also.

iii) For other plant and non Plant buildings rigid insulating board (expanded / extruded polystyrene block) as per HVAC requirement shall be laid over screed concrete mix (1:2:4) grading having minimum 25mm thickness at the lowest point of the slope over R.C.C. slab and shall be laid as per the slope specified elsewhere in the specification. Top surface of rigid insulating board shall be finished with 15mm thick cement plaster (1:4) which shall be laid over Geo-textile membrane layer. Over the finished surface APP Bitumen membrane as specified below shall be laid and top of the Bitumen membrane shall be finished with pressed precast concrete tiles (size minimum 600 mm x 600 mm) of 20 mm thickness on 15 mm thick cement: sand (1:4) mortar underbed. 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.

a) APP modified Bituminous Polyester reinforced waterproofing membrane of Sika® WP Shield-104 P or similar approved shall be manufactured from a rich mixture of bitumen and selected polymers blended together to obtain excellent heat resistant, flexibility, UV resistance. Modified bitumen then coated onto a dimensionally stable carrier to obtain excellent tensile strength, tear and puncture resistance.

b) APP membrane shall conform to Conforms to: UEAtc,ASTM D146, DIN52123, ASTM D36, ASTM D5, UEAtc, ASTMD 5147, ASTM D4799.

c) Technical Data

- Chemical Base — APP modified Bituminous Polyester
- Thickness — 4mm
- Unit weight — 4.40 kg/m2(According to UEAtc)

d) Mechanical / Physical Properties

- Tensile Strength (L/T) N/SCM - 800/600 (According to UEAtc,ASTM D146)
- Elongation at break (L/T) - 40/50 - (According to UEAtc,ASTM D146)
- Resistance to water pressure - No leakage - (According to DIN52123)
- Carrier (Polyster) weight- 180 g/m2

- Softening Point - 145 oC - (According to ASTM D36)
- Penetration - 15-25 at 25oC d mm-(According to ASTM D5)
- Tear resistance (L/T) N-170/180- -(According to UEATc)
- Water Absorption% (BSP)- <0.15-(According to ASTMD 5147)
- Heat Resistance- No Flow at 100oC-
- Resistance to Aging after 2000 hrs (Weather –O-Meter)- No Delamination- (According to ASTM D4799)

e) Concrete, mortar surfaces must be clean, free from grease, oil, and loosely adhering particles. Steel and iron surfaces must be free from scale, rust, grease and oil. All surfaces must be as true as possible.

f) Bituminous primer is to be applied to a clean, smooth and dry surface by brush, roller or spray. The material is to be Unrolled and align and re rolled correctly before torching. Overlaps should be minimum 100 mm. Gas burner is to be used to heat the substrate and thermo fusible film on the underside on lower face of membrane. When the thermo- fusible film melts after torching, the membrane is ready to stick. The membrane should be Rolled forward and press firmly against the substrate to bond. Both the overlaps shall be heated and the round tipped trowel shall be used for heating the same to smoothen and press into seam.

g) All angles and abutments should be sealed with extra care to ensure full bondage. The edges should be sealed well into the grooves.

iv) For Liquid, cold-applied PU elastomeric waterproofing membrane system shall be a single component the liquid, cold applied, of elastomeric polyurethane base that cures by reaction with atmospheric moisture to form a tough but flexible waterproofing membrane of BASF's SONOSHIELD HLM 5000R or similar approved. It is elastomeric, seamless waterproof membrane applied in 2 coats to a DFT of 1.2 mm thick having a elongation capacity of over 600% and average tensile strength of 1 MPa, tear resistance as per GBT 19250-2003 >20N/m. The material shall comply with – ASTM C 836 National Std. of Canada 37.58 – M86 by CGSB.

Note : Waterproofing materials should be applied by the manufacturer authorised applicators only.

3.01.03 **Partition Wall**

All intermediate walls shall be full brick thick wall in 1:4 cement sand mortar. Half brick thick wall in 1:4 cement: sand mortar with RCC band 100 mm thick & with 2 nos. 8 mm dia rod in every eighth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided or shall be provided with structural steel member at minimum 2.5 m clear height with MS inserts/lugs for anchoring in brick work shall be provided. Similarly MS lugs shall be provided on the structural member at spacing 500/600 mm on vertical face for proper anchorage for brickwork, lugs embedded in concrete and suitable vertical structural member at maximum 5m c/c. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area.

3.01.04 **Plastering**

Exterior & rough side of interior brick wall	20mm thick minimum sand faced plaster in two layers with 1:4 cement sand mortar of 12mm thick first layer and 1:3 cement sand mortar with 8mm . Where external finish will require rich plastering for special finish plaster shall be of 1:4/1:3.
Interior wall	12 mm thick with 1:4 cement-sand mortar.
Ceiling	6 mm thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

3.01.04 **False Ceiling**

Aluminium pre-painted/Powder coated false ceiling, either lineal panel system or aluminium tile/plank system for control rooms and other important areas, with suspension system as per manufacturer's details shall be used.

Areas like office space or where specified Mineral Fibre Based Acoustic Ceiling Board either Armstrong or similar to Armstrong, in aluminium snap grid suspension system as per manufacturer's specification shall be provided. As an alternative Moisture & Fire Resistant Gypsum Board false ceiling system of Saint Gobain Gyproc India Ltd or similar manufacturer may be used.

Unimportant areas Calcium Silicate Board/Tiles false ceiling shall be of HILUX or AEROLITE or Fibre Cement Board of EVEREST Industries Ltd shall be used.

The false ceiling work shall take care of all illumination, fire detection & fighting, HVAC and all other service requirement. False ceiling shall be provided with 25 mm thick insulation of resin bonded mineral wool conforming to IS: 8183. Wherever under-deck insulation is required the insulation shall be as per specification mentioned elsewhere in the specification.

3.01.05 **Special Finish**

a) The main entrance of powerhouse, Service Building, control room and other important areas shall have high quality finish to floors, walls, ceilings etc.

b) Main stairs and landing shall be equally treated.

3.01.06 **Doors**

a) Generally factory made hollow metal (steel) double plate flush doors shutters comprising of two outer steel sheets with pressed steel frame shall be provided for plant and utility areas.

b) Factory made Solid core wooden flush doors in teak wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.

c) Rolling steel shutters shall be used where frequent use is not envisaged and large openings are required. Operation shall be manual/mechanical/ electrical depending on the size of opening.

d) Special areas like control rooms and other special area shall be provided with minimum 15 micron pre-coated i.e. colour anodized aluminium glazed partitions with air lock facilities having two sets of doors and preferably double door systems.

e) Minimum 2 hour Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard and also to all fire exists as per TAC requirement.

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

g) Wooden panel doors shall be provided for toilet entrance and toilet internal doors shall be solid core PVC.

h) Weather stripping shall be provided to all outside doors as well as air conditioned areas and all other doors where dust-free environment is required.

3.01.07 **Windows & Ventilators**

In Powerhouse building, full glazed windows and ventilators in minimum 15 micron anodized aluminium window frame shall be provided with 6 mm thick clear wired/laminated glass where required from safety point of view.

For operating floor of Power House, structural glazing may be considered as an important façade element. All windows and ventilators shall meet the requirement of industrial windows and Ventilators.

In other areas aluminium windows with 4 mm thick clear float glass shall be provided suitably in panels not exceeding 1200 mm wide. The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Glass thickness and member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Contractor before execution.

3.01.08 **Landscaping**

Generally the natural contour shall be retained except where modifications needed for drainage or other technical reasons. Rockeries, appropriate trees, shrubs, ground cover, lawns along with landscape furniture, sculptures, fountains, decorating/ornamental fencing, electric lights & fittings, etc. Shall be provided to create a visually pleasant environment. Special landscaping shall be made around main entrances of powerhouse and other important buildings. Irrigation facilities shall be provided for all green areas.

The plant area shall be covered under Landscaping. Minimum 33% or as per recommendation of MoEF (whichever is higher), of plant area shall be kept as Green Belt. Some of the plantation area shall be fenced suitably as per the choice\advise of the Owner. Trees for formation of green belt of minimum width 100 M for segregation of CHP area from the raw water reservoir will be chosen to match with prevailing landscape in the adjacent areas. Names of some of avenue trees are given for selection, which are "Arjun, Ashoke, Elengi, Amaltus, Gulmohur, Mohua, Sirish, Margose, and White Ceden" and of other species suitable to the local environment. Special landscaping shall be made around main entrance of Power House, Service Building, Main Gate Complex. The area shall be covered by shrubs and seasonal flowers. Plantation for green belt shall commence immediately after the mobilisation of the Contractor at site, so that trees are sufficiently grown at the time of commissioning. The plants shall be maintained for a minimum period of one year after planting, and dead plants, if any shall be replaced. The Contractor shall also lay and commission the irrigation scheme for the landscaped areas which shall include supplying and installing pumps to draw water from the sewage and effluent treatment plant and pump into the system at required head, supplying and laying buried GI pipes of adequate capacity with associated fittings and control valves and sprinklers of approved

design for distribution and sprinkling of water to various disposal points. A nursery has to be set up in the area to cater to the need of plantation. Some beatification work like decorative landscaping, rockeries, fountain, and lily pond shall be provided at locations to be suggested.

The Contractor shall furnish detail drawing schedule for landscaping prepared by experts in the respective discipline. The work shall be taken up duly after approval of the Owner.

Arboriculture and avenue plantation all along roads suitable to environment shall be provided.

3.01.09 **Facilities in Buildings**

Adequate toilet and drinking water facilities shall be provided for personnel working in each floor of building. Each floor of building shall have toilet facilities both for Gents and Ladies. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.

However minimum 1 Water Closet with cistern, 1 washbasin with mirror, towel rail, soap case, 1 urinal shall be provided in each toilet.

Each floor shall have drinking water facility connected through potable water with water cooler.

3.01.10 **Potable Water System and Service water Plumbing**

This system for various buildings shall be connected to the drinking water and service water systems, the scheme for which is indicated elsewhere in this specification.

Water outlets shall be provided for an instantaneous flow rate of approximately 7 Cu.M/Hr. (25 GPM).

System will satisfy state and local plumbing codes. Following I.S. Codes for the

system shall be followed :

a) IS-2065: Code of Practice for water supply in buildings.

b) IS-1172: Code of basic requirements for water supply, drainage and sanitation.

c) IS-1200: (Pt. XVI) Laying of water and sewer lines including appurtenant items.

d) IS-1239 Specification for mild steel tubes and mild steel tubular and other wrought steel pipe fittings. (10 mm to 15 mm nominal diameter).

e) IS-3589: Specification for electrically welded steel pipes for water, gas and sewage (220 mm to 2000 mm nominal diameter).

Potable water shall be supplied to basins, water coolers, showers and other plumbing fixtures. Soil and waste piping shall drain through traps to the yard sanitary sewer system.

Service water shall be supplied to water closets, urinals, sinks, and other plumbing fixtures.

3.01.11 **Roof Drainage Systems**

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

a) Roof Drain Heads/ dome strainer

b) Rain Water Down comers

c) Gully pits

IS-1742 code of practice for building drainage shall be followed for this purpose.

Adequate numbers of rainwater drains heads shall be provided for all roof areas as per standard norms for roof area.

System will be designed to handle rainfall at a rate as specified elsewhere in this specification and in accordance with stipulations of IS-1742.

Slope of roof for drainage should be not less than 1 in 100.

Any roof more than 8.0 metres above grade shall have access from within the building for cleaning of roof drains.

Roof drains will conduct water to storm sewers. No rain water pipes shall be exposed to outside view. 150mm dia. Medium duty G.I pipe of TATA, Jindal or equivalent approved make shall be used.

3.01.12 **Glazing & Glazed Partition**

a) Glazing in Control room between A.C. and non-A.C. areas shall be insulating glass consisting of two 6 mm thick toughened float glass sheet hermetically sealed and separated by 12 mm gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.

b) 4 mm thick ground glass shall be provided for toilets.

c) Glazing between two A.C. areas shall be with 6 mm thick clear float glass.

d) All glazing shall be in aluminium frame having 15-micron colour anodization.

e) 6mm thk. Wired / laminated glass shall be used for windows / ventilators at higher level for safety.

f) 24mm thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with 12mm air gap & hermetically sealed shall be mounted on 15 micron coloured anodised aluminium frame suitable for structural glazing system.

3.01.13 **Sealant**

Two part polysulphide sealant conforming to IS: 12118 shall be used for sealing of joints in contact with water. For other cases, bitumen sealing compound conforming to IS: 1834 shall be used. Preformed bitumen impregnated fibre board conforming to IS: 1838 or polystyrene filler board of HD100 of Supreme or equivalent shall be used as joint filler. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water- lightness.

3.01.14 **Damp Proof Course**

40 mm thick 1:1.5:3 concrete with 2% waterproofing admixture or as per manufacturer's recommendation to be provided.

3.01.15 **Plinth Protection**

Minimum 1000 mm wide concrete plinth protection having thickness of 150mm with PCC M20 and over 150 mm soling, along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be connected to station main drainage system..

3.01.16 **Miscellaneous Metal Railing**

a) For main stair & lobby of Powerhouse building upto operating floor, around large openings at operating floor, main stair of Service building, Administrative building shall have 40mm diameter stainless steel railing with minimum 3mm thick SS posts & decorative minimum 3mm thick seamlessly joined SS handrails. Stainless steel pipe handrail in shall be of grade SS-304 and of approved design to meet the functional requirement as well as very good aesthetic appearance. Other hand railings of Power house building shall be MS Galvanised hand railing with 40 mm NB (medium) main post and 32 mm NB (medium) as horizontal rails. With toe guard shall be provided.

b) For Service Building & Administrative building, ESP control room, switch yard control room, chemical house & other all control rooms stainless steel railing with SS posts & decorative SS handrails or CP teak wood rails shall be provided.

c) For any other RCC For any other RCC stairs of non-plant buildings shall be MS Galvanised hand railing with 40 mm NB (medium) main post and 32 mm NB (medium) as horizontal rails with toe guard shall be provided.

d) For plant & non-plant buildings, unless otherwise indicated in the specification the post and handrails of stairs, railings, etc. Shall be of 32 mm dia NB medium class G.I. pipes as per IS-1239-part (I).

3.01.17 **Painting**

Exterior Masonry Surface	:	Buildings shall be finished with waterproof External Quality Acrylic Emulsion Paint similar to “Apex Ultima”, “Weathergurd”/ “Weathershield” over plaster. Granular textured paint may also be combined along with External Quality Acrylic Emulsion Paint to form suitable pattern on building façade. Aluminium composite panels (ACP) may be used to accentuate certain portion of the façade or certain element of the façade as the case may be.
Exterior Steel Work	:	Two finish coats of high built epoxy finish of 90 microns each over two primer coats of Zinc silicate 50 microns each shall be applied on exterior steel work.
All Woodwork	:	Synthetic paint over a coat of primer.

All Internal Steel Work	:	Epoxy Paint over approved primer
Steel in contact with acid /alkali	:	Acid/Alkali/Chemical resistant paint
Interior Office Spaces Control Rooms, All A.C. Areas	:	Acrylic emulsion paint over 3 mm thick white cement putty punning.
Other Plant Buildings	:	Interior masonry surfaces of all plant buildings shall be painted with synthetic enamel paint up to 1.50 m height from floor level and balance portion with Acrylic Distemper paint of two coats over one coat of primer over white cement putty.
Fire Door	:	Post Office red shade shall be provided.

3.01.18 **Miscellaneous Work**

a) Counter tops in kitchen, Washbasin, pantry & similar areas shall be polished granite over RCC slab or Kota stone top.

b) Pavements, walkways, etc. Shall be 50/ mm or of standard thickness thick anti-skid interlocking concrete pavers

c) Anodized aluminium grill of heavy duty of thickness not less than 7.5mm and weight not less than 3.58Kgs/Sqm shall be provided for aluminium glazed windows. But in specific cases, M.S. grills shall be used as per approved design for security purpose made of 25 mm X 6mm M.S. Flats / 12mm – 20mm M.S. square bar of approved design shall be provided to suit security requirements.

d) R.C.C. stair railing shall be with 20 mm square M.S. Bar balustrades with suitable M.S. flats & anodized aluminium / CP Teakwood handrails shall be provided. Stainless steel pipe railing in specific areas shall be used.

e) For RCC main stair and landing of powerhouse building shall be of Kota stone and white marble strip combination, RCCstair of Service Building & Administrative building shall be of white marble/combination of Baroda green and pink marble with all edges and nosing moulded.

f) Anti-termite treatment shall be given to columns pits, foundations, and trenches, below floor as per IS: 6313.

g) Suitable arrangement of floor drain with trap shall be provided in floor where spillage of water may occur.

h) RCC staircase shall be provided in main entrance of Turbine building, Facility building and other important buildings. Turbine hall staircase shall be provided with Structural steel work

i) Covered car parking stand for 20nos cars module with minimum 50mm thick coloured interlocking cement concrete tile flooring over reinforced concrete hard standing and module for 50 nos. Two-wheelers & cycle parking stand shall be provided as per requirement at the desired location of the owner. Structure shall be of RCC. The structure shall be aesthetically harmonious.

j) Access Floor panel of size 600x600 mm shall be all steel welded construction, with an enclosed bottom pan of 49 hemispherical and 36 reverse cones and top plain sheet which are fuse welded at 129 locations to form a panel of an overall depth of 37 mm. The panel after cleaning, degreasing, phosphating by 11 tank process is coated with 40-60 micron epoxy coat and is heated to achieve maximum adhesion to the panel surface and corrosion resistance. The inner empty core of the panel is injected with a light weight fire retardant, non combustible cementitious compound at high pressure to fill in all the crevices of the panel and ensures support of not less than 90% of the top surface area of the panel. The panel is then laminated with 1.5/2.00 mm thick fire retardant floor grade Antistatic Laminate / ESD Laminate – PVC / Conductive PVC on a semi –automated lamination line to ensure maximum bonding to the steel surface. The edges of the laminated are protected with black Conductive PVC edge trim 5mm wide on all sides. This edge trim is mechanically locked and sealed in place to avoid detachment. Location and area of such access flooring shall be as per electrical requirement and Electrical GA Drawings.

k) Doors, windows and rolling shutter in all buildings shall have sun-shade either recessed in the wall or projected out. Projection of sunshade shall be 750 mm for door and 450 mm for windows. Where doors and windows are side by side, 750 wide continuous sunshades shall be provided. For recessed type shed minimum 450 mm offset shall be provided.

l) North Light provisions on the powerhouse shall be made of Polycarbonate sheet of M/s BAYER fixed to structural framework as per approved design. Arrangement shall have to be provided to prevent ingress of rainwater if any. The system shall be of M/s McCoy Architectural Systems Pvt. Ltd or similar approved.

3.01.19 Chain Link Fencing

Chain link fencing for areas as per safety requirement shall be provided. This shall be as per Civil/Structural specification.

3.01.20 **Temporary Fencing**

The construction of Temporary Fencing shall be done as mentioned below :

a) RCC post and its foundation shall be at 3.0m interval.

b) Fence shall be installed along lines shown on approved drawings.

c) Post size shall be 150sqr at bottom and 100sqr at top.

d) Total height of the posts shall be 2400mm from grade level.

e) Strainer posts shall be provided at sharp changes in grade, at comers at change of direction and where directed, and at every 30.0m interval.

f) All comer post will have two stay posts and every tenth post will have a transverse stay post.

g) Barbed wires shall run post to post and to be fixed to the posts by tightening hooks.

h) Diagonals and vertical per span with barbed wire shall be provided. In general CPWD specification is to be followed.

3.01.21 **Boundary Wall for Admin Building**

The construction of boundary wall shall be done as mentioned below:

a) RCC column and its foundation at 3 m interval.

b) RCC plinth beam with top 100 mm below ground level between RCC columns.

c) Fly Ash Brick masonry wall with cement sand mortar 1: 6.

d) 12 mm thick inside plastering with cement-sand mortar (1: 4).

e) 20 mm thick outside plastering in two layers – 12 mm internal & 6 mm external with cement – sand mortar (1: 4).

f) Minimum 100 mm thick RCC coping at top of wall with 75 mm projection on both side of wall.

g) The height of the boundary wall (at top of coping) shall be 0.75 m above the ground level. The top of RCC column shall be 150 mm above the top of boundary wall.

h) Over the boundary wall there shall be 1.25m high ornamental fencing made of wrought iron or MS Bars & Flats, with support posts & pillars having same ornamentation. The posts are to be fixed to the boundary wall with proper grout inside grouting hole of size 75x75x150mm and pillars are to be welded or bolted to cap plate fixed to the RCC columns.

i) The boundary wall shall be painted with one coat of approved primer and two coats of cement-base painting of approved manufacturer. Metallic portion shall be painted with Epoxy or PU Paint over coats of approved primer.

j) 10m on both side of the Main Gate of Admin Building complex, boundary wall shall be specially treated, aesthetically inviting with proper landscaping.

3.01.22 **Plant Main Gate and Material Gate**

a) Gate complex shall have separate vehicular entry & exit gates and also separate pedestrian entry & exit gates.

b) Vehicular entry & exit gates shall be both electrically and mechanically operated retractable gate of reputed manufacturer like DiTEC-Gandhi Entrance Automation Pvt Ltd or similar approved.

c) Gate complex building shall house observation post for security personnel, frisking area with toilet facility, baggage scan area and locker facility, gate pass issuing counter, security officer room, staff office, pantry, toilets, etc.

d) Gate complex shall have inviting and landmark quality expressed through modern material and innovative idea.

e) Provision of card punching area may be kept as per discretion of the owner.

f) Construction of Material Gate shall be as follows:

g) The Gate frame shall be made of medium duty MS sections conforming to relevant IS with welded joints.

h) The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primmer and two coats of synthetic enamel paint.

i) Gates shall be fitted with approved quality iron hinges, latch and latch catch. Latch and latch catch shall be suitable for attachment and operation of pad lock from either side of gates. Hinges shall permit gates to swing through 180 degree back against fence.

j) Gates shall be fitted with galvanized chain hook or gate hold back to hold gates open. Double gates shall be fitted with centre rest and drop bolt to secure gates in closed position.

k) Gates shall be installed in locations shown on drawings. Next to the main gate, a human access gate (1.25 m wide, single leaf) shall also be provided.

l) Bottom of gates shall be set approximately 40mm above ground surface and necessary guiding mechanism shall be fitted.

3.01.23 **Watch Towers**

a) Watch Towers shall be steel structure having watch platform at (+)7.0m level, 2m x 2m clear space for security staff and 1m wide watch balcony around the room or as per National security standards and as per site requirement and land terrain.

b) Steel stair shall be provided to access the platform.

c) Security room shall be brick clad/ sheeting/ Aero com panelling with full length vision window on every side.

d) Minimum roof height shall be 2.2m at edges of the balcony.

e) Roof may be of RCC or insulated metal sheet roofing.

f) Distance between watch towers shall be about 300m and at every corner or turn of the boundary wall one watch tower is to be provided.

g) Hollow metal pressed steel doors shall be used.

h) Windows shall be Aluminium/steel windows with 4mm thick clear float glass.

i) External wall surface shall be painted with Cement Paint over 20mm thick external plaster. Internal wall surface shall be painted with Oil bound Distemper over 12mm thick internal plaster. Internal ceiling surface (if RCC roof) shall be painted with Oil bound Distemper over 6mm thick ceiling plaster.

j) All steel work shall be painted with Epoxy paint over approved primer.

k) Balcony railing height shall be 1200mm.

3.01.24 **Sanitary Drainage System**

a) Diameter of Soil Pipe and Waster Pipe shall not be less than 100 mm.

b) Drainage pipes shall be UPVC Type-B pipes as per IS: 13592-1992 (amended to 1995) or Cast Iron pipes as per IS: 1537 & IS: 3486 within the building.

c) IS : 1742-Code of Practice for building drainage & IS: 5329 -Code of Practice for sanitary pipe work above ground for buildings should be followed.

d) If not specified the minimum gradients of soil and drainage pipe line shall be as follows:

i) 100 mm nominal dia : 1 in 35

ii) 150 mm nominal dia : 1 in 65

iii) 230 mm nominal dia : 1 in 120

iv) 300 mm nominal dia : 1 in 200

e) Each floor drain should have 'P' or 'S' trap connection as required.

f) Pipe to pipe should be connected in 45^0 or 135^0 both vertically and horizontally.

g) For cleaning purpose during maintenance, Floor Cleanout and Wall Cleanout should be provided for horizontal run and vertical run of the pipes.

h) In no case soil pipe shall be connected to waste pipe.

i) In vertical stack proper venting system with anti-siphonage vent pipes should be provided for all Water Closets.

j) CI pipes shall be joined by lead caulking and UPVC pipes shall be joined by thermoplastic joint as per manufacturer's detail.

k) Soil & Waste pipes shall be taken out of the building separately and shall be connected to separate Inspection chambers. From inspection chamber further connection shall be made to either septic tank or STP line as per plant drainage scheme.

4.00.00 INTERIOR FINISH SCHEDULE FOR POWER HOUSE BUILDING (Refer Attachment)

4.01.00 Architectural Specification of Control Room & Annexure Room

The control room of the Turbine Building is located at Operating Floor level. It is the nerve centre of the plant having state of the art facilities and requires a highly sophisticated hi-tech expression and ambience. To accentuate the Front portion of the UCB control room façade a suitable combination of Aluminium composite panel (ACP)/granular textured paint may be used.

The room will be fully air-conditioned and have access from T G hall side through Air locks to reduce the noise level as well as heat load. Each Air-lock space shall have two numbers of double leaf glazed sensor operated sliding aluminium doors. The wall facing the turbine hall shall be fully glazed aluminium partition wall with hermetically sealed insulating glass panels. Control room shall have an internal acoustic partition wall along the entire length of the room, facing operating desks. This partition shall be integrated with Digital Display Boards at different locations and have monolithic fabric finishes with high acoustical properties. It will have fully vitrified tiled floor, linear metal ceiling with A.C and lighting fixtures and wall with acrylic emulsion paint. The control room shall have very high quality furniture of approved make similar to Godrej/ Featherlight. The control desk of laminated and moulded finish of approved colour and texture, appropriate to accommodate/ house control panels, monitors shall be equipped with all functional requirements. Operator's chairs shall be swivel type on casters and have cushioned seat and back of approved material and colour. Necessary arrangement for sealing expansion joints on floor, wall and ceiling has to be ensured. Brief technical specifications of different items to be used for the control room are as follows.

a) Flooring : Non-skid, full body vitrified, 10 mm thick non-porous, homogenous, abrasion resistant, floor tiles of 1st quality dual charged similar to MARBONITE", "FERRASTONE" of "BOSS Profile Ltd", "RESTILE", ENDURA" of H & R Jonson (India) Pvt. Ltd of minimum size minimum 600 mm x 600 mm x 10mm of approved colour and shall be laid over concrete floor with laying compound strictly as per manufacturer's specification. Total thickness of the flooring shall be 50mm thick including the thickness of the tiles, under bed.

b) Skirting : Walls of UCB control room from floor level upto false ceiling level shall be provided with vitrified tiles of 1st quality, full body vitrified, 10 mm thick nonporous, homogenous, abrasion resistant cover base of matching colour, internal and external corner strip similar to "MARBONITE", "FERRASTONE" of "BOSS Profile Ltd", "RESTILE", ENDURA" of H & R Jonson (India) Pvt. Ltd and fixed to the wall strictly as per manufacturer's specification.

c) Wall finish : Columns, bracings or any other element within the room as the case may be shall be clad with polyester coated 3mm thick Aluminium Composite Panels (Aluminium thickness minimum 0.2mm) of approved make or composite panelling of approved pattern upto the false ceiling level. The colour and design composition of ACP cladding or composite panelling is to be submitted for approval of the authority before taking up the work.

d) False ceiling : The bottom level of false ceiling shall be kept 3500mm above floor level and as applicable. Gypsum plaster board false ceiling of approved pattern having state of the art facilities and requires a highly sophisticated hi-tech expression and ambience in order to enhance the aesthetic appearance of the control room. The false ceiling work shall take care of all illumination, fire detection & fighting, HVAC and all other service requirement. Under-deck insulation with 50 mm thick resin bonded rigid mineral wool / polystyrene block with protective aluminium foil lining shall be provide on the ceiling, on the walls and beams above false ceiling level.

e) Air lock doors : Double acting glazed aluminium door with minimum 15 micron colour anodized finish with 3mm thick shall be used having glazing thickness 6mm of clear float glass of approved brand .The doors shall be complete with weather seal, gaskets, floor spring, doorstopper, door locks, push/pull bars of similar finish and all necessary hardware. The aluminium sections shall be similar to HYDRO-Domal system.

f) The doors shall be complete with weather seal, gaskets, floor spring, doorstopper, door locks, push/pull bars of similar finish and all necessary hardware. The aluminium sections shall be similar to HYDRO-Domal system.

g) Glazed partition wall : The glazed partition wall shall be made of aluminium sections having same finish that of aluminium doors with double-glazed insulating glass panels. This partition height shall be from top of floor finish to the bottom of the false ceiling. Insulating glass shall consist of 2 nos. 8 mm thick toughened plain glass separated by an air gap of 12mm thick, hermetically sealed, moisture resistant and of approved manufacturer. The partitions shall be weather proof complete with gaskets, clips, hardware, etc. The aluminium sections shall be similar to HYDRO-Domal system.

h) Internal partition wall of control room : The internal partition wall along the entire length of the room, facing operating desk shall consist of Digital Display Boards at different locations, integrated with wall panels of Anutone Acoustic Ltd or equivalent laid flush with the display board and two nos. of matching doors on either sides for access to the rear side for maintenance. This special purpose partition shall be as manufactured by Anutone Acoustic Ltd or equivalent and

shall have rigid frame work consisting of G.I. Studs of adequate size @ 600 mm c/c and floor, ceiling and intermediate channels to provide a strong wall system capable of supporting wall hung C.C.T.V. at designated locations. The framing system shall be integrated with independent floor supported structural framework of digital display board so as to cover the entire exposed surface around the board with partition panels.

The front side of the frame shall have Excelsior Acoustical Panels – Elega finish – 2400/1200 x 600 x 19 mm thick FABRICO SoundSoak – Plane Texture of approved colour. The rear side of partition shall have Excelsior Acoustical Panels – Elega finish – especially Sound Smart – Burl of size 2400/1200 x 600 x 19 mm thick smooth finished with gypsum plaster and finished with acrylic emulsion paint. The entire wall shall have Class I fire rating as per BS code. The partition shall not transmit any load to false ceiling. The entire partition wall shall have concealed framing system and have monolithic fabric finish of approved colour or composition of two different colours as per approved design to entire exposed surfaces including door panels on control room side.

5.00.00 INTERIOR FINISH SCHEDULE FOR AUXILIARY BUILDINGS
Refer attachment for Finish schedule)

6.00.00 BRIEF DESCRIPTIONS OF NON PLANT BUILDINGS

6.01.00 Brief Description of Service Building

The Service Building is a multi storied building. However the Number of stories shall depend upon the TG operating floor level. Building is located adjacent to the Power House Building as shown in the Plot Plan. Minimum space between the service building and power house building shall be kept for Approach road for Workshop floor at Zero metre in service building. An all weather covered access corridor to be provided with powerhouse building at operating floor level. Overall area per floor of the building shall be approximately 2000 Sqm. However the building size shall be suitably decided during detail engineering stage. It will house the facilities as listed below. Building shall have 2(two) nos. Passenger elevator (13 passenger) and 1 (one) main staircases and 1 (one) fire escape staircase. Overhead water PVC / RCC tank of 10,000-litre capacity should be provided at roof of the building.

It is an important part of operation and maintenance of the plant having state of the art facilities and requires a highly sophisticated hi-tech expression and ambience.

Facilities at Different floors shall be decided during detail engineering stage.

The Building will be centrally air-conditioned. All finishing items, Layout, and other requirements should be of owner's choice. However modern design approach of an office building like- open & flexible (workstation based) layout, usage of natural light, solar control, energy efficient, etc shall be considered. Since this is one of the most prestigious buildings, aesthetically this should achieve landmark quality.

Specially designed long and spacious RCC porch shall be given in front of the main entrance for receiving cars of VIP's.

Special attention to be given in front of service building in landscaping the area and developing garden with flowering plants and fountains etc

Shaded car parking facility with RCC roof shall be provided as per requirement of the owner.

Brief technical specifications of different items to be used for the area as follows :

a) **Flooring**

Generally floor finish shall be Non-skid double charged, fully vitrified, of Class-I quality 10/11 mm thick or as per manufacturer non-porous, homogenous, and abrasion resistant, floor tiles, of minimum size minimum 600 mm x 600 mm of approved colour & design, and shall be laid over concrete floor with laying compound strictly as per manufacturer's specification. Total thickness of the flooring shall be 40mm thick including the thickness of the tiles, under bed. However Workshop floor shall be provided with 50 mm thick heavy duty floor or 20 mm thick steelcrete tile floor.

For Entry cum reception lounge, VIP lounge, Main meeting/ conference room:-

Suitable and approved combination shed of marble slab and strips shall be used. Floor pattern shall be approved by the owner before erection.

For staircase and Corridors :

Steps – risers & tread, stair skirting, corridor floor should be combination of Aranga white marble and Abu green marble or Baroda green and Jaishalmir yellow marble combination. Wall cladding of Elevator Lobby shall be of polished granite slab of light grey/any other approved shade by owner.

For Toilet :

Minimum 10 mm thick non-skid vitrified tile, of minimum size 400 mm x 400 mm (overall 40 mm thick) with glazed ceramic tile of same make, Dado shall be 100 mm higher than bottom of lintel level. Only for toilet at operating floor and Third floor, dado shall be topped with 50 mm wide matching moulded ceramic trims.

For other areas like AHU room, Generator room, Electrical room, Etc: shall have 40 mm thick heavy duty cement concrete (IPS) floor with metallic hardener and matching skirting or 20 mm thick steelcrete tile floor.

b) **Wall finish**

Two coats of Acrylic Emulsion paint of approved colour shall be applied over a coat of approved primer on the masonry surface prepared with White Cement Putty (Birla White or JK White or similar approved) for all area except areas like AHU room, Generator room, Electrical room, Etc which shall be of plastered surface with Acrylic Distemper paint. Front wall for elevator shaft shall have polished granite slab wall cladding (min 12 mm thick).

Painting to exterior surfaces of wall shall be of Acrylic Emulsion Paint similar to “Apex Ultima”, “Weathergurd”/ “Weathershield” over plaster. To accentuate the building façade a suitable combination of Aluminium composite panel (ACP)/granular textured paint may be used.

c) **False ceiling**

It will be applicable for all areas excluding non A/C areas like AHU room, Generator room, Electrical room, Etc, pantry and toilet. It shall be of aluminium panelled (size 600x600mm) acoustic false ceiling with rock wool insulation on top similar to LUXALON of Hunter Douglas or INTERARCH having approved colour with stove enamel finish, and or Mineral fibre board of Armstrong and or Gypsum MR board as per functional requirement and interior design scheme, integrated with light fixtures, HVAC grills and other ceiling mounted accessories, complete in all respect with metal suspension system, trims, profiles etc.

For pantry and toilet false ceiling shall be perforated aluminium stove enamel finished panels of size 600x600mm.

d) **Doors**

Factory made Solid core wooden flush doors with high quality PVC lamination on both sides giving hi-tech expression in teak wood frame shall be used in interior office areas. The doors shall be complete with weather seal, gaskets, floor spring, doorstopper, door locks, push/pull bars of similar finish and all necessary hardware. The aluminium sections shall be of similar to HYDRO- Domal system. Glazed partition may be etched with suitable and approved designed. Wooden doors shall be of factory made solid core wooden flush door with C. P. Teak veneered surfaces in wooden frame with wooden architrave.

Toilet & pantry doors shall be wooden panel door.

Doors for areas like AHU room, Generator room, Electrical room, Etc shall be hollow metal flush door.

e) **Glazed Panels**

The glazed panels shall be made of aluminium sections having same finish that of aluminium doors with double-glazed insulating glass panels. This partition height shall be from top of floor finish to the bottom of the false ceiling and maximum available width. Insulating glass shall consist of 2 nos. 6 mm thick clear float glass separated by an air gap of 12mm thick, hermetically sealed, moisture resistant and of approved manufacturer. The partitions shall be weather proof complete with gaskets, clips, hardware, etc. The aluminium sections shall be of HYDRO-Domal system.

Glazed partition may be etched with suitable and approved designed.

f) **Windows, Glazed Curtain wall**

All windows of A/C areas shall be separated with heat reflecting glass/double insulated glass from non AC areas. Other windows shall be 15micron thick colour anodized aluminium glazed window with minimum 4mm thick clear float glass. Window system shall be of HYDRO-Domal system.

Glazed curtain wall shall be Unitised structural glazing system comprising of 30 micron colour anodised aluminium extrusions with double insulated heat reflecting glass. The system shall be able to withstand wind pressure as per relevant data given elsewhere in this specification at all heights. Structural glazing system shall be of HYDRO-Domal system or equivalent.

g) **Utilities**

All utility lines like water supply line, Electrical wiring, telephone line etc. Shall be concealed type. Fittings and fixtures for toilets should be of best quality and to be got approved by Owner prior to installation. Roof treatment, sanitary & sewerage system, roof drainage etc. Shall be as per detail technical specification.

h) Any other items of work not specifically mentioned here shall be as per the guidelines indicated in relevant Architectural Technical Specification.

6.02.00 **Brief Description of the Canteen Building**

a) This shall be single storey RCC framed structure with brick cladding. Spacing of columns shall such that large column free areas are available in the dining area.

b) The dining area shall have the arrangement to seat minimum 75 people at one time. In addition there shall be a separate executive dining area fully air-conditioned and with gypsum board false ceiling to accommodate about minimum 25 executives and separate dining area for women.

c) Adequate space shall be provided for stores, preparation, cooking, serving and washing facility.

d) Toilet and hand wash shall be kept sufficiently away from cooking area to satisfy statutory requirements.

e) Walls of the dining hall, cooking and serving area shall be given dado of glazed ceramic tiles to a height of 2100 mm.

f) Adequate exhaust fans and ventilation facility shall be given in the cooking area and in dining area.

g) Special arrangement shall be made to lead off the wastewater from canteen to the effluent treatment plant.

h) Main entrance door shall be of aluminium glazed swing type with two leaves opening outside. Doors of other areas shall be wooden panel door, hollow metal flush door as applicable.

i) All windows shall be glazed aluminium window with diamond grill.

6.03.00 **Brief Description of the Fire Station.**

a) Fire station shall be a single/double storied RCC framed building with brick walls in office area.

b) The fire station shall have provision for parking for fire tenders including one bay for maintenance with pit, office for the station-in-charge, duty room, stores, recreation cum class room, record cum general room, toilet blocks etc.

c) Parking area for tenders shall ensure fast movement of the fire tender in an emergency.

d) In addition adequate space shall be provided for hose drying and drill ground.

e) The arrangement shall in general satisfy requirement of the local fire brigade.

6.04.00 **Brief Description of the Permanent Store.**

a) This building shall be brick clad of RCC framed structure with RCC roof or sheet metal roofing on metal deck or steel truss as per structural design consideration.

b) In the heavy material storage area, electric hoist of adequate capacity shall be provided.

c) Store building shall have facility to store heavy materials, light materials, electronic equipment & parts, etc.

d) Store building shall also provide for office space for superintendent and his supervisory staff, locker room and change room for workers, toilet etc.

e) Entry and exit of trucks shall be through adequately sized rolling shutters. In addition a minimum 2 single leaf steel flush door shall be provided for entry of the staff.

f) Adequate windows shall be provided for ventilation and lighting. Offices inside shall be of glazed partition above 900 mm high single brick wall. Total height of partition including brickwork shall be 2400 mm. Doors to the cabins shall be of glazed aluminium.

g) Gypsum board false ceiling shall be provided for AC areas.

6.05.00 **Brief Description of the Gate Complex**

a) Gate complex shall have separate vehicular entry & exit gates and also separate pedestrian entry & exit gates.

b) Vehicular entry & exit gates shall be both electrically and mechanically operated retractable gate of reputed manufacturer like DiTEC-Gandhi Entrance Automation Pvt Ltd or similar approved.

c) Gate complex building shall house observation post for security personnel, frisking area with toilet facility, baggage scan area and locker facility, gate pass issuing counter, security officer room, staff office, pantry, toilets, etc.

d) Gate complex shall have inviting and landmark quality expressed through modern material and innovative idea.

e) Provision of card punching area may be kept as per discretion of the owner.

6.06.00 **Coal handling plant structures**

6.06.01 **General arrangement**

The architectural descriptions of some major structures/components covered under this package are given below :

i) **Track Hopper**

The super structure of track hopper shall have structural framing with provision for electric traction wire for electric locomotive. The roof and side sheeting shall be single skin metal cladding system comprising of profiled sheet manufactured out of 0.55 mm TCT (Total Coated Thickness) permanently colour coated zincalume steel (150 gsm zinc – aluminium alloy coating total of both sides as per AS 1397 : 1993) having 300 Mpa yield strength. The colour coating shall comprise of SMP/super polyester XRW (as per AS/NZS-2728:1997 category 3). The colour coating shall comprise of 20 microns finish coat over a 5-micron primer coat on the exposed side and a back coat of 5 microns over a primer coat of 5 micron on the reverse side. The metal cladding shall have 500 mm cover width, 47 mm high crests at 250 mm centres with special male / female side laps and anti siphoning feature to prevent leakage. 2.0 mm thick fire resistant and UV resistant polycarbonate sheet of approved make for adequate natural light and louvers for ventilation purpose shall be provided for side cladding. The polycarbonate sheet shall have troughed profile to match with the metal cladding profile & to be provided 15 % of floor area.

Continuous gutter (same as roof sheet of adequate thickness) with 150 dia. GI/ MS pipe rain water down comers conforming to IS:1239 / IS:3589 shall be provided. The number and size of down comers shall be governed by IS:1742 & IS:2527. Suitable monorails and stair shall be provided at two ends of track hopper where machine hatches are provided. The hopper shall be provided with M.S. grating as stated elsewhere in this specification. Standard G.I. hand railings on sides, as per system requirement are to be provided.

ii) **Wagon Tippler**

The super structure of wagon tippler shall have structural framing with provision of electric traction wire for electric locomotive. The roof and side sheeting shall be single skin metal cladding system comprising of profiled sheet manufactured out of 0.55 mm TCT (Total Coated Thickness) permanently colour coated zincalume steel (150 gsm zinc – aluminium alloy coating total of both sides as per AS 1397 : 1993) having 300 Mpa yield strength. The colour coating shall comprise of SMP/super polyester XRW (as per AS/NZS-2728:1997 category 3). The colour coating shall comprise of 20 microns finish coat over a 5-micron primer coat on the exposed side and a back coat of 5 microns over a primer coat of 5 micron on the reverse side.The metal cladding shall have 500 mm cover width, 47 mm high crests at 250 mm centres with special male / female side laps and anti siphoning feature to prevent leakage with provision of minimum 2.0 mm thick fire resistant and UV resistant polycarbonate sheet of approved make for adequate natural light and louvers for ventilation purpose. The polycarbonate sheet shall have troughed profile to match with the metal cladding profile & also to be provided 15 % of floor area in a staggered fashion on the roof.

Continuous gutter (same as roof sheet of adequate thickness) with 150 dia. GI/ MS pipe rain water down comers conforming to IS:1239 / IS:3589 shall be provided. The number and size of down comers shall be governed by IS:1742 & IS:2527. The hopper shall be provided with M.S. grating as stated elsewhere in this specification. Provide continuous standard G.I. hand railings on one side covering the entire length of the hopper fulfilling requirement of railway clearance to prevent any person falling inside.

iii) **Underground Transfer Points**

All underground transfer points shall be of RCC construction with waterproofing as per specification. The intermediate floor and basement floor shall be provided with floor finish as per specification.

All underground TPs shall be provided with minimum 1.2 m wide RCC stair with hand railings as per specification. Risers for steps shall not exceed 180 mm and tread width shall not be less than 250 mm. Hand rails shall comprise of posts 40 NB M.S. galvanized pipe 1.1 m high not exceeding 1.5 m (max) c/c with 2 nos. 32 NB M.S. galvanized pipe horizontal placed at top and mid height respectively and continuous flat iron toe guard at bottom.

iv) **Over Ground Transfer Points, Pent Houses & Pump Houses**

All over ground TPs shall have R.C. foundations resting on firm strata. The super structure for TPs shall be structural steel framed with adequate bracing arrangement. All intermediate floors and roof shall be of RCC. The ground floors for buildings shall be of RCC over PCC sub base over min. 230 thick compacted boulder/stone soling. The RC floors shall be provided with floor finish as per specification and roof shall be provided with heavy water proofing treatment as per specification. The cladding shall be of brick work plastered on both faces up to 3.0 M from lowest working floor and remaining height with 0.55 mm TCT (Total Coated Thickness) permanently colour coated zincalume steel sheet as specified above. The colour coating shall comprise of 20 microns finish coat over a 5-micron primer coat on the exposed side and a back coat of 5 microns over a primer coat of 5 micron on the reverse side. Sheeting shall be fixed with the help of concealed compatible interlocking clips and wafer head zinc coated self drilling fasteners. The clips shall be concealed and no fasteners are to penetrate the sheeting. Height of plinth shall be 500mm from ground level and RCC pedestals for column shall be 300mm above floor level. In all the floors steel column shall be encased with R.C.C. of min. grade M-20 with min reinforcement upto 300mm from respective floor. Adequate windows and doors shall be provided as per specification.

The polycarbonate sheet shall have troughed profile to match with the metal cladding profile & to be provided in a continuous band around periphery at suitable locations in between floors with at least 20% of cladding area.

TPs shall be provided with independent steel stair block with steps of M.S. grating from ground to roof with access to roof. The width of the stair shall be minimum 1.2 m. The tread shall be minimum 250mm and riser shall be uniform throughout the height and not exceeding 180mm. Continuous hand rails shall be provided in stair. For Pent House continuous GI handrail shall be provided on roof over R.C.C. kerb. For other structures RCC parapet of 900 mm height shall be provided. The pent houses and pump houses shall be of brick cladding and treated with cement based paint as per specification. Adequate provision shall be made for roof drainage. Roof shall be

provided with 150 dia. GI rain water down comer pipes, steel door and steel windows (with Chajjas/fins) access and stair ways etc.

v) **Crusher House**

The Specification for Crusher house is similar to over ground TPs mentioned above except cladding area of Polycarbonate sheeting.

The polycarbonate sheet shall have troughed profile to match with the metal cladding profile & to be provided in a continuous band around periphery at suitable locations in between floors covering at least 25% of cladding area.

The crusher house shall have an independent stair with access to roof for general use like other TPs. In addition, it shall have a separate stair block for fire escape suitably located complying with fire fighting norms of TAC. 250mm thick brick wall to be placed in suitable structural frames for stability and safety between two crushers in full height with a provision of a door.

vi) **Over Ground & On Ground Galleries & Trestles**

Over ground and on ground galleries shall be of enclosed type. The gallery shall have walkways and the width and height shall be as per system requirement. A continuous slit opening of 500 mm height shall be provided on both sides of gallery just below roof sheeting. The gallery shall be made of structural steel with galvalume sheet and minimum 2.0 mm thick fire resistant and UV resistant polycarbonate sheet of approved make for adequate natural light on roof and walls to be provided as mentioned elsewhere in this specification.

The floor for on-ground galleries shall be raised at least 500 mm above finished ground level and paved with min. 150 thick RCC (M-25) over 100 mm thick lean concrete (M10) over 230 thick boulder/stone pitching interstices filled with sand. The raised floor shall be retained by continuous brick walls at both sides of enclosures running along length of the conveyor and the surface of the wall shall be plastered and finished with cement based paints externally as per specification.

For Conveyor Galleries washing water down comer shall be provided at every Trestle location.

Roof, side sheeting and slit opening on walls for over ground conveyor galleries shall be similar to ground conveyor explained above. The area for natural light shall not be less than 15% of floor area. Crossover shall be provided at intervals not exceeding 100m c/c & stair upto the ground floor level shall be provided at every location of crossover. Crossovers shall preferably be located over four-legged rigid trestle location. Platforms for cross over shall be provided with

chequered plate flooring and hand railing as per specification. The foundations & structures for gravity take up with platform and hand railing shall be provided by the bidder's drawing and specification. Fencing with lockable gate shall be provided around Gravity take ups. Trestles shall be of structural steel braced adequately and provided at suitable locations. Location of trestles adjacent to boiler house and railway lines shall have to be decided carefully so that there is no interference (both underground and over ground) with other buildings, equipment/equipment structures foundations nearby as well as railway lines, ducting, trenches, drains etc. Adequate clearance required by Railway authorities shall be maintained shall have. The Contractor has to execute work very carefully so that any existing foundations are not damaged. Execution and erection sequence of foundation for trestles and galleries or any other coal handling plant equipment and structures has to match erection sequence of boiler, ESP or other adjoining structures.

vii) **Substations & Control Rooms**

These shall be RCC framed structures with columns, beams, slabs and foundation etc. Cladding shall be of brick work with plaster on both side. Adequate aluminium doors and windows shall be provided for natural ventilation & views. Roof shall be provided with roof water proofing treatment as per specification. The control rooms shall have superior ambience and finish employing high quality glass, Aluminium false ceiling, dust free superior flooring etc. All air-conditioned areas (specified in Electrical Specification) shall be provided with the suspended permanently anodised aluminium natural colour matt finish false ceiling system with corrosion resistance aluminium alloy panels of minimum thickness 0.5 mm. 50mm thick mineral wool insulation (as per IS:8183) bound in polythene bags shall be laid on top of panels. Additional hangers and height adjustment clips shall be provided for return air grills, light fixtures, AC ducts etc. Suitable M.S. channel (min. MC 75) grid shall be provided above the false ceiling level for movement of personals to facilitate maintenance of lighting fixtures. Under deck insulation shall be provided on the ceiling (underside of roof slab) and underside of floor slab of air-conditioned areas depending upon the functional requirements.

Control panel room for control room near track hopper shall be provided with thick wired glass (min. 5.5 mm thick) on all sides so as to permit operators to have full view on operation of Track Hopper. Adequate number of 150 mm dia. RWDC pipe has to be provided. Control room floor shall be Heavy duty vitrified Ceramic Tiles tiled finish. Well polished Kota stone shall be provided for staircase, passages, lobbies and general circulation areas. 40 mm thick IPS (28 mm under bed & 12 mm thick topping with metallic hardener) shall be provided for MCC rooms, cable vault/cable spreader rooms etc. For battery room & areas of corrosive liquids, 20 mm thick acid & alkali resistant tiles set in with acid & alkali proof epoxy mortar underbed

shall be used. Silica based epoxy mortar which is chemical resistant shall be used in dado at least up to 1.5 m from finished floor level. The ceiling, door and windows and all other fixtures shall be provided with acid resisting paint as per specification.

Separate Fire escape stair shall be provided in Control Building.

All control room shall be provided with toilet facilities with toilet fixtures as specified elsewhere for 20 (twenty) users and drinking water supply facilities. All doors of toilet shall be of standard PVC door of approved make & colour. If the effluent for sewer should have independent septic tank then the septic tank shall be located at a distance of 15m (min.) from building.

viii) **Crusher House Control & MCC Room**

These shall be RCC framed structures with columns, beams, slabs and foundation etc. Cladding shall be of brick work with plaster on both sides. Adequate aluminium doors and windows shall be provided for natural ventilation & views. Roof shall be provided with roof water proofing treatment. All air-conditioned areas shall be provided with the suspended permanently anodised aluminium natural colour matt finish false ceiling system with corrosion resistance aluminium alloy panels of minimum thickness 0.5mm. 50mm thick mineral wool insulation (as per IS: 8183) bound in polythene bags shall be laid on top of panels. Additional hangers and height adjustment clips shall be provided for return air grills, light fixtures, AC ducts etc. Suitable M.S. channel (min. MC 75) grid shall be provided above the false ceiling level for movement of personals to facilitate maintenance of lighting fixtures. Under deck or over deck insulation shall be provided on the ceiling (underside of roof slab) and underside of floor slab for air-conditioned areas depending upon the functional requirements.

Control panel room for control room shall be provided with thick wired glass (min. 6.0 mm thick) on all sides so as to permit operators to have full view on operation. Adequate number of 150mm dia. GI RWDC pipe shall be provided. Control room floor shall be Heavy duty vitrified Ceramic Tiles tiled finish. Well polished Kota stone shall be provided for staircase, passages, lobbies and general circulation areas. Overall 50mm thick IPS (27mm underbed & 13mm thick topping) shall be provided for MCC rooms, cable vault/cable spreader rooms etc. For battery room & areas of corrosive liquids, 20 mm thick acid & alkali resistant tiles set in with acid & alkali proof epoxy mortar underbed shall be used. Silica based epoxy mortar which is chemical resistant shall be used in dado at least up to 1.5 m from finished floor level. The ceiling, door and windows and all other fixtures shall be provided with acid resisting paint as per specification.

Separate Fire escape stair shall be provided in Control Building.

All control rooms shall be provided with toilet facilities and drinking water supply facilities. All doors of toilet shall be of standard PVC door of approved make & colour.

6.07.00 **Interior Finish Schedule For Non Plant Buildings (Refer attachment for finish schedule)**

7.00.00 **DESIGN DATA FOR ARCHITECTURAL WORKS**

1	Brick works – internal and external	:	230 mm thick fly ash brick wall with 1:6 Cement- Sand mortar. All Brick work as mentioned in this document shall be with Fly Ash Bricks unless noted otherwise.
2	Half brick thick wall	:	1:4 cement: Sand mortar with 2 nos. 6 mm dia M.S. rod in every fourth layer.
3	One third brick wall	:	1:3 cement: sand mortar with 2 nos. 6 mm dia M.S. rod at every alternate layer.
4.	Damp proof course	:	40mm thick 1:1.5:3 Concrete with a 2% admixture of water proofing compound or as per manu-facturer's recommendation.
5.	Plaster: Exterior & rough side	:	20 mm thick with 1:4 cement-sand of interior brick wall mortar in two layers except where special finish provided.
	Interior	:	12 mm thick with 1:4 cement-sand mortar
	Ceiling	:	6 mm thick with 1:3 cement-sand mortar
6.	White Cement Putty Punning	:	2 mm thick punning to be provided to all areas receiving acrylic emulsion or Acrylic Distemper paint.

7. Cladding for Power house

Providing and fixing of double skin insulated wall cladding system comprising of profiled external sheet manufactured out of 0.55mm TCT (Total Coated Thickness) permanently colour coated zincalume steel (150 gsm. Zinc – aluminium alloy coating total of both sides as per AS 1397: 1993) having 300 Mpa yield strength. The colour coating shall comprise of SMP. The inner sheeting shall be 0.50mm/0.6mm TCT of SMP coated zincalume steel 150 gsm. (Zinc – aluminium alloy coating mass total of both sides as per AS 1397:1993) having 550 Mpa yield strength or 180gsm galvanised of 240 mpa. The colour coating shall comprise of 20 microns finish coat over a 5-micron primer coat on the exposed side and a back coat of 5 microns over a primer coat of 5 micron on the reverse side.

The external sheet shall have 500mm cover width, 47mm high crests at 250mm centres with special male / female side laps and anti- siphoning feature to prevent leakage. The inner sheet shall have 980mm cover width 28mm high crests at 195mm centres with special male / female side laps and anti-siphoning features to prevent leakages. The inner sheet shall be fixed to the structure by means of self drilling fasteners no. 12-24 x 25 mm conforms to AS: 3566 Class-3 long at valley. Sub-girts of size 50mm x 50mm x 50mm manufactured out of 16G GI (1.6mm GI) 'Z' shape would be fixed the inner sheeting on face side at runner locations and outer sheeting shall be fixed with the help of concealed compatible interlocking clips and wafer head zinc coated self drilling fasteners / screws 4.2 x 25mm long on to the sub-girts. The clips shall be concealed and no fasteners are to penetrate the external sheeting. An insulation of 50mm thick Rockwool Insulation of density 48KG/M3 conforming to IS: 8183 shall be provided and fixed to the inner sheet and between the two sheets as per specification. If the insulation is made of polyurethane foam then the core in between the outer profiled sheet and the inner sheet will be formed out of polyurethane foam in 30mm thickness having a density of 40-45 kg/cum. The foam shall be in filled in between the outer and the inner sheet using a highly dedicated foaming machine and the entire process of forming the panel will be carried out at factory Panels may be prefabricated factory made panels or in-situ type. Wherever single skin metal cladding shall be used over brickwork, the material shall be same as the outer skin of insulated metal cladding system.

Approved Manufacturer : LLOYD Insulations (India) Ltd. TATA Blue Scope Steel, or similar approved.

8. False Ceiling : Aluminium pre-painted false ceiling, either lineal panel system or aluminium tile/plank system.

   Approved make : LUXALON by Hunter Dauglas, LLOYD, Armstrong, INTERARCH or similar approved.

   In other air-conditioned areas 12.5 mm Gypsum board/Mineral fibreboard /Calcium Silicate Board / Fibre Cement Board ceiling with aluminium grid will be used.

   Approved make : Saint Gobain Gyproc India Ltd, Armstrong, AMF, Everest, HILUX, Aerolite or similar approved.

9. Floor finish

a) Generally finish to utility areas shall be 40 mm thick heavy-duty patent stone with metallic hardener on concrete slab.

   The heavy-duty overlay shall be ready-to-use, metallic aggregates based powder after application of epoxy based bonding agent of two components, solvent less epoxy resin based equal or similar to BASF's MASTERTOP 230i. It shall be formulated to meet the requirement of ASTM C881 Type 2, Grade 2, and Class B &C. The Bonding agent shall exhibit minimum open time of 6 hours and shall exceed the tensile strength of concrete in terms of its adhesive bond strength. The Floor topping product shall be high strength with compressive strength of 80 MPa at 28 days; flexural strength exceeding 8 MPa at 28 days. The product shall be capable of resisting metal crawler chassis and shall have abrasive wear less than 0.15 mg/cycle on H22 wheel, ASTM C501 test method. The product shall have adhesive bond strength in excess of 1.5 MPa when tested as per ASTM D4541. Curing of the layer to be done with non-degrading membrane forming curing & sealing compound shall be equal or similar to MASTERKURE 181, acrylic resin based formulation. The product shall comply with ASTM C 309 Class B. The product shall exhibit water loss not more than 0.55 kg/m2 in 72 hours when tested as per ASTM C156. The product shall form non-degrading abrasion resistance film which shall also exhibit capability as primer for subsequent protective coatings or bituminous overlays.

   Approved make : BASF, Ironite or similar

b) For T.G. Hall (operating floor) Granite / Kota stone flooring finish will be as follows :

Minimum 18~20 mm thick polished Granite/ Kota stone slab or 600x600 mm tiles to be used over minimum 30 mm thick under-bed. Stones shall be hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, and free from chipping and surface shall be plane. The slabs shall preferably be machine cut to the required dimensions. Tolerance of ± 5 mm in dimensions and ± 2 mm in thickness will be allowed. During laying the slabs the edges of the slab shall be buttered with slurry of cement, mixed with pigment matching the colour of the stone slabs. Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. Per. Sq.m. water sprinkled on to it and finished by buffing with felt or Hessian bobs.

c) For battery room, battery charger room, chemical laboratories, chlorination room etc., the areas handling corrosive liquids, overall 40 mm thick Acid and Alkali resistant vitrified tiles flooring with 20mm thick tiles with silica based epoxy mortar shall be used. Acid and Alkali resistant vitrified tiles with silica based epoxy mortar up to 2.1M height from finished floor level shall be used as dado. Acid and Alkali resistant paint shall be applied up to the ceiling level above Acid and Alkali resistant tiles dado. Ceiling shall also be painted with Acid & Alkali resistant paint.

Approved Make	:	ENDURA of Jhonson, Chemstone of BOSS Profiles Ltd, RESTILE Ceramics Ltd. Or similar approved.
Paints	:	ICI, ASIAN Paints, Berger or similar approved.

d) For battery room finished with Epoxy Flooring (where required)

On the prepared substrate, one coat of a solvent free, resin based dispersion, Primer shall be applied. Density of the primer is around 1kg/lt and the mixing ratio of two components,

Comp A and B : 1:2.5 by weight

Over the primed surface, epoxy modified cementitious self □levelling floor topping shall be laid maintaining the thickness of 2mm. The mixing ratio of three component Comp.A :Comp.B: Comp.C: 1:2.5:17 by weight, compressive strength at 30ºC approx. 45N/mm² after 28days, the mortar density is around 2.2 kg/lt.

Priming should be done again with a primer of two component product, comp. A: comp. B: 4:1 (By weight). Prior to mixing of these two components,only comp. A shall be stirred mechanically. When all of part B is added to part A, the mix is to be stirred for 3 minutes until a smooth consistency is achieved. Finally, after drying of the primer, two coats of high-build, slightly thixotropic, chemical resistant epoxy protective coating shall be applied as the top coat. Minimum 2 coats are required. This is two component products, comp. A: comp. B: 3:1 (by weight). The mixed density is 1.5kg/lt at 27^0 C. The system shall be allowed for curing for 3 days.

Approved Make : Sika India (P) Ltd., BASF or similar.

e) All areas of toilet, including W.C and urinal shall have vitrified ceramic tiles floor. Dado shall be of glazed tiles of minimum 5/6 mm thickness up to 100 mm higher than lintel level starting from finish floor level.

Approved Make : Ferrastone/Hardstone of BOSS Profiles Ltd, RESTILE Ceramics Ltd. , Marbonite, Kajaria, Nitco, Endura of H R Jonson, or similar approved.

f) Access Floor panel of size 600x600 mm shall be all steel welded construction, with an enclosed bottom pan of 49 hemispherical and 36 reverse cones and top plain sheet which are fuse welded at 129 locations to form a panel of an overall depth of 37 mm. The panel after cleaning, degreasing, phosphating by 11 tank process is coated with 40-60 micron epoxy coat and is heated to achieve maximum adhesion to the panel surface and corrosion resistance. The inner empty core of the panel is injected with a light weight fire retardant, non combustible cementitious compound at high pressure to fill in all the crevices of the panel and ensures support of not less than 90% of the top surface area of the panel.

The panel is then laminated with 1.5/2.00 mm thick fire retardant floor grade Antistatic Laminate / ESD Laminate - PVC/ Conductive PVC on a semi –automated lamination line to ensure maximum bonding to the steel surface. The edges of the laminated are protected with black Conductive PVC edge trim 5mm wide on all sides. This edge trim is mechanically locked and sealed in place to avoid detachment

Sub structure installed to support the panel shall be suitable to achieve a minimum finished floor height of 65mm to a maximum of 600 mm from the existing floor level. Pedestal design shall confirm speedy assembly and removal for relocation and maintenance. The assembly shall provide easy adjustment of levelling and accurately align panels for a maximum ± 25 mm in the vertical direction. Pedestals shall support an axial load without permanent deflection and an ultimate load as laid out in System Performance requirement. The Pedestal head assembly shall consist of a 90 x 90 mm x 4.00 mm embossed head mechanically riveted to a 100mm long 20mm Dia rolled formed stud and 2 check nuts for level adjustment and arresting vertical movement. The pedestal head shall consist of an anti-vibrational PVC cap, for Panel and stringer location.

The Pedestal Base assembly shall consist of 25.00 mm OD pipe of thickness 2.00 mm mechanically locked on a press for perpendicularity and then welded to a base plate of 125 x 125 x 2.50 mm thick with stiffening folds.

The sub structure assembly shall be suitably anchored to the floor with suitable adhesive or fastener as recommended by the manufacturer. All steel components shall be zinc electro plated.

The stringer is hot dipped galvanized steel cold rolled construction specially designed with ribs embossed on 3 sides for strength, lateral stability, and rolling loads and to support the panels on all four sides for alignment. The stringer to have a counter sunk holes at both ends to accommodate bolting of M6 machine screws to the pedestal head assembly. The stringers shall be 21 x 32 x .8mm x570 mm length.

Approved make of Til e: Unitile® USF 1500 or similar approved.

g) Floor/staircase and the areas prone to slippage due to oil spillage etc. Shall be provided with non-skid floor finish.

h) 750 mm wide, minimum, R.C. paving as plinth protection, shall be provided around all buildings with surface drain of required size.

i) Risers and treads of concrete staircase of powerhouse shall be of white marble slab and in all other stairs; same shall be of Kota stone finish. 20/25 mm thick Kota stone finish excepting main stair riser and treads shall be of marble. All areas shall have 150 mm high skirting unless indicated otherwise in the specification.

j) For MCC and Switchgear rooms flexible electric insulated PVC synthetic sheet as per IS: 15652 2006 of Suntex Insulatic Pvt Ltd or similar shall be applied.

10. Doors and Windows

a) Hollow metal door at all levels shall be installed from ISO 9001-2000 certified Manufacturer. All hollow metal general doors with or without vision panel. Pressed Galvanised steel Single /Double leaf to required sizes which consist of frame, shutter, infill and finish as detailed below and conforming to IS 277.

Door frame shall be Single rebate profile of size 100 x 57 mm made out of 1.20 mm thick galvanised steel sheet (18 gauge). Frames should be Mitered and field assembled with self tabs. Frames should be provided with back plate bracket and anchor fasteners for installation on a finished plastered masonry wall opening. Once frame installed should be grouted with cement slurry if recommended on the clear masonry opening.

Door leaf should be 46 mm thick fully flush double skin door with or without vision lite. Door leaf shall be manufactured from 0.8mm (22 gauge) minimum thick galvanised steel sheet. The internal construction of the door should be rigid with steel stiffeners/ pads and reinforcement. The infill material shall be resin bonded honeycomb core. All doors should be factory prepped for receiving appropriate hardware and provided with necessary reinforcement for hinges, locks, and door closers. The edges should be interlocked with a bending radius of 1.4mm. For pair of doors astragals has to be provided on the meeting stile for both active and inactive leaf. Vision lite wherever applicable should be as per joinery details with a screw on glass beading on the inside. The glass should be 5 mm clear toughened glass. Louvers when recommended should be site proof and shall be flush fixed on the external surface.

All doors and frames shall be finished with etched primer coating, stove zinc phosphate primer and thermosetting polyurethane aliphatic grade paint of approved colour. The door leaf and frame shall have passed minimum 250 hours of salt spray test.

Rate should include supply and installation of door and hardware.

Approved make	:	Shakti Met Dor, NCLSeccolor, Godrej, Gandhi Automation Pvt Ltd, or similar.
Approved Harrware	:	DORMA, Guardian

b) Hollow metal fire rated doors as per IS 3614 part-1 & part-2 for stability and integrity. Pressed Galvanized steel confirming to IS 277 with the following specification shall be used. Recommended fire door shall have doors tested at CBRI for maximum rating of 2 hrs with vision panel. Test certificates should be available for vision litters /panels as part of the fire door assembly. Independent glass test certificates will not be accepted. Manufacturer test certificate shall cover doors both single and double leaf and all doors supplied should be within the tested specimen, deviation in specification and sheet thickness other than what is mentioned in the test certificates are not allowed. Proper label confirming the type of door and the hourly rating is mandatory.

Door frame shall be double rebate profile of size 143 x 57 mm made out of 1.60 mm (16 gauge) minimum thick galvanized steel sheet. Frames shall be Mitered and field assembled with self tabs. All provision should be mortised, drilled and tapped for receiving appropriate hardware. Rubber door silencers should be provided on the striking jamb. Frames should be provided with back plate bracket and anchor fasteners for installation on a finished plastered masonry wall opening. Once frame installed should be grouted with cement & sand slurry necessary for fire doors on the clear masonry opening.

Door leaf shall be 46 mm thick fully flush double skin door with or without vision lite. Door leaf shall be manufactured from 1.2 mm (18 gauge) minimum thick galvanised steel sheet. The internal construction of the door should be rigid reinforcement pads for receiving appropriate hardware. The infill material shall be resin bonded honeycomb core. All doors shall be factory prepped for receiving appropriate hardware and provided with necessary reinforcement for hinges, locks, and door closers. The edges should be interlocked with a bending radius of 1.4 mm. For pair of doors astragals has to be provided on the meeting stile for both active and inactive leaf. Vision lite wherever applicable should be provided as per manufacturer's recommendation with a beeding and screws from inside. The glass should be 6 mm clear borosilicate fire rated glass of relevant rating of the door.

All doors and frames shall be finished with etched primer coating, stove zinc phosphate primer and thermosetting polyurethane aliphatic grade paint of approved colour. The door leaf and frame shall have passed minimum 250 hours of salt spray test.

Rate should include supply and installation of door and hardware set as mentioned in the door and hardware schedule.

Approved Make	:	Shakti Met Dor, Godrej, Navair, Promat, Gandhi Entrance Automation Pvt Ltd, or equivalent.
Hardware list	:	Hinge, Door closer, Panic Bar with external trim, Mortise lock & latch with lever handle for without panic bar door.
Approved Hardware	:	DORMA, Guardian

c) Main Entrance of Control Room, Control Equipment Room shall be provided with air-locked lobby with provision of double doors of aluminium framework with glazing with sensor operated sliding type for main entrance for main control room, service building, administrative building and double swing type for control equipment room, etc.. Doors of control room, control equipment room, computer room, etc. Shall be full glazed pre-coated minimum 3mm thick aluminium i.e. coloured anodized aluminium. Full glazed aluminium partition with airlock shall be provided along (B) row of Turbine hall operating floor where clear view is desired. Glazing between air-conditioned areas shall be single glass whereas that between air- conditioned and non-air- conditioned area shall be with hermetically sealed insulating glass.

Approved Make	:	Ferrastone/Hardstone of BOSS Profiles Ltd, RESTILE Ceramics Ltd. , Marbonite, Kajaria, Nitco, Endura of H R Jonson, or similar approved. al Systems of HYDRO, Hidalco, DORMA, or equivalent.

d) Doors of W.C. and shower shall be wooden panel door.

e) All windows and ventilators for prestigious buildings like power house, service building canteen, fire station, administrative building etc. Shall be glazed aluminium windows conforming to IS:1949 & IS: 1948.

Approved Make	:	Domal Systems of HYDRO, Hindalco, DORMA or equivalent.

f) Pre-coated (polyester painted) steel windows and ventilators may be used for auxiliary plant buildings.

Approved make : Ncl Altek & Seccolor Ltd.

g) Alternatively steel reinforced UPVC windows may be used for some non plant building if agreed by the owner.

Approved make : "Fenesta" by DSC Ltd.

Approved Hardware for doors shall be of HAFELE, DORMA or similar approved.

11. Rolling Shutters : Rolling shutters as per IS: 6248 with suitable operating arrangement (manual, mechanical and/or electric) according to size shall be provided in buildings to facilitate handling and transportation of equipment. The curtains of rolling shutter will be of interlocking scrolls made of hot rolled double dipped galvanised steel lath section of 18swg tested mild steel strips at 75mm rolling centres, locked with galvanised malleable iron clips. The bottom lath will be coupled to a locked plated fabricated from 3mm thick galvanised steel plate and security riveted with stiffening angles.

Approved Make : DiTEC-Gandhi Entrance Automation Pvt Ltd or similar approved.

12. **Glazing**

a) Glazing for windows in general shall be minimum 6 mm clear float glass and as mentioned elsewhere in this document.

b) Glazing in Control room between A/C & non-A/C area shall be with double glazed insulating glass consisting of 2 nos. 6 mm clear toughened float glass with 12 mm air gap in between, hermetically sealed.

c) Minimum 6.0 mm thick toughened float glass as specified below shall be provided in doors, partitions, windows of Power house building, Service Building, Administrative Building, etc.

d) 24mm thick insulated double glazing having 6mm thick tinted heat-reflecting type outer float glass and 6mm thick plain inner float glass with 12mm air gap & hermetically sealed shall be mounted on 15 micron coloured anodised aluminium frame suitable for structural glazing system. Quality of glass is given below.

e) 6mm thick Glass quality shall be toughened hard coated CVD on line process glass with Low –E coated in surface # 2 having (Light Transmission 82%, Visible light Reflectance- 10% & inside – 11%, Total Solar Energy Transmittance – 66% Reflectance–10% UV transmission – 49%, Solar Heat Gain Coefficient – 0.70 Shading Coefficient – 0.81 ,U – Factor Air 2.77 W/m2k, Sound Insulation – 31db outer lite.

f) 6 mm thick toughened Blue low E hard coated CVD on line process glass with Low –E coated in surface # 2 having (Light Transmission 35%, Reflectance 13%outside & inside – 30 %, Total Solar Energy Transmittance – 19%, Reflection – 9%, UV – 9 %, Solar Heat Gain Coefficient – 0.29 Shading Coefficient – 0.33,U –Factor Air – 1.9 W/m2k, Sound Insulation – 33db outer lite (# 2 surface) Glass with a combination of 6 mm thick toughen Optifloat clear 6mm glass inner lite (# 3 Surface) Now the two sheets of glass will be separated by an aluminium spacer leaving an air gap of 12.7 mm thick and sealed with the weather proof sealant.

Approved make : AIS of Asahi India Glass Ltd., Pilkington Glass India Pvt. Ltd. Saint Gobain or approved equivalent.

13. **Roof waterproofing**

a) Roof water proofing treatment shall be as follows :

i) For roofs with structural slope :

The cleaning and preparation of the substrate to which the elastomeric membrane is applied must be carried out thoroughly to leave a sound base for the application. Any laitance present on the surface must be removed mechanically. Release oil and other contaminants which may impair adhesion must be removed.

Over the finished well prepared sloped surface of RCC slab, application of elastomeric membrane shall be, a single component the liquid, cold applied, elastomeric polyurethane based, that cures by reaction with atmospheric moisture to form a tough but flexible waterproofing membrane. It is elastomeric, seamless waterproof membrane applied in 2 coats to a DFT of 1.2 mm thick having a elongation capacity of over 600% and average tensile strength of 1 MPa, tear resistance as per GBT 19250-2003 >20N/m. The material shall comply with –

ASTM C 836 National Std. of Canada 37.58 – M86 by CGSB. over the entire surface of waterproofing membrane laying a separation layer of non-woven polypropylene geo-textile of 120 gsm followed by application of rigid insulation board expanded polystyrene BASF PERIPOR of BASF or similar approved for thermal insulation as per HVAC requirement shall be laid over the finished separation layer of geotextile. The insulation board shall have interlocking tongue-groove arrangement. The insulation board shall have the following specifications :

- Colour: Orange
- Thickness: 50 mm
- Compressive strength: 200-220 kN/m2
- Thermal Conductivity (K): 0.034 W/mK
- Thermal Transmittance (U): 0.5-0.6 W/m2 oC
- Water Absorption (% vol): <0.1% (by total immersion)

The top surface of the rigid polystyrene block of Peripore of BASF or similar approved shall be finished with pressed precast concrete tiles (size minimum 600 mm x 600 mm) of 20 mm thick on 15 mm thick cement plaster (1:4) which laid over 120 gsm non-woven polypropylene geo-textile separation layer. 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 under bed layer also.

ii) For roofs having no structural slope: The cleaning and preparation of the substrate to which the elastomeric membrane is applied must be carried out thoroughly to leave a sound base for the application. Any laitance present on the surface must be removed mechanically. Release oil and other contaminants which may impair adhesion must be removed.

Over the finished well prepared flat surface of RCC slab, application of elastomeric membrane shall be a single component the liquid, cold applied, elastomeric polyurethane based, that cures by reaction with atmospheric moisture to form a tough but flexible waterproofing membrane. It is elastomeric, seamless waterproof membrane applied in 2 coats to a DFT of 1.2 mm thick having a elongation capacity of over 600% and average tensile strength of 1 MPa, tear resistance as per GBT 19250-2003 >20N/m. The material shall comply with –

ASTM C 836 National Std. of Canada 37.58 – M86 by CGSB. over the entire surface of SONOSHIELD HLM 5000R waterproofing membrane laying a separation layer of non-woven polypropylene geo-textile of 120 gsm followed by application of rigid insulation board expanded polystyrene BASF PERIPOR for thermal insulation as per HVAC

requirement shall be laid over the finished separation layer of geotextile. The insulation board shall have interlocking tongue-groove arrangement. The insulation board shall have the following specifications :

- Colour: Orange
- Thickness: 50 mm
- Compressive strength: 200-220 kN/m2
- Thermal Conductivity (K): 0.034 W/mK
- Thermal Transmittance (U): 0.5-0.6 W/m2 oC
- Water Absorption (% vol): <0.1% (by total immersion)

The top surface of the rigid polystyrene block of Peripore shall be finished with pressed precast concrete tiles (size minimum 600 mm x 600 mm) of 20 mm thick on screed concrete mix (1:2:4) grading having minimum 25 mm thickness at the lowest point of the slope over R.C.C. slab and shall be laid as per the slope laid over 120 gsm non-woven polypropylene geo-textile separation layer. 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 under bed layer also.

iii) For other plant and non Plant buildings rigid insulating board (expanded / extruded polystyrene block) as per HVAC requirement shall be laid over screed concrete mix (1:2:4) grading having minimum 25mm thickness at the lowest point of the slope over R.C.C. slab and shall be laid as per the slope specified elsewhere in the specification. Top surface of rigid insulating board shall be finished with 15mm thick cement plaster (1:4) which shall be laid over Geo-textile membrane layer. Over the finished surface APP Bitumen membrane as specified below shall be laid and top of the Bitumen membrane shall be finished with pressed precast concrete tiles (size minimum 600 mm x 600 mm) of 20 mm thickness on 15 mm thick cement: sand (1:4) mortar underbed. 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.

h) APP modified Bituminous Polyester reinforced waterproofing membrane of Sika® WP Shield-104 P or similar approved shall be manufactured from a rich mixture of bitumen and selected polymers blended together to obtain excellent heat resistant, flexibility, UV resistance. Modified bitumen then coated onto a dimensionally stable carrier to obtain excellent tensile strength, tear and puncture resistance.

i) APP membrane shall conform to Conforms to: UEAtc, ASTM D146, DIN52123, ASTM D36, ASTM D5, UEAtc, ASTMD 5147, ASTM D4799.

j) Technical Data

- Chemical Base APP modified Bituminous Polyester
- Thickness 4mm
- Unit weight 4.40 kg/m2(According to UEAtc)

k) Mechanical / Physical Properties

- Tensile Strength (L/T) N/SCM - 800/600 (According to UEAtc,ASTM D146)
- Elongation at break (L/T) - 40/50 - (According to UEAtc,ASTM D146)
- Resistance to water pressure - No leakage - (According to DIN52123)
- Carrier (Polyster) weight- 180 g/m2
- Softening Point - 145 oC - (According to ASTM D36)
- Penetration - 15-25 at 25oC d mm-(According to ASTM D5)
- Tear resistance (L/T) N-170/180- -(According to UEATc)
- Water Absorption% (BSP)- <0.15-(According to ASTMD 5147)
- Heat Resistance- No Flow at 100oC-
- Resistance to Aging after 2000 hrs (Weather –O-Meter)- No Delamination- (According to ASTM D4799)

l) Concrete, mortar surfaces must be clean, free from grease, oil, and loosely adhering particles. Steel and iron surfaces must be free from scale, rust, grease and oil. All surfaces must be as true as possible.

m) Bituminous primer is to be applied to a clean, smooth and dry surface by brush, roller or spray. The material is to be Unrolled and align and re rolled correctly before torching. Overlaps should be minimum 100 mm. Gas burner is to be used to heat the substrate and thermo fusible film on the underside on lower face of membrane. When the thermo- fusible film melts after torching, the membrane is ready to stick. The membrane should be Rolled forward and press firmly against the substrate to bond. Both the overlaps shall be heated and the round tipped trowel shall be used for heating the same to smoothen and press into seam.

n) All angles and abutments should be sealed with extra care to ensure full bondage. The edges should be sealed well into the grooves.

iv) For Liquid, cold-applied PU elastomeric waterproofing membrane system shall be a single component the liquid, cold applied, of elastomeric polyurethane base, that cures by reaction with atmospheric moisture to form a tough but flexible waterproofing membrane of BASF's SONOSHIELD HLM 5000R or similar approved. It is elastomeric, seamless waterproof membrane applied in 2 coats to a DFT of 1.2 mm thick having a elongation capacity of over 600% and average tensile strength of 1 MPa, tear resistance as per GBT 19250-2003 >20N/m. The material shall comply with – ASTM C 836 National Std. of Canada 37.58 – M86 by CGSB.

Approved make of elastomeric membrane: SIKA India Pvt. Ltd, LLOYD, STP Ltd., BASF, Dr. Fixit or similar approved.

Approved make of APP Bitumen membrane: SIKA or similar approved.

Note : Waterproofing materials should be applied by the manufacturer authorised applicators only.

b) For efficient disposal of rainwater, the run off gradient for the roof shall not be less than 1:100. The top surface of finished roof shall be such as to allow quick drainage of rainwater.

c) The contractor shall give guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specified agency for the roof water proofing treatment work. The guarantee shall be for materials and workmanship for twenty (20) years. The mode of execution of the guarantee shall have to be acceptable to the owner.

d) Heavy duty HDPE pipes conforming to relevant BIS Code shall be provided to drain off rainwater from the roof. The numbers and size of down comers shall be governed by IS: 1742 and IS: 2527.

14. **Painting**

a) External masonry surfaces of all buildings shall be finished with External Quality Acrylic Emulsion paint similar to "Apex Ultima", "Weathergurd" / "Weathershield" over plaster. Granular textured paint may also be combined along with External Quality Emulsion paint to form suitable pattern on building façade.

b) Acrylic plastic emulsion paint of AkzoNobel/Asian Paints/ Berger or any other reputed make approved by TSGENCO shall be provided in control room, control equipment room, computer room, UPS room, all office areas and all air-conditioned areas including entrance lobby.

c) All other areas shall be provided with Acrylic Distemper paint.

d) Internal surface of walls in rooms for pumps, machineries and maintenance shall be painted with washable synthetic enamel paint of dark shade up to a height of 1.5 m above floor level.

e) Battery room and all other areas coming in contact with acid/alkali or other corrosive liquid shall be painted with acid/alkali resistant paint. Acid and Alkali resistant paint shall be applied up to the ceiling level above Acid and Alkali resistant tiles dado as specified elsewhere in this section. Ceiling shall also be painted with Acid & Alkali resistant paint.

f) All structural steel members including doors, windows, ventilators, louvers, rolling shutters and all other exposed steel work shall have two or more coats anti-corrosive paint and shall have minimum 110 micron DFT. Anti corrosive paint shall be Specification in short: Self Priming, Single Pack, Elastomeric (450% elongation), thermoplastic, fire retardant, Coating skin tensile strength 18 to 21 kg. Per sq. Cm. Antifungal, antibacterial, anticorrosive, non toxic graft Co-polymer coating of Meta Chem Paints & Adhesive Pvt. Ltd or similar approved.

g) All woodwork shall be painted with two coats of synthetic enamel paint over a coat of approved primer. DFT shall conform to IS specification.

h) All fire exits shall be painted in Post Office red.

i) Epoxy paint shall be provided in oil equipment room, oil canal, fuel oil pump house, etc.

j) Fire-proof putty in cable penetration on walls of cable spreader rooms shall be provided.

k) Paints shall be of reputed brand of reputed manufacturer like AkzoNobel/Berger/Asian Paints, Nerolac. For granular textured coating Vineratex, Heritage or equivalent shall be used.

15. Aluminium Composite Panels

    1. Material:

       Total thickness of the panel – 4mmThickness of the aluminium skin – 0.5mm, Tensile strength of aluminium skin –120N/mm2 minimum, Density of PE core – 920 – 980 Kg/m3 (Non toxic grade Polyethylene) Coating – PVDF Adhesive film – DUPONT, USA Coating thickness (front foil) – 24µ - 30µ in PVDF including primer.15µ - 18µ in polyester coating. Coating thickness (back foil) – 4µ - 7µ polyester coating.

    2. Colour – as indicated in the drawing.

    3. Fixing arrangement – aluminium composite sheets shall be folded inwardly on four edges (without cutting the outer skin) to from Aluminium Composite Panels (ACP) and shall be riveted to the aluminium extruded section like angel or channel. There shall be at least one rivet at the both ends of the folded edge and other rivets shall be200mm c/c per panel edge/fold. Aluminium angles shall form a frame around the panel and shall be fixed to the steel sub-frame by self tapping screws with EPDM shim to prevent by-metallic reaction. The gap/groove between two adjacent panels shall be filled with Silicon sealant of approved make (GE or similar make) to prevent water seepage.

    4. The supply fabrication and erection of ACP is inclusive of steel sub-base frame work if necessary as per site condition. The contractor shall take site measurement and produce working drawings for approval of engineer before erection of ACP.

    5. Name of system provider- Eurobond, Alu Bond, or similar.

16. Poly Carbonate Sheet:

    1. 4mm thick Compact Polycarbonate sheet, transparent or smoke tinted, of Lexan Polycarbonate or similar approved.

    2. Framing shall be specially designed aluminium sections, colour anodised, with EPDM Gasket as per system provider's details. Framing shall be fixed to the steel structure as per site measurement, drawings and – Engineer in Charge.

    3. Sealing of joints shall be done with Silicon sealant.

       Approved make : BAYER India, GE or similar

a) Shape of the roofing shall be as per drawing and approved by the owner.

b) Name of system provider – McCoy Architectural Systems Pvt. Ltd. / Citadel Architectural Solutions Pvt. Ltd. / or equivalent.

c) System provider shall prepare and submit the detailed working drawing for approval of engineer before erection.

17. **Stairs**

a) All stairs shall have not more than 13 risers in one flight but in case of fire escape stairs, 15 risers may be allowed instead of 13 risers. Height of risers and width of treads shall be180 mm (maximum) and 250 mm (minimum) respectively for fire escape stairs and 166mm (maximum) & 250mm (minimum) for general staircases. Minimum width of stairs shall be1000mm for fire escape stairs and 1200 mm for general stairs. In general rises shall be 150 mm.

b) Aluminium angle nosing shall be provided for edge protection of RCC stairs. Moulded marble nosing shall be provided for the main stairs finished with marble slab / Kota slab finishes.

c) 40ø NB stainless steel pipe handrail for stair in T.G. Hall area and 32ø NB medium class G.I pipe Handrail for stairs in other areas, minimum1.0 metre high, shall be provided around all floor/roof openings, projections/balconies, walkways platforms, concrete and steel stairs.1200mm high railing may be provided for external fire escape stairs. Handrail shall be two rail systems with the top rail 1000mm / 1200mm above the walkway/ platform/ floor surface and the intermediate rail 500mm below the top rail. Guardrail post spacing will be proportional to the length of the protected horizontal opening but will not exceed 1500mm c/c to posts. Stainless steel class shall be 304 grades.

18. Draining out water from floors

In all buildings, suitable floor drainage system to drain out water collected from equipment, blow downs, leakages, floor washings, fire fighting etc. Shall be provided in each floor.

19. **Fencing**

Minimum 3.0 metre high fencing above toe wall shall be provided around switch yard, trans-former yard, building transformer area, fuel oil area, Dry ash storage silo area & other areas where fencing is necessary due to statutory requirements. Fencing shall comprise 2.4 metre high PVC quoted galvanized chain link fencing of minimum 8 gauges (including PVC coating) of mesh size 75 mm and galvanized concertina for switch yard/transformer yard. Galvanized barbed wires of a height of 0.6 metres shall be provided above the chain link fence. The diameter of steel wire for chain link fencing excluding PVC coating shall not be less than 12 gauges. Steel entry gate matching construction shall be provided for all fenced areas. Top of the toe wall shall be minimum 200 mm above the formation level.

20. **Water Supply and Sanitation**

a) RCC roof water tank of adequate capacity depending on the number of users for 8 hours storage shall be provided for each building.

b) Galvanized MS Pipe of medium class shall be used for internal piping work for potable water supply.

c) Extra heavy cast iron pipes with lead joints or UPVC pipes with thermoplastic joints shall be used for sanitary work below ground.

d) UPVC pipes with proper sealing shall be used for sanitary work above ground level.

e) Each toilet shall contain following best quality fittings/porcelain fixtures in adequate numbers as per National Building Code. In toilets primarily meant for workers an additional squatting type WC shall be provided. Minimum one exclusive toilet facilities for handicapped shall be provided in each floor.

- Water closet – Indian & European type.
- Large flat back urinal with porcelain divider.
- Shower set.
- Wash basin – Counter-top wash basin to be provided in office areas selectively as per Owner's desire.
- Sink – Stainless steel sink with integrated drain-board to be provided in janitor's closets, kitchen, pantry areas of "FRANKE" or similar approved make.

- Metal storage cabinets, under- counter as well as overhead, shall be provided in janitor's room, kitchen, pantry and similar areas as per requirement of Owner.
- Minimum 600 mm long porcelain tray.
- Minimum 500 mm long stainless steel towel rail.
- Stainless steel liquid soap holder.
- Recessed porcelain soap tray in shower area.
- Stainless steel toilet paper roll holder.
- Robe hooks
- 450x750 mm high square edge 6 mm thick float glass mirror of adequate width to match toilet layout and interior décor.
- Septic tanks with up-flow filter including all accessories and extra heavy cast iron soil lines shall be provided.
- Effluent from septic tank shall pass through chlorination chamber to bring down BOD level to acceptable limit before discharging to nearest drain or to STP Main line.
- Drinking fountains in adequate numbers.

The exact number of fittings and fixtures, brand, colour etc. shall, however be finalized during detail engineering stage and same shall be of Owner's choice and Approval.

Note Toilets in Power House Operating Floor, Operating floor of service shall have coloured fixtures including counter-top wash basins with wide mirror, European type water closet with flush valve, sensor operated urinal, exclusive shower set etc. Other toilets in general shall have white porcelain fixtures, low down cisterns, sensor operated urinals etc. Toilets for handicapped persons shall have adequate grab bars, barrier-free access and appropriate fittings and fixtures.

Approved Make of toilet fixtures	:	KOHLER, Hindware, Parryware, Nycer, Cera.
Approved make of toilet fittings	:	KOHLER, Jaquar, ESCO, ESS ESS,.

21. **Under-Deck & Over-Deck Insulation**

- Insulation material shall be Closed Cell Elastomeric Nitrile Rubber
- Density of Material shall be between 40 to 60 Kg/m3
- Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/m°K at an average temperature of 0°C
- The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990
- Material should be FM (Factory Mutual), USA approved.
- Water vapour permeability shall not exceed 0.017 Perm inch (2.48×10^{-14} Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor 'μ' value should be minimum 7000.

  Under-deck Insulation thickness shall be minimum 26mm for Kizen Project. Under-deck insulation shall be provided for all AC areas having roof exposed to sun.

Approved manufacturer- Armaflex, Kflex

For thermal over-deck insulation on the terrace BASF's PERIPOR board or similar shall be used. The insulation board shall have interlocking tongue-groove arrangement. The insulation board shall have the following specifications;

Colour: Orange

Thickness: 50 mm

Compressive strength: 200-220 kN/m2

Thermal Conductivity (K): 0.034 W/Mk

Thermal Transmittance (U): 0.5-0.6 W/m2 oC

Water Absorption (% vol): <0.1% (by total immersion)

Actual area covered would be used for measurement.

22. **Sealant**

1. Polysulphide Elastomeric joint sealant shall be, two-component, high performance polysulfide formulation equal or similar to MASTERFLEX 700i of BASF having weathering resistance to ultraviolet ray property. The product shall exhibit shore 'A' hardness of 25 and have movement accommodation factor of 25%. The sealant must comply with the performance specifications as laid in BS:4254 and ASTM C 920. All the joints must be primed using compatible primer for the substrate from the equal or similar to MASTERFLEX PRIMER range of BASF. Sealant application shall be carried out, strictly in accordance with Manufacturer's recommendations.

2. Polyurethane based single component joint sealant materials based upon polyurethane resins shall be similar or equal to Masterflex 472/474 of BASF. They have been formulated with different modulus of elasticity 0.25-0.45 N/mm2 and Shore 'A' hardness of 15-30 which makes them suitable for slightly different applications. The product shall exhibit elongation at break 600 % and recovery of 80%.

3. Bitumen sealing compound shall be conformed to IS:1834. Preformed bitumen impregnated fibre board conforming to IS:1838 shall be used as joint filler.

23. Approved make of other items

a)	Expansion Joint Control	3R Construction Solutions Pvt Ltd or similar
b)	Silicon Sealant	Dow Corning India Pvt. Ltd, McCoy Silicones Ltd. Or similar
c)	Insulation	TWIGA-for glass wool insulation, LLOYD, Mineral Rock Fibers Ltd.- for mineral fibre wool insulation. LLOYD for Rockwool insulation

		For extruded polystyrene foam insulation, "Insuboard" by The Supreme Industries Ltd BASF, TEXA or similar approved. For PU Insulation by BAYER India or similar approved.
	d) Toilet Partition:	Merino-Besco or equivalent.

24. **Statutory rules**

a) Design shall be complied with all applicable statutory rules pertaining to Factories Act as applicable for the State, Rules of Tariff Advisory Committee (TAC), and Water Act for pollution control etc.

b) Provision of safety, health and welfare according to Factories Act shall be complied with. These shall include provision of continuous walkway, minimum 500 mm wide, along the crane girder at crane girder level on both sides, comfortable approach to EOT crane cabin, fire escape, locker room for workmen, pantry, toilets, rest rooms etc.

c) Provision for fireproof doors, number of staircases, fire separation walls, encasing of structural members (in fire prone areas) etc. Shall be made according to the recommendation of Loss Prevention Association of India / Tariff Advisory Committee.

d) Statutory clearance and norms of State Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

ANNEXURE- I
DESCRIPTION OF TG BUILDING

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Interior Finish Schedule For Power house Building							
1.	T.G. Hall Area,	Overall 50mm thick flooring shall be finished with 18 mm thick polished Granite for unloading areas and walkways shall be demarcated with 75 mm wide and 18 mm thick Granite stone (black) on both sides of Granite finished walkways.	Granite tiles/10mm thick high polished decorated coloured background 1st quality digital series dual charged glazed tiles of size not less than 18"x12" shall be provided for inner faces of all four sides walls of operating floor TG hall and columns (by encasing structural steel columns along A-row and both gable ends with brick masonry for 3.0mts height above operating floor) up to bottom of window lintel level or 1.80mts height from operating floor level whichever is high and balance portion of brick wall shall be painted with two coats of plastic emulsion paint over primer and white cement putty. A row and gable end shall have double skin metal cladding system above brick masonry wall. Synthetic enamel paint up to 1.50mts height and acrylic emulsion paint for balance height for all other floors of STG building.	T.G. Hall – anti-corrosive paint to metal deck and all metal works. Acrylic Distemper on exposed plastered ceiling (without false ceiling). Aluminium panel pattern false ceiling for false ceiling areas	Hollow metal flush door in general and 2Hr Fire Check door for fire escape stairs and electrical rooms. Important areas shall have Glazed aluminium door. For main entrance to Main control room shall be sensor operated glazed sliding door.	Aluminium glazed window. Main glazed partition for Main control room shall be insulated double glazed as per specification. A Row shall have structural glazing with low E glass blue tinted toughened glass on outer face and clear toughened float low E glass on inner face as per specification.	
	Switchgear Room, MCC Room,	Electric insulated flexible PVC sheet as per IS: 15625-2006 to be laid over heavy duty IPS flooring. Overall thickness shall be 50mm.	Synthetic enamel paint upto 1.50mts height from floor level and balance portion with plastic emulsion paint over primer and white cement putty.	Acrylic Distemper	Hollow metal flush door / fire door	-Do-	

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Interior Finish Schedule For Power house Building							
2.	Control Rooms, Control Equipment Room, Computer Rooms, etc. Other than Main Control Room.	Non-skid, fully vitrified, 10 mm thick non-porous, homogenous, abrasion resistant, floor tiles similar to "MARBONITE", "FERRASTONE" of "BOSS Profile Ltd", "RESTILE", ENDURA" of H & R Jonson (India) Pvt. Ltd, "Kajaria" of minimum size minimum 600 mm x 600 mm x 9~10 mm of approved colour and shall be laid over concrete floor with laying compound strictly as per manufacturer's specification. Total thickness of the flooring shall be 50mm thick including the thickness of the tiles and under bed.	Vitrified tiles dadoing up to false ceiling level in UCB control room and annexure room shall be provided. Front portion of the UCB control room facade above glass panelling a suitable combination of Aluminium composite panel (ACP)/granular textured paint may be used.Columns, bracings or any other element within the room as the case may be shall be clad with polyester coated 3mm thick Aluminium Composite Panels (Aluminium thickness minimum 0.2mm) of approved make or composite panelling of approved pattern upto the false ceiling level.	Gypsum board plaster false ceiling for control room and annexure rooms. The false ceiling work shall take care of all illumination, fire detection & fighting, HVAC and all other service requirement.	Aluminium glazed double door.	-Do-	
3.	All office areas, Conference Room and other important areas.	10/11 mm thick non-skid fully vitrified dual charged tiles of minimum size 600 mm x 600 mm similar to "MARBONITE", "FERRASTONE" of "BOSS Profile Ltd", "RESTILE", ENDURA" of H & R Jonson (India) Pvt. Ltd, "Kajaria" (overall 40 mm thick) laid in pattern with different colour of tiles.	Acrylic emulsion paint over white cement putty.	Acoustic precoated aluminium alloy panelled ceiling (600x600mm panels) stove enamelled on both sides on pre coated aluminium grid system. Acrylic emulsion paint over white cement putty in areas without false ceiling with necessary lighting arrangements for illumination shall be provided.	Factory made Solid core wooden flush doors with high quality lamination on both sides giving hitech expression in teak wood frame as per owner's choice with floor spring, mortise lock & latch and all accessories.	Aluminium glazed window with minimum 6mm thick clear float glass of specific values as mentioned in the specification with all accessories. Windows shall be partially open able and partially closed type having shutter size not more than 750Wx1500H mm with diamond shape alminimum grill for protection.	
4.	Access floor where required	Minimum 600 mm high false floor with adjustable metal supporting system and fire resistant floor panels finished with antistatic vinyl flooring and matching skirting.	–	–			

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Interior Finish Schedule For Power house Building							
5.	Stairs & Lobby	Kota stone slab in general.	Coloured 6mm thick(min) ceramic tiles up to 1.50mts height and Acrylic emulsion Paint over white cement putty for balance height.	Acrylic Distemper Paint	Hollow metal flush fire door	-Do-	
	Main Stair & Landing	Aranga White marble slab//makarana pink / Jaishalmir Yellow and Baroda green combination 25 mm thick (min.) with larger possible size to be approved by the owner.	Acrylic emulsion paint over white cement putty.	Acrylic emulsion paint over white cement putty.	Aluminium glazed door/ fire door	-Do-	
	Lift lobby	Aranga White marble slab/makarana pink / Jaishalmir yellow and Baroda green combination 25 mm thick (min.) with larger possible size to be approved by the owner.	Granite slab cladding	Aluminium plank panelled pattern false ceiling.	Aluminium glazed door/ fire door	-Do-	
6.	Battery Room & Battery Charger Room, UPS Room	Minimum 20 mm thick acid and alkali resistant vitrified tiles “ENDURA” or similar, set in and jointed with epoxy mortar (overall 40 mm thick)	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height .	Acid/Alkali resistant epoxy paint for balance height.	Hollow metal flush fire door	-Do-	
7.	Chemical Feed Station	Minimum 20 mm thick acid and alkali resistant vitrified tiles “ENDURA” or similar, or Minimum 37mm thick Acid /Alkali resistant brick, set in and jointed with epoxy mortar (overall 40 mm thick) .	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height.	Acid/Alkali resistant epoxy paint for balance height.	Hollow metal flush fire door with chemical resistant paint finish	-Do-	
8.	AHU Rooms, Air Washer Rooms, Cable Spreader Rooms & all other service areas	50 mm thick heavy-duty cement concrete floor with metallic hardener.	Synthetic enamel paint up to 1.50mts height and acrylic emulsion paint for balance height over white cement	Acrylic Distemper Paint	Hollow metal flush fire door. For AHU Room and Air Washer rooms airtight doors are to be provided.	-Do-	

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Interior Finish Schedule For Power house Building							
9.	Toilet and other wet areas	Minimum 10 mm thick non-skid vitrified tile, of make “MARBONITE”, “FERRASTONE” of “BOSS Profile Ltd”, “RESTILE”, ENDURA” of H & R Jonson (India) Pvt. Ltd, of minimum size 400 mm x 400 mm (overall 40 mm thick) with glazed ceramic tile of same make dado topped with 50 mm wide matching moulded ceramic trims. Dado height shall be full height starting from finish floor level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic emulsion paint over white cement putty.	Acrylic emulsion paint over white cement putty. Aluminium false ceiling where required.	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame with PVC lamination on both sides and doors for WCs shallbe PVC door frame & shutter	Aluminium glazed window/ ventilator	
10.	Oil Spillage area	Non-skid self-leveling epoxy over IPS (overall 40 mm thick)	Epoxy paint.	Epoxy paint.	Hollow metal flush door / fire door	-Do-	
11.	Electrical Switchgear Room, MCC Room, etc	Electric insulated flexible PVC sheet as per IS: 15625-2006 to be laid over heavy duty IPS flooring. Overall thickness shall be 40mm.	Synthetic enamel paint up to 1.50mts height and acrylic emulsion paint for balance height over white cement putty.	Acrylic Distemper	Hollow metal flush door / fire door	-Do-	
12.	All other general areas except operating floor	Overall 50 mm thick heavy-duty concrete floor (IPS) with metallic hardener or 40mm thick steelcrete tiles finish.	Synthetic enamel paint up to 1.50mts height and acrylic emulsion paint for balance height over white cement putty.	Acrylic Distemper	Hollow metal flush door / fire door	-Do-	

ANNEXURE - II

DESCRIPTION OF AUXILIARY PLANT BUILDINGS

Interior Finish Schedule For Plant Buildings

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
1.	Mill Building	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Metal cladding	Synthetic enamel paint	Hollow metal flush door / fire door	Steel glazed window / ventilator	
2.	ESP Control Building	10 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern for Control room. Other areas 50mm thick heavy duty IPS flooring with metallic hardener. MCC & Switchgear rooms shall have flexible electric insulated PVC synthetic sheet finish over IPS.	Acrylic emulsion paint over white cement putty for control room and Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint over white cement putty for balance height for Other areas	Pre-coated aluminium panelled (600mmx600mm size) ceiling ‘Luxalon” or “INTERARCH” in air-conditioned areas. Acrylic Distemper paint in other areas.	Hollow metal flush fire door/ Aluminium glazed door	Aluminium window with diamond grill window / ventilator	
3.	CHP Control & MCC Building,	10 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern for Control room. Other areas 50mm thick heavy duty IPS flooring with metallic hardener. MCC & Switchgear rooms shall have flexible electric insulated PVC synthetic sheet finish over 50mm thick heavy duty IPS flooring.	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint over white cement putty for balance height for control room and Other areas	Pre-coated aluminium panelled (600mmx600mm size) ceiling ‘Luxalon” or “INTERARCH” in air-conditioned areas. Acrylic Distemper paint in other areas.	Hollow metal flush fire door/ Aluminium glazed door	- DO -	
4.	AHP Compressor Building	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	- Do -	- Do -	- Do -	- Do -	

Interior Finish Schedule For Plant Buildings

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
5.	Switch yard control building						
	i) Control Room, Offices	10 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern for Control room and offices.	Vitrified tiles dado up to 1.50 m height and Acrylic emulsion paint over white cement putty for balance height for control room and Acrylic emulsion paint over white cement putty for offices for full height	Precoated aluminium panelled (600x600mm size) ceiling ‘Luxalon with insulation on top	Aluminium glazed door with collapsible door at the main entry	Aluminum glazed window / ventilator Windows of yard side shall be suitable sized to view entire yard area fixed with MS grill	
	ii) MCC & Switch gear rooms	50 mm thick heavy duty cement concrete floor with metallic hardener or flexible electric insulated PVC synthetic sheet finish and matching skirting.	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint over white cement putty	Acrylic Distemper paint	Hollow metal flush fire door	Aluminum glazed window / ventilator	
	iii) Other areas	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	-Do-	-Do-	-Do-	-Do-	
	iv) Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 400 mm x 400 mm (overall 40 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic emulsion paint over white cement putty.	Acrylic Distemper paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be PVC door frame & shutter.	-Do-	
	v) Battery Room	Minimum 20 mm thick acid and alkali resistant vitrified tile “ENDURA” or Minimum 37 mm thick Acid /Alkali resistant brick, set in and jointed with epoxy mortar (overall 40 mm thick) along with 2100 mm high dado of same tile having 20 mm thickness.	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height and Acid/Alkali resistant epoxy paint for balance height	Acid/Alkali resistant paint.	Hollow metal flush fire door	-Do-	

Interior Finish Schedule For Plant Buildings

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
6.	Crusher House & TP's	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Metal cladding	Painted exposed structure	Hollow metal flush door / fire door	Steel glazed window / ventilator	
7.	Chemical House	Minimum 20 mm thick acid and alkali resistant vitrified tile "ENDURA"or Minimum 37mm thick Acid /Alkali resistant brick, set in and jointed with epoxy mortar (overall 50 mm thick) along with 2100 mm high dado of same tile having 20mm thickness. Where required, other areas with 50mm thick heavy duty flooring with metallic hardener.	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height and Acid/Alkali resistant epoxy paint for balance height in acid & alkali prone area and rest with Acrylic emulsion paint paint	Chemical resistant paint for acid & alkali resistant area and other areas with Acrylic Distemper paint.	-Do-	Aluminum glazed window / ventilator.	
8.	Raw Water Pump House & Electrical Building	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper	Hollow metal flush door / fire door	Steel glazed window / ventilator	
9.	HFO & LDO Forwarding Pump House	Self-levelling epoxy floor paint on oily areas and heavy duty IPS flooring with hardener in balance areas.	-Do-	Acrylic Distemper Paint	Hollow metal flush door / fire door	-Do-	
10.	CW, ACW Pump House	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	-Do-	Acrylic Distemper Paint	Hollow metal flush door / fire door	-Do-	
11.	DG & Compressor Building/ AHP Compressor Building	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	-Do-	-Do-	-Do-	-Do-	
12.	Misc. Pump Houses/ Fire Water Pump House/ Clarified water pump house	-Do-	-Do-	-Do-	-Do-	-Do-	
13.	HCSD & Silo Utility Pump House	-Do-	-Do-	-Do-	-Do-	-Do-	
14.	Ash Slurry & Ash Water Pump House	-Do-	-Do-	-Do-	-Do-	-Do-	

Interior Finish Schedule For Plant Buildings

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
15.	DM Plant						
	a) Plant area	Minimum 20 mm thick acid and alkali resistant Vitrified tile of "ENDURA" or similar set in and jointed with epoxy mortar (overall 40mm thick).	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height and Acid/Alkali resistant epoxy paint for balance height in acid & alkali prone area and rest with Acrylic emulsion paint	Chemical resistant paint for acid & alkali resistant area.	-Do-	Aluminiuml glazed window / ventilator	
	b) MCC Room	50 mm thick heavy duty cement concrete floor with metallic hardener or flexible electric insulated PVC synthetic sheet finish and matching skirting.	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper Paint	-Do-	-Do-	
	c) Control Room & Offices	10/11 mm thick non-skid fully vitrified tiles of make "MARBONITE", "FERRASTONE" of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern for Control room and offices.	Acrylic emulsion paint over white cement putty.	Gypsum Board / Clacium Silicate Board or tiles false ceiling with insulation on top.	Aluminium glazed door At the Main entrances collapsible door shall also be provided	-Do-	
	d) Laboratories	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 40mm thick) along with 2100mm high dado of same tile.	Acid / Alkali resistant paint in acid & alkali prone area.	Acid / Alkali resistant paint in acid & alkali prone area.	-Do-	-Do-	
	e) Toilet	10 mm thick non-skid fully vitrified tiles of make "MARBONITE", "FERRASTONE" of minimum size 400 mm x 400 mm (overall 40 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be full height	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic emulsion paint over white cement putty.	Acrylic Distemper Paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be PVC door frame & shutter.	-Do-	

Interior Finish Schedule For Plant Buildings

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
16.	Ash Handling Electrical / Control Room						
	a) Electrical Room	50 mm thick heavy duty cement concrete floor with metallic hardener or flexible electric insulated PVC synthetic sheet finish and matching skirting.	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper Paint	-Do-	Steel glazed window / ventilator	
	b) Control Room	10/11 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern for Control room.	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Gypsum Board / Clacium Silicate Board or tiles false ceiling with insulation on top.	Aluminium glazed door At the Main entrances collapsible door shall also be provided	-Do-	
17.	CPU Regeneration Building	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper	Hollow metal flush door / fire door	Steel glazed window / ventilator	
18.	Vacuum Pump House	-Do-	-Do-	-Do-	-Do-	-Do-	
19.	Centrifuge Building	-Do-	-Do-	-Do-	-Do-	-Do-	
20.	CW Chlorination Building	Minimum 20 mm thick acid and alkali resistant vitrified tile “ENDURA”or Minimum 37mm thick Acid /Alkali resistant brick, set in and jointed with epoxy mortar (overall 50 mm thick) along with 2100 mm high dado of same tile having 20mm thickness. Where required, other areas with 50mm thick heavy duty flooring with metallic hardener.	Chemical resistant paint in acid & alkali prone area and rest with Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint over white cement putty for balance height	Chemical resistant paint for acid & alkali resistant area and other areas with Acrylic Distemper paint.	-Do-	Aluminum glazed window / ventilator.	

Interior Finish Schedule For Plant Buildings

	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
21.	CW Chemical Treatment Building	-Do-	-Do-	-Do-	-Do-	-Do-	
22.	Condensate Transfer Pump House	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint for balance height	Acrylic Distemper	Hollow metal flush door / fire door	Steel glazed window / ventilator	
23.	Track Hopper, Wagon Tippler, Under Ground and Over Ground Transfer Points, Pent Houses & Pump Houses	-Do-	-Do-	-Do-	-Do-	-Do-	

ANNEXURE - III
DESCRIPTION OF NON-PLANT BUILDINGS

Interior Finish Schedule For Non Plant Buildings

	BUILDING/AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
1.	Service building						
	a) Entry cum reception lounge, VIP lounge, Main meeting/ conference room	Suitable and approved combination shed of marble slab and strips shall be used	Two coats of Acrylic Emulsion paint of approved colour shall be applied over a coat of approved primer on the masonry surface prepared with white cement putty.	Aluminium panelled (600x600mm size)acoustic false ceiling with glass wool insulation on top similar to LUXALON of Hunter Douglas or “INTERARCH” having approved colour with stove enamel finish, integrated with light fixtures, HVAC grills and other ceiling mounted accessories, complete in all respect with metal suspension system, trims, profiles etc.	Sensor operated Aluminium glazed sliding door at main entry Collapsible door shall also be provided.	Aluminium glazed window At ground floor Aluminimum diamond l Grill @ 20 Kg/sq.m shall be provided	
	b) Other floors/ office area etc.	10/11 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” , “Kajaria” of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern with matching shirting of same make	- Do -	Gypsum board or Acoustic precoated aluminium alloy panelled ceiling (600x600mm panels) stove enamelled on both sides on pre coated aluminium grid system false ceiling of approved make as per specification	Aluminium glazed door/Pressed steel hallow metal door/ Fire door	Aluminium glazed window	
	c) For staircase and Corridors	Steps – risers & tread, stair skirting, corridor floor should be combination of Aranga white marble and Abu green marble. Wall cladding of Elevator Lobby shall be of polished granite slab of light grey shed or colour as approved by the owner.	Two coats of Acrylic Emulsion paint of approved colour shall be applied over a coat of approved primer on the masonry surface prepared with white cement putty.	Acrylic Distemper paint colour super white.	-Do-	-Do-	

Interior Finish Schedule For Non Plant Buildings

	BUILDING/AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	d) Toilet & pantry	Minimum 10 mm thick non-skid vitrified tile, of minimum size 400 mm x 400 mm (overall 40 mm thick) with glazed ceramic tile of same make dado topped with 50 mm wide matching moulded ceramic trims. Dado shall be 100 mm higher than lintel level starting from finish floor level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic emulsion paint over white cement putty.	False ceiling shall be perforated aluminium stove enamel finished panels of size 600x600mm	"Main entry to toilet or wet areas shall be wooden panel door in hard teak wood frame and doors for WCs shall be UPVC door frame & shutter."	-Do-	
	e) AHU room, store Generator room, Electrical room, Etc:	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting.	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper paint	Hollow metal flush fire door	-Do-	
2.	Canteen Building						
	a) Kitchen, Dining hall etc.	10/11 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic tiles. Dado shall be full height for Kitchen and 1500mm. high for other areas. All counter for Kitchen and service areas shall have Polished Granite slab over RCC slab or Kadapa stone	1st quality coloured glazed tiles of minimum 6/7 mm thickness up to 1.20mts height and balance height with Acrylic emulsion paint over primer and white cement putty	Acrylic Distemper paint over white cement putty. Airconditioned areas shall have Acoustic precoated aluminium alloy panelled ceiling (600x600mm panels) stove enamelled on both sides on pre coated aluminium grid system false ceiling of approved make as per specification	Aluminium glazed door	Aluminium glazed window	
	b) Other areas	Kota stone flooring and skirting	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper paint	Solid core flush door	Aluminium glazed window / ventilator	

Interior Finish Schedule For Non Plant Buildings

	BUILDING/AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	c) Toilet & wash areas	10/11 mm thick non-skid fully vitrified tiles of make "MARBONITE", "FERRASTONE" of minimum size 400 mm x 400 mm over IPS floor (overall 40 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic emulsion paint over white cement putty.	Acrylic Distemper paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be PVC door frame & shutter.	Aluminium glazed window / ventilator	
3.	Permanent Store & Inflammable Store Building	50 mm thick heavy-duty cement concrete floor with metallic hardener and matching skirting. For office areas & AC stores vitrified tiles shall be used.	Acrylic emulsion paint with white cement putty for office & AC store areas and Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height for other areas	Acrylic Distemper paint over white cement putty. Offices and Airconditioned areas shall have Acoustic precoated aluminium alloy panelled ceiling (600x600mm panels) stove enamelled on both sides on pre coated aluminium grid system false ceiling of approved make as per specification	Hollow metal flush fire door/ Aluminium glazed door. Rolling shutter wherever necessary	Aluminium glazed window / ventilator	
4.	Main Gate Complex	Overall 40 mm thick Kota stone slab flooring	Acrylic emulsion paint over white cement putty	Acrylic emulsion paint over white cement putty	Hollow metal flush fire door/ Aluminium glazed door	Aluminium glazed window / ventilator	
5.	Weigh Bridge Control room	10/11 mm thick non-skid fully vitrified tiles of make "MARBONITE", "FERRASTONE" of size 600 mm x 600 mm (overall 40 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper paint	Hollow metal flush fire door/ Aluminium glazed door	Aluminium glazed window / ventilator with MS grill	

Interior Finish Schedule For Non Plant Buildings

	BUILDING/AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
6.	Workshop Area & Bull dozer maintenance building						
	a) Workshop area, Bulldozer shed area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with white cement putty for balance height	Acrylic Distemper paint	Hollow metal flush fire door & Rolling shutter wherever necessary	Steel glazed window / ventilator	
	b) stores	-Do-	-Do-	-Do-	-Do-	-Do-	
	c) offices	10 /11mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern for offices.	Acrylic emulsion paint over white cement putty	Moisture resistant Gyp Board or Calcium silicate Board false ceiling with insulation on top.	Aluminium glazed door	Aluminiuml glazed window	
	d) Laboratory	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 40mm thick) along with 2100mm high dado of same tile.	Acid / Alkali resistant paint in acid & alkali prone area.	Acid / Alkali resistant paint in acid & alkali prone area.	Aluminium glazed door	Aluminiuml glazed window	
	e) toilet	Overall 50mm thick Kota stone finish with 25mm thick Kota stone slab and 5 mm thick glazed ceramic tile dado of approved make. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	Acrylic Distemper Paint	Acrylic Distemper Paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be PVC door frame & shutter.	-Do-	

Interior Finish Schedule For Non Plant Buildings

	BUILDING/AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
7.	Fire Station						
	a) Office area, Toilet, Stores, Training room, Kitchen / Dining area, Dormitory,	"10/11 mm thick non-skid fully vitrified tiles of make “MARBONITE”, “FERRASTONE” of minimum size 600 mm x 600 mm (overall 40 mm thick) laid in pattern for office, dormitory area with 150 high matching skirting with 5 mm thick glazed ceramic tile dado of approved make topped with 50 mm wide matching ceramic trims 2200mm. High."	Acrylic emulsion pain	Acrylic emulsion paint	Aluminium glazed door/ hollow metal flush door	Aluminiuml glazed window	
	b) Fire tender parking area and equipment store	50mm thick heavy duty IPS flooring with metallic hardener with matching skirting. or Paving with 65/70 mm thick pressed interlocking precast blocks	Cement paint and for equipment store Acrylic Distemper all be used	Parking area cement paint and for equipment store Acrylic Distemper shall be used.	Aluminium glazed door/ hollow metal flush door for equipment store	Aluminiuml glazed window for equipment store.	
8.	Watch Tower	IPS flooring with Cement Skirting	Acrylic Distemper, Epoxy paint over exposed steel structure.	Acrylic Distemper, Epoxy paint over exposed steel structure.	Hollow metal flush fire door	Steel glazed window / ventilator	
9.	Car & Scooter parking shed and Cycle parking shed	Mimimum 50mm thick coloured and polished interlocking concrete tiles with pattern as approved by the owner, set on sand bed over PCC underbed. Parking near Administrative block shall have vitrified tiles suitable for parking of brand Endura of HR Jonson or similar approved.		Polycarbonate roof sheeting over RCC framed structure.			

ANNEXURE-IV

APPROXIMATE SIZES OF NON-PLANT BUILDINGS

Sl No.	Name of Building	No. Of Stories	Approximate Plan Area
1.	Fire Station Building	Ground floor + one	20.0m X 15.0m (double storey)x 4.0m height of each floor + 18.0m x 15.0m for fire tender parking.
2.	Canteen Building	Ground floor	25m X 30mx4.0m H
3.	Gate House including security office	Ground floor & Ground floor + one for Security office	36m X 12m roof area of gate house and 200sqm per floor shall be security office area. Clear height of gate structure shall be 8.0m
4.	Car Parking	Ground floor	2.5m x 5.0m clear area for each car for a module of 20 cars and 5.m x 12.0m clear for each bus parking area for a module of 3 buses. Height of structure shall be 2.8m clear for car parking and 6.0m clear for bus parking.
5.	Two Wheeler Parking /Cycle shed	Ground floor	20.8m x 7.8m area per shed. For a module of 100 Nos. of two wheelers. Similar module shall be made for cycle parking for 50 Nos. cycles. Clear height shall be 2.80m
6.	Permanent store	Ground floor	3000sqm storage area for Heavy material store, Light material store, Electronic equipment store, AC store + 200sqm for office area. Store area height shall be 10.0m up to bottom of truss and 4.0m clear height for office area.10MT EOT crane to be provided along with access for mobile crane.

Sl No.	Name of Building	No. Of Stories	Approximate Plan Area
7.	Workshop	Ground floor	To be decided during detail engineering stage.
8.	Service Building	Ground + 3 (appx). To be decided during detail engineering stage.	To be decided during detail engineering stage
9.	Bulldozer shed	Ground floor	220Sqm x 8m height
10.	Car parking near administrative building	Ground floor	2.5m x 5.0m clear area for each car for a module of 20 cars having 2.8m clear height of the structure.
11.	Watch tower	+7.0m level from NGL	2.0m x 2.0mx3.0m (H) + 1.0m wide veranda around the room.
12.	Truck weigh bridge control room	Ground floor	6.5m x 3.25mx4.0m (H)
13.	Covered store & semi open store	Ground	50m x 15.0m x 4.5m height up to bottom of truss for covered store. For semi open store refer plot plan.

VOLUME : VII-C

TECHNICAL SPECIFICATION
FOR
CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

CONTENT

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SECTION-XXI	ROLLING STEEL SHUTTERS AND GRILLS
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SECTION-XXIV	FALSE FLOORING
SECTION-XXV	PAINTING, WHITE WASHING AND POLISHING ETC.
SECTION-XXVI	SUSPENDED CEILING
SECTION-XXVII	SHEET WORK IN ROOF AND SIDE WALL
SECTION-XXVIII	ROOF WATER PROOFING, INSULATION AND ALLIED WORK
SECTION-XXIX	WATER SUPPLY
SECTION-XXX	DRAINAGE AND SANITATION

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SECTION-I

TECHNICAL SPECIFICATION
FOR
LAND SURVEY AND ESTABLISHING REFERENCE GRIDS AND BENCH MARK PILLARS

CONTENT

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2.0	GENERAL	VII-C/S-I : 2
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SECTION-I

TECHNICAL SPECIFICATION FOR LAND SURVEY AND ESTABLISHING REFERENCE GRIDS AND BENCH MARK PILLARS

1.0 SCOPE

This specification is intended to cover topographical surveys and preparation of plans (maps) showing all permanent features including buildings, large trees, pucca & kutchha nullas, ditches, (with or without water), nearby roads / approaches, railway track, culverts, overhead transmission & communication lines, ridges, boundary wall, fencing, demarcation line etc. of the project area as well as sectional views of the drains, ditches, creek, culverts and similar items (with all dimensions and invert levels). Carrying of the Bench Mark (existing reference BM outside the project area) to project site by levelling, establishing bench marks and grids in the field, spot level survey at specified intervals and on change points, contouring, constructing and fixing of bench mark pillars & grid pillars in the field, clearing of jungles & debris and cutting of trees (to the minimum extent as required for the work and as per instruction of the Owner) etc. shall also form a part of the scope of work. In addition, the true north, magnetic north and the angle between the grid lines (established at site) and the true north or magnetic north shall be indicated in all drawings.

It may also be necessary to interconnect the existing grid lines (with measured angles and distances) and level references as well as a few permanent buildings and permanent roads adjacent / near the specified project site area during the proposed survey work and thus incorporate the same in the survey plans / maps.

The drawing no 13A06-DWG-M-001 (Plot Plan) gives location of the project and an indication of the project area to be surveyed. These drawings are preliminary and do not cover the entire scope of work. These may be modified, survey area increased / decreased, and any new drawing may be given before award of the Work or during execution of the work (keeping sufficient time for field survey work and plotting).

Permanent features and levels of a few existing items as given in the above drawings shall not be used as reference without verification by actual survey with precision instruments by the contractor and plotted in his maps / drawings accordingly.

The grid pillars and B.M. pillars shall be maintained and checked frequently to ensure the correctness of the value of the pillar till the completion of the job and handing them over to the Owner. It shall be responsibility of the Contractor to check the pillars jointly with Owner / Engineer at the time of final handing over of the work to the Owner.

The tenderers should visit the project site, at his own cost, before quoting rates for this tender. No extra claim (in terms of extension of time or revision in rates, etc.) shall be entertained at a later date on the ground of insufficient knowledge about the site or for lack of clarifications on this specification.

2.0 GENERAL

2.1 Work to be Provided for by the Contractor

2.1 Work to be provided by the Contractor, unless specified otherwise, shall include but not be limited to the following :

a) Furnish necessary instruments and all other tools and materials including pegs, marking plates for reference grid and bench mark pillars, construction materials for pillars, labour & skilled surveyors, supervision by competent engineers, services, necessary transport, full insurance and all other incidental items as may be necessary for on-time and successful completion of the surveying and mapping work.

b) Furnish original field & level books, notes taken on special features and field drawings with readings & relevant features plotted.

c) Preparation, thorough checking & cross checking in the field and submission of completed survey plans / maps and drawings in specified scale incorporating sectional views and details as included under Section - 1.0.

d) Construction and installation of reference grids and bench mark pillars at specified locations.

2.2 Work to be provided for by others

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

2.3 **Information to be Submitted by the Tenderer.**

2.3.1 **With Tender**

The tenderer shall indicate in his tender the number of different surveying instruments (with make and year of manufacture), skilled & experienced surveyors, and competent engineers that will be deployed at the site for this work. His experience during last five years in similar survey work shall be detailed in the tenderer's offer which shall also include his present commitments.

2.3.2 **After Award**

The contractor shall inform and satisfy the Engineer regarding deploymet of personnel engaged by him for quality work under an agreed time-frame for completion of the work under this Contract.

He shall also prepare, discuss with Owner / Engineer and submit an agreed work programme within seven (7) days of award of the Work and during which period he shall also mobilize his instruments, tools, personnel at the project site.

The survey documents shall be submitted to the Owner / Engineer by the Contractor progressively during execution of the Work in order to enable him to review the work and, if necessary, cross-check at site along with Contractor's surveyor and engineer and point out the deficiencies / discrepancies, if any, therein. However, the Contractor shall be still responsible for the correctness of the entire work and shall resurvey and replot any portion of the Work which may be found to be defective later on. During such checking / cross-checking as well as supervision during execution of the entire work, the Contractor shall extend all facilities including proper instruments, tools, other materials, surveyors & labour, etc. to the Owner / Engineer.

The Contractor shall engage qualified engineers, surveyors, drafting persons, etc. for executing the work under this Contract.

3.0 **INSTRUMENTS AND CONSTRUCTION MATERIALS**

3.1 **Instruments**

The entire field surveying shall be done with the combination of transit / optic Theodolites (which can read upto 20 seconds or less), Prismatic Compass, Precision Levelling Instruments with well-graduated & accurate staff, Chain, Measuring Steel Tapes and Plane Table Survey by Clenometer with the help of Clenograph Scale, ranging rods, etc.

Theodolite should be optically centred and the levels should be tilting type. Measuring tapes shall be used with calibrated tension. The calibration charts for the instruments shall be submitted before the start of the Work.

High quality surveying instruments (particularly, theodolites & levels) of reputed manufacturers shall be deployed for accurate and dependable survey work. Electronic instruments, if available with the Contractor, will be preferred.

3.2 Construction Materials for Reference Grid and Bench Mark Pillars

Concrete for pillars shall be of mix 1:2:4 (one cement : two coarse sand : four 20 mm down stone aggregates). All the component materials shall be of best & acceptable quality and conforming to the provisions of the latest version of the Indian Standards.

Steel plates for engraving B.M. value and reference grids shall be of mild steel, conforming to IS : 2062.

4.0 EXECUTION

4.1 Permanent Adjustments

All permanent adjustments of the instruments shall be made before starting the work, to the satisfaction of the Owner / Engineer.

4.2 Contour Intervals and Scale of Drawings

4.2.1 Contour Intervals

For contouring, spot levels shall be taken at 10 m horizontal intervals or less in both directions to establish the contours at 300 mm intervals for nearly flat terrains and at 0.5 m to 1.0 m intervals for undulating hilly terrains, as per schedule of items and direction of the Owner / Engineer.

4.2.2 Scale of Drawings

Depending upon the area to be covered, survey maps shall be prepared in the scale of 1 : 500 or 1 : 1000, as indicated in Schedule of Items, and all permanent features (as indicated under Section - 1.0), grid pillars, bench mark pillars, reference grid and bench mark pillars, contours (as specified in 4.2.1 above) etc. shall be plotted.

Sectional views of the drains, ditches, culverts, roads, etc., however, can be prepared in a scale suitable for furnishing all pertinent dimensions, levels and information, and in a separate drawing sheet.

4.3 **Submission of Drawings and Documents**

The following documents shall submitted to the Owner / Engineer :

4.3.1 Original field and level books and notes taken on special features, plus a photo-copy each of the above documents.

4.3.2 Field drawings with readings and relevant features and sectional views plotted - three (3) copies for review by Owner / Engineer. (One copy will be returned to the Contractor with comments, if any).

4.3.3 Original and one (1) copy of the above field drawings (item 4.3.2 above) after field verification of the comments and incorporating the corrected features.

4.3.4 Original tracing and four (4) prints of the final survey maps and drawings showing other details, all prepared in ink and in clear legible form. Format of and title block on the drawing / map shall be as per direction of Owner / Engineer.

4.4 **Time of Completion**

Time shall be deemed to be the essence of the Contract. The entire survey work including submission of the final survey maps and drawings as well as other documents (ref. : 4.3 above) shall be completed within a period of weeks / months in the following manner :

a)	Mobilisation and firming up time schedule and survey groups...	:	1 week
b)	Completion of field survey work and submission of three (3) copies of the field drawings and a photo-copy of the field & level books and the field notes, etc. (Items 4.3.1 & 4.3.2 above).	:	6 weeks
c)	Submission of the final survey maps & drawings and other documents (item 4.3.1, 4.3.3 & 4.3.4 above).	:	2 weeks

Construction and installation of grid and bench marks pillars, however, are to be subsequently completed within 2 weeks of the clearance from Owner / Engineer.

If the Owner / Engineer feels that the progress of the work is not satisfactory, he shall notify the Contractor to take necessary measures to complete the Work on time. If the Contractor fails to comply with the Owner's directive or fails to complete the Work on time, Owner will be at liberty to get the Work done by any other agency and forfeit the amount related to unfinished works and the Earnest Money / Security Deposit of the Contractor.

4.5 **Security Rules and Statutory Regulations**

The Contractor shall strictly follow at site all security rules and regulations enforced by Owner from time to time regarding movement of materials, equipment / instrument, personnel to and from site, issue of identity cards, badges, control of entry and all similar matters.

The Contractor, his employees and agents shall not disclose any information or drawings prepared by him or furnished to him by the Owner / Engineer.

He shall also follow all safety rules and regulations and shall take sufficient measures to adhere to the same.

The Contractor shall conform in all respects with the provisions of any statute, ordinance law, rules, regulations, by-laws of Central, State, Local or other duly constituted Authority. The Contractor shall give all notices and fees to be given or paid.

In respect of labour, the Contractor shall comply with all rules framed by the Government for the protection of health, wages, welfare and safety of the workers. The Contractor shall be responsible for effective insurance under the Indian Workman's Compensation Act., Third Party Liability Insurance, etc. in accordance with the Indian Law and Regulation at his own cost.

In fine, the Contractor shall keep the Owner and Engineer indemnified against all penalties and liabilities of every kind.

5.0 TECHNICAL SPECIFICATIONS

5.1 Establishing of Bench Marks

At least two permanent bench marks at each site at approved locations shall be established from the existing bench marks. While carrying the bench mark, levels shall be established on permanent objects as directed by the Engineer. Levelling survey shall be done in the forward and reverse direction and the closing error should not be more than $\pm$ 05 mm.

5.2 Establishing of Grid Pillars

Permanent grid pillars shall be established in either direction at every 100 m intervals or as directed. *One reference pillar and one reference grid direction shall be provided by the Owner. For carrying reference pillars, additional station points shall be established for traversing or triangulation as directed by the Engineer. The closing error for any closed traverse shall not exceed the specified limits as per clause 5.6. The maximum tolerance for any grid location shall be $\pm$ 1 mm. Generally for all angular measurements, transit of theodolite shall be done. Measurement shall be verified by cross-checking the diagonal angle as directed by the Engineer. For observing bearing from magnetic north, care should be taken that no magnetic substance to influence the bearing reading is there. The magnetic north should also be periodically verified.

Reference shall be taken from the existing permanent objects identifying from the Cadestal map for establishing the new grid line and shall be related to true north line where grids are not existing.

5.3 Reference Grid Pillars and Bench Marks

All reference grid pillars and permanent bench marks shall be 900 mm x 200 mm x 200 mm cement-concrete pillars with 150 mm projecting above ground. 150 mm square x 12 mm thick steel plates (with two L-shaped 20 cm long M.S. lugs welded to the plate) or 6 mm thick aluminium plates with bolts shall be embedded or bolted on top of the pillars. Grid points & lines shall be accurately punched on the plates as also the numerical values of grid lines and levels. Grid lines and levels as required shall be painted.

5.4 Topographical Surveying and Mapping

Positions, both in plan and elevation, of all natural and artificial features of the area in question (including permanent objects) are to be established and subsequently delineating them on survey maps by means of conventional symbols (preferably those of Survey of India maps). Necessary levelling work of the project area shall be combined with methods of establishing horizontal location so that location and sketching of contours for the area can be done at specified intervals and in specified scales on maps. Rock outcrops, springs / falls (if any) and other unusual ground formations / conditions shall be noted and locations plotted on the maps.

The field work shall be done in the following steps :

a) Establishing horizontal and vertical controls and locating reference grids and bench marks in the area.

b) Levelling and plotting contours.

c) Surveying and locating the natural, artificial and permanent features in details as described earlier.

d) Taking of longitudinal and cross-sections of the corridors for pipe line and road / rail and drains, ditches, water bodies, culverts, etc.

All survey work shall be related with true north and true north shall be established at site beforehand.

5.5 Traversing and Ground Controls

Triangulation or Traversing or a combination of the two methods shall be adopted for the purpose of establishing horizontal controls, in order to determine the exact relationships between various existing points / features on ground, so that surveys required under the present scope of work and in future may be correlated and tied together.

Before commencement of work, the plan showing base lines and the grid lines and their spacings shall be got approved by the Owner / Engineer at site. First, a traverse covering the entire survey area shall be established with reference to a permanent object / reference grid pillar already existing at Site (as instructed by the Owner / Engineer).

The closing error in traverse (primary / secondary) shall not exceed one in three thousand in terms of length or, L $\sqrt{N}$ second (total) in angular measurement, whichever is less. (Where, L = the least count of the instrument and N = the number of stations).

5.6 Contouring

Spot level surveying at specified intervals shall be adopted for contouring the area, so that accurate contouring can be done. At places of sharp curvature or abrupt changes in direction and elevation, points selected shall be close to represent the actual ground configuration.

Levelling operation shall always start on a control station / nearby bench mark and end on the same.

5.7 Route Survey

Route Survey shall be conducted along a narrow strip / belt of the terrain selected after field reconnaissance or as directed by Owner / Engineer at Site. Topographical survey for existing storm drainage lines as well as for routing pipe lines, transportation and communication lines, etc. shall be conducted. Longitudinal profiles as well as cross-sections shall be taken at 50 m intervals or less in nearly flat / undulating terrains and at 20 m intervals in hilly terrains, as per direction of the owner / Engineer. All cross-sections shall be with reference to centre line of corridor showing levels at every 2 - 5 metre intervals and all breaks in the profile. The width of strip / corridor shall be as specified in the drawing or as directed by Owner / Engineer.

6.0 RATES

The rates for the items of land survey and establishing reference grids and bench mark pillars shall include the cost of materials consumed in this work or incidental to it, the cost of instruments, tools and plants, labour, supervision, transport, installation, taxes, insurance, royalties and revenue expenses, security and safety measures, approaches, power, fuel, services, preliminary and enabling works, camps, stores, water, etc. and overheads & profits complete. In case no specific item is provided in the schedule to cover any particular item of work, it is implied that the contractor will include the cost of executing such work in the rates quoted for connected items in the schedule.

7.0 METHOD OF MEASUREMENT

Unless specified otherwise in the schedule of items, the measurement of items shall be done as follows :

7.1.0 Carrying and Establishment of Bench Mark (B.M.)

Carrying of the bench mark from nearby available permanent B.M. to site (at boundary point) shall be measured in running kilometre along the route of survey passing over all kinds of ground conditions which includes levelling, establishing bench marks, complete as per specification. Supply and installation of B.M. pillars shall be measured separately.

7.2.0 Topographic Survey

Areas of topographic survey shall be measured in Hectare which includes surveying and plotting of topographic features, physical features of all objects, areas of shallow water bodies, pucca & kutcha nallas, ditches, nearby roads / approaches, railway tracks, culverts, overhead transmission & communication lines and supports, ridges, etc., levelling and establishing grid lines complete as per specification. Supply and installation of grid pillars shall be measured separately.

7.3.0 Route Survey

Area of route survey shall be measured in Hectare for the specified corridor width of land which includes surveying and plotting of topographic features, physical features of all objects, pucca & kutcha nallas, ditches (with or without water), roads / approaches, railway tracks, overhead transmission & communication lines, and supports, ridges, etc., levelling and establishing grid lines complete as per specification. Supply and installation of grid pillars shall be measured seperately.

7.4.0 Bench Mark Pillars and Grid Pillars

Pillars shall be measured in number as per specification and schedule of items.

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SECTION-II

TECHNICAL SPECIFICATION
FOR
GEO TECHNICAL INVESTIGATION

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SECTION-II

TECHNICAL SPECIFICATION FOR GEO TECHNICAL INVESTIGATION

1.00.00 SCOPE

This specification covers the complete soil exploration work including carrying out field tests and laboratory tests to evaluate static as well as dynamic parameters of soil/rock and preparation of detailed report including the recommendations regarding founding level, type of foundation for different kinds of structures/machines and methods of deep excavation.

2.00.00 GENERAL

The contractor shall perform all work under the purview of this specification along with all incidentals and related work including setting out, staging, approach to test locations, contractor's office, stores and protection of adjacent buildings, structures or services / facilities. No separate payments shall be made on such accounts. The tenderer should therefore take into account all such relevant items while quoting his unit rates against the schedule of items.

2.01.00 Work to be provided for the contractor

The work to be provided by the contractor, unless specified otherwise shall include but not be limited to the following.

a) Furnish necessary plant and equipment, tools and tackles, instruments, necessary power, fuel, water, labour, supervisions by qualified and experienced engineers and supervisors specialised in the type of investigation, transport of materials, men and equipment etc., services, full insurance and all other incidental items as may be necessary for entime and successful completion of the work as per tender terms, drawings, specifications and instruction of the owner / engineer.

b) Locate in the field and in layout drawing all boreholes and other field investigation items.

c) Furnish progressively and periodically field bore logs, investigation observations, test results with relevant data and features in triplicate.

d) Prepare and submit draft (in duplicate) and final (after incorporating comments, if any) sub soil investigation report as per specification, schedule of items and instructions of the owner / his engineer.

2.02.00 **Work to be provided by others**

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

2.03.00 **Location and Levels**

Location of all boreholes and field test points and levels of the existing ground at such locations shall be established by the contractor at his own cost from two reference grids and one bench mark given by the owner/ his engineer and these shall be subsequently plotted in the layout plan, bore logs and other relevant field test data sheets / tables to be incorporated in the report by the contractor.

Making bench mark pillar (s) and reference line pillers (whatever are required for the work) and maintaining them upto the completion of the work shall be the responsibility of the contractor at no extra cost by the owner,

2.04.00 **Codes and Standards**

The following is the general list of IS Codes to be used for the soil investigation work and preparation of report. In all cases latest revision along with amendments, if any, shall be referred to.

IS:1498 - Classification and identification of soils for General Engineering purposes.

IS:1888 - Method of load tests on soils

IS:1892 - Subsurface investigation for foundation

IS:1904 - Structural safety of buildings : shallow foundations

IS:2131 - Method for standard penetration test for soils

IS:2132 - Code of Practice for thin walled tube sampling of soils

IS:2720 - Methods of tests for soils

IS:2809 - Glossary of terms and symbols relating to Soil Engineering.

IS:2810 - Glossary of terms relating to soil dynamics

IS:3025	-	Methods of sampling and testing for water used in industry
IS:3043	-	Code of Practice for earthing
IS:4078	-	Indexing and storage of drill cores
IS:4434	-	Code of Practice for insitu vane shear test for soils
IS:4453	-	Code of Practice for exploration by pits, trenches, drifts and shafts
IS:4464	-	Presentation of drilling information and core description in foundation investigation
IS:4968 (Part-II)	-	Dynamic Cone Penetration Test.
IS:4968 (Part-III)	-	Static Cone Penetration Test.
IS:5249	-	Method of test for determination of dynamic properties of soil.
IS:5313	-	Guide for core drilling observations
IS:5529 (Part I)	-	In situ permeability tests - tests in over-burden
IS:5529 (Part II)	-	In situ permeability tests - tests in bed rock
IS:6403	-	Determination of allowable bearing pressure on shallow foundations.
IS:6926	-	Diamond core drilling for site investigation for river valley projects.
IS:6935	-	Method of determination of water level in boreholes
IS:7746	-	In situ shear test on rock
IS:8009	-	Calculation of settlement of foundations -
(Part-I)		Shallow foundations subjected to symmetrical static vertical loads
(Part-II)		Deep foundations subjected to symmetrical static vertical loading.

IS:8763	-	Guide for undisturbed sampling of sands
IS:8764	-	Method for determination of point load strength index of rocks
IS:9143	-	Method for the determination of unconfined compressive strength of rock materials
IS:9179	-	Method for preparation of rock specimen for laboratory testing
IS:9214	-	Method of determination of modulus of subgrade reaction (k-value) of soils in field
IS:9221	-	Method for determination of modulus of elasticity and poisson's ratio of rock materials in uniaxial compression.
IS:9259	-	Liquid limit apparatus for soils
IS:9640	-	Specification for split spoon sampler
IS:10108	-	Sampling of soils by thin wall samples with stationary piston
IS:10589	-	Equipment for subsurface sounding of soils
IS:10837	-	Specification of moulds for determination of relative density and its accessories
IS:11229	-	Specification for shear box testing of soils
IS:11315 (Part II)	-	Description of discontinuities in rock mass - core recovery and rock quality

3.00.00 SOIL EXPLORATION

3.01.00 Test Boring

Test Boring through different layers of soil shall be carried out by the contractor at the locations marked in the drg. no. and/or at such other locations as directed by the Engineer in a manner described below.

Various methods of boring as described in IS:1892 may be adopted. The tenderer shall furnish in his tender the complete details of the equipment and the method he proposes to follow. Minimum diameter of boring shall be 150 mm.

During the boring operations if rock strata is not encountered, the boring shall be continued upto 30 m depth for two bore holes and upto 20m depth for the remaining boreholes unless stated otherwise. Incase rock strata is encountered within the above depths, boring operations shall be discontinued and drilling operation as enumerated in clause 4.0 below shall be resorted to. If the present formation level is above the natural ground with filled-up soil, the depth of boring mentioned above shall exclude such filled-up soil.

The contractor shall describe in detail the equipment and method of boring he proposes to use. In the absence of dry boring equipment, wash boring at the discretion of the Engineer may be allowed, but the particular way of cleaning the casing by washing has to be approved by the Engineer. However, if the engineer, at any time, feels that the washing process is disturbing the samples to be taken, he may stop the work and the contractor shall have no claim whatsoever on this score. If the contractor can, however, improve the method to the satisfaction of the Engineer, he may be allowed to resume the wash boring work.

When boring cannot be advanced due to presence of hard material, it should be checked whether there is continuous strata of hard material below before resorting to drilling methods. If only a local boulder is present it should be chopped using suitable chopping bits and the detris removed and normal boring continued.

Ground water level for each bore hole shall be checked during boring operation and shall be recorded in bore log. Sub-soil water samples shall also be collected from each borehole and recorded.

Where possible, completed boreholes shall be capped and a G.I. pipe inserted in order to preserve them for future ground water level observation. The contractor shall use his own materials for this and the unit rate quoted shall be inclusive of the same. These bore holes after completion of observation shall

be handed over to the owner in such condition as to enable future observation of ground water possible. The other boreholes not used for observation shall be backfilled by the contractor using sand fill as and when directed by the Engineer.

3.01.00 **Stabilization of Boreholes**

Boreholes shall is stabilized, whenever required, against caving of the sides of the drill hole and heaving of the bottom of the hole. especially in cases where the hole is carried below the ground water level, by use of drive pipe or casing or by means of drilling fluids (water or mixtures of water and colloidal, gel forming thixotropic clays such as betonite), grouting (in rack) or other suitable methods.

3.02.00 **Open Trial Pits**

The location of open trial pits shall be as indicated in approved drawing and/or at such other locations as directed by the Engineer. If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall be upto a depth of 3.5m below natural ground level or not below the ground water table or as directed by the Engineer. In no case, the depth shall be extended over 5m. The size of pits shall be 3.0m x 3.0m or as directed by the Engineer. Samples of undisturbed soil shall be obtained preferably at every 1.5m or where a change in strata is noticed.

The contractor shall provide a suitable access to the bottom of the pits. Sampling in trial pits shall be done as directed by the engineer.

The contractor shall be paid at contract unit price for each trial pit which will include all costs for earthwork in excavation with necessary side slope and backfilling and shoring/ sheeting for side protection, if required. If the pits exceed over 3.5m in depth, the contractor shall be paid at unit price for the extra depths of excavation.

After completion of the test, sampling and visual examination, the pit shall be suitably backfilled as directed by the engineer. Unless otherwise specified, excavated soil shall be used for this purpose.

3.03.00 **Boring in River Bed**

For carrying out boring in river bed, the barge / boat should be properly anchored so that there is no movement of the platform due to waves which can cause damage to the drill rods and casing.

3.04.00 **Rock Drilling**

During boring operation, once rock strata is encountered, the normal method of boring operation as described under clause 3.01.00 earlier shall have to be stopped and drilling operation will be resorted to for determining depth and nature of rock strata, in a manner as described below.

Rotary core drilling technique with continuous core recovery should be adopted for drilling through rock. The tenderer shall indicate in his tender the type of coring bit he proposes to use. The behaviour of rock mass is governed more significantly by the nature of fractures in the rock then by the type and hardness of the material composing the rock itself. Hence, good drilling technique should be adopted to obtain an intact sample truly representative of the in-situ material and for achieving highest percentage of recovery possible. Variations in the speed of rotation, the downward pressure on the core barrel, the pressure at which the drilling fluid is introduced into the hole and the length of hole drilled (run length) prior to removal of the core are major items which must be controlled by the driller. In general, coring should be initiated with short runs both because the upper portions of rock masses are commonly highly fractured and also because the elevations at which core

losses occur can be more accurately determined. If conditions indicate that it is possible, the length of the runs may be determined by the length of the core barrel.

In zones which are highly fractured or where the barrel continuously becomes blocked it is essential that short runs be used even though this means removal of the entire string of drilling tools every 300 mm or less. Reduced bit pressure should be resorted to when rod vibration or chatter occurs. The pressure under which the drilling fluid should be introduced into the hole will be the minimum to be consistent with adequate removal of cuttings from the hole and proper cooling of the bit. To minimise the erosive action of the drilling fluid on the core and thereby to improve core recovery, double tube core barrels should be used. The casing and core barrel to be used shall be of designation BX or NX.

During the drilling operation for each bore-hole the contractor shall record the rate of sinking of drill rods, ground water table elevations, if any, nature, type and sequence of rock drilled. From the recovered cores the contractor shall determine nature of fractures and degree of weathering of rock for each bore hole. The contractor shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each bore hole. The contractor shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stages of core advance and for all the bore-holes. Rock quality designation is defined as the ratio of cumulative lengths of intact pieces of core greater than 10 cm to the length of core advance.

The contractor shall furnish all the information mentioned above fully verified and signed by the Engineer at site and submit them in triplicate to the Engineer.

The drilling operation shall be terminated when more than 75% of the core recovery is possible. If core recovery is lower and the nature of rock is weathered, drilling must be continued upto 30m for two bore holes and 20m for the remaining boreholes below the natural ground level.

In addition to the above mentioned points the contractor shall also take into consideration the provisions of the latest revisions of the following Codes of Practice :

a) IS:6926 - Code of practice for diamond core drilling for site investigation for river valley projects (optional).

b) IS:4078 - Code of Practice for indexing and storage of drill cores.

c) IS:4464 - Code of Practice for presentation of drilling information and core description in foundation investigation.

3.05.00 **Adits and Test shafts**

An exploratory adit is a horizontal or near horizontal excavation made by mining methods in rock . The term "test shaft" is used to refer to a vertical excavation, generally in rock and to very deep test pits . These are used for in- situ examination of the nature of the rock and its structural features such as joints, fractures, faults and shear zones. Adits may also be used for insitu tests to determine the modulus of deformation of rock.

3.06.00 **Sampling**

Bored spoil shall be collected continuously during boring to note any change of strata . Samples of undisturbed soil shall be obtained preferably at every 1.5 m where a change in strata is indicated by the slurry flowing out . In no case shall the depth between successive sampling be more than 3.0 m and a sample shall be obtained on the average for every 2.0 m depth of boring, since it is intended to ascertain the characteristics of the soil at various depths. If, however, there is fair uniformity in the characteristics of the soil for certain depths the engineer may limit the number of samples stipulated above.

3.06.01 **Tube Sampling**

For obtaining undisturbed samples in its simplest from, an open drive thin wall tube sampler shall be attached to a rod and shall be lowered to the bottom after completely cleaning the borehole bottom by washing. The samplers to be used should have area ratio less than 13 percent and preferably less than 10 percent. The head should have check valve and ports to permit easy escape of drilling fluid or air from the sample tube as the sample enters it.

Sampling will be accomplished by jacking or driving the tube depending on the type of soil to be sampled. Upon completion of the sampling operation the sampler shall be withdrawn from the borehole and the sample of soil carefully taken out. Approximately on inch length of soil is to be removed from each end for identification . If there is any surface water on the sample, this shall be wiped off with soaking paper, all sludge of cuttings from advancement of borehole removed and the sample immediately packed in an airtight, close fitting container marked with respective test bore numbers, elevation at which the sample was taken and other relevant information as per IS:1892 . The size of soil test samples shall preferably be 65 mm dia x 200 mm high, but not less than 50 mm dia. x 150 mm high.

Representative / disturbed samples shall also be taken in different strata for visual classification, water content, grain size analysis, Atterberg limits, determination of specific gravity and compaction tests.

3.06.02 **Chunk Samples**

In cohesive soils, undisturbed samples of regular shapes shall be collected. The samples shall be cut and trimmed to a suitable size (0.3 x 0.3 x 0.3 m). A square area (0.35 x 0.35 m) shall be marked at the centre of the levelled surface at the bottom of the pit. Without disturbing the soil inside the marked area, the soil around this marking shall be carefully removed upto a depth of 0.35 m. The four vertical faces of the soil block protruding at the centre shall be trimmed slowly so that its size reduced to 0.3 x 0.3 m. Wax paper cut to suitable size shall be wrapped uniformly and covered with two layers of thin cloth over all the 5 exposed surfaces of the soil block and sealed properly using molten wax. A firmly constructed wooden box of size 0.35m x 0.35m (internal dimensions) with the top and bottom open shall be placed around the soil block and held in such a manner that its top edge protrudes just above the surface of the block. The space between the soil block and the box shall be filled uniformly and tightly with moist saw dust. The top surface shall also be covered with saw dust before nailing the wooden lid to cover the box firmly taking care that the soil block is not disturbed. The area of contact between the bottom portion of the block and the ground shall be reduced slowly by removing soil in small quantities using small rods, so that the block can be separated from the ground slowly without disturbance. After inverting the wooden box along with the soil block, the bottom portion shall be trimmed and covered with wax paper, cloth and sealed with molten wax. A wooden lid shall be nailed to the box after providing proper saw dust cushion below it. An arrow mark shall be made on the vertical face of the wooden box to indicate the top surface along with the coordinates and depth of sampling.

3.06.03 **Sampling in rock**

Sampling in rock shall be accomplished during the drilling process by employing double tube core barrels for continuous core recovery . The drilling procedure to be followed should be the one which brings about the highest percent recovery and the exact procedure must be determined in the field.

3.07.00 **Record of Boring**

Detailed chronological record of drilling and sampling operations shall be maintained in the field log and should be submitted to the owner after completion of boring work at site. The final log showing pertinent subsurface information and results of field and laboratory testing should be submitted with the soil report.

The field log should contain at least the following information :

a) Reference information like project number, title and location, exploration number and location by coordinates, inclination of the boring and if inclined the bearing or azimuth of the dip of the hole, reference level and datum.

b) Personnel information - name of drilling contractor, driller and inspecting engineer.

c) Equipment data - manufacturer's name and model designation.

d) Sampling and coring information :

i) General : Sample type and number, sampler dimension, depth at start and completion of sampling, length of sample, recovery ratio and complete visual description of each sample in "as retrieved" state.

ii) Drive samplers : weight and height of drop of hammer and number of blows for each 150 mm penetration.

iii) Push samplers : hydraulic pressure and rate of penetration.

iv) Soil or rock coring : average rotational speed, down-ward hydraulic pressure and rate of penetration.

v) Rock coring : Rock quality designation (R Q D).

e) Description of material penetrated but not sampled.

f) Casing information - size, depth at which required, length and depth of bottom of casing; weight and height of drop of hammer and number of blows for each 300 mm of penetration for driven casing, and average rotational speed and downward pressure on casing and average rate of penetration for drilled casing.

g) Seepage pressure test information-depth and duration of test.

h) Groundwater information - depth to water surface recorded daily and continued till water level has stabilized.

I) Artesian pressure information - depth at which encountered, measured head and lime at which each measurement is made.

j) Elevation of top and bottom of hole and top of rock

k) Date and time of all operations and delays with reasons.

l) Miscellaneous information to aid interpretation of sub-surface conditions.

m) Additional pertinent information.

The final log shall be a condensation of the field log refined on the basis of field and laboratory tests. The final log should present a clear, concise and accurate picture of subsurface conditions to be utilized by the engineer.

4.00.00 PENETRATION TESTS

Penetration tests using various types of equipment as specified shall be conducted to measure the resistance of soil to penetration.

4.01.00 Standard Penetration Test

Standard penetration test (SPT) shall be carried out in accordance with IS:2131 at every change in strata or at 1.5 m intervals or as directed by the engineer. The contractor shall record the number of blows for each 150 mm penetration of the standard split spoon sampler over a depth of 450 mm. The number of blows for the first 150 mm of penetration shall not be considered in evaluating the penetration resistance. Rammer used for driving the sampler rod shall be 65 kg and drops of 750 mm shall be maintained. Records of the test including depth at which driving is initiated and the number of blows for each 150 mm penetrating shall be shown in the field log, the final log shall indicate the actual SPT value (sum of number of blows for last 300 mm of penetration) at appropriate depths.

4.02.00 Static Cone Penetration Test

The test shall be carried out at locations as shown on the drawing and/or at such other locations as directed by the Engineer. A steel cone with an apex angle of 60 deg. and overall base diameter of 35.7 mm giving a cross-sectional area of 10 Sq.cm shall be pushed through soil strata through a distance in accordance with the design of the equipment and cone resistance is noted. Thereafter the cone and the friction jacket with 36 mm OD are pushed together for a distance depending upon the design of the cone and the friction jacket assembly and combined values of cone and friction resistance noted. The procedure shall be repeated upto the desired depth. Rate of penetration shall be 1 cm/sec. unless otherwise instructed by the Engineer. The test shall be carried out upto a depth of ... m or upto the top of rock layer whichever is earlier.

The driving mechanism shall have a capacity of not less than 10 tonne for the mechanically operated equipment. If approved by the Engineer, manually operated equipment may be used for shallow depths (Not greater than 10 m) in case of soft clay layer.

The contractor shall get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the actual test and produce the test certificates to the Engineer.

The test shall be carried out in accordance with IS:4968 (Part-III), latest edition. Cone resistance and frictional resistance shall be separately provided in the report together with a borehole log.

4.03.00 **Dynamic Cone Penetration Test**

Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity etc. of soils. The test shall be conducted by driving a standard size cone attached to the bottom of a string of drill rods. The test shall be conducted upto the specified depth or terminated earlier if the number of blows exceeds 35 for 100 mm penetration when the cone is driven dry and 20 for 100 mm penetration when the cone is penetrated by circulating bentoite, in order to avoid damage to the equipment.

The specification for the equipment and accessories for performing this test, test procedure , field observations and reporting or results shall conform to IS:4968 Part - II . the driving system shall comprise of a 65 kg . drive mass having a free fall of 0.75m . The cone shall be of 62.5 mm diameter provided with vents for continuous flow of bentonite slurry through the cane and rods in order to avoid friction between the rods and soil. The use of bentonite slurry may not be necessary when the investigation required is upto a depth of 6m only. On completion of the test, the results shall be presented as a continuous record of the number of blows required for every 300 mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300 mm penetration vs. depth.

5.00.00 **GROUND WATER INVESTIGATION**

Groundwater investigation shall comprise determination of groundwater levels and pressures and permeability of subsurface materials. The effect of tidal variations (if applicable for the site) on ground water level shall also be observed by noting the water level in boreholes during high and low tide periods.

5.01.00 **Ground water level observation**

The contractor shall make necessary arrangements to prepare the boreholes for ground water observation . Completed boreholes should be capped and a G.I. pipe inserted in order to preserve them for future ground water observation. These observations will be taken by the contractor during the period of investigation . At the end of the site investigation work , these boreholes shall be handed over to the owner in such a condition that further observations can be taken by the owner for a period of at least a year.

Piezometers will have to be installed in boreholes as directed by the owner . A piezometer consisting of either a simple standpipe of PVC tubing with a slotted end and surrounded by granular filter of plastic fabrics shall be used for granular soils or permeable rocks . In impermeable soils, hydraulic piezometer consisting of a porous element connected by twin small-bore plastic tubing to a remote reading station will be used.

5.02.00 **In-Situ Permeability Test**

In-situ permeability test shall be performed in the ... boreholes specified in drg. no. and/or at such other locations at specified depths as directed by the Engineer for determination of the permeability co-efficient of the soil. The type of test shall be either pump-in or pump-out test depending on the sub-soil and ground water conditions. Pump- in test shall be conducted whether ground water in the borehole exists or not. Pump-out test with piezometer installations shall be conducted to obtain data for dewatering purposes when ground water is met in the borehole.

The specification for the equipment required for the test and the procedure of testing shall be in accordance with IS:5529, Part-I. The contractor shall provide all necessary equipment (diesel operated). When it is required to carry out the permeability test for a particular section of the soil strata above the ground water table, bentonite slurry shall not be used while boring.

5.02.01 **Pump - in Test**

Pump-in test shall be conducted in the borehole/trial pit by allowing water to percolate into the soil. Choice of the method of testing shall depend on the soil permeability and prevailing ground water level. Only clear water shall be used for conducting the test. Before conducting the test, the bore hole shall be cleaned. Water shall be allowed to percolate through the test section for sufficient period of time to saturate the soil before starting the observation.

a) **Constant Head Method (in borehole)**

This test shall be conducted in boreholes where soils have a high permeability. Water shall be allowed into the bore hole through a metering system ensuring gravity flow at constant head so as to maintain a steady water level in the bore hole. A reference mark shall be made at a convenient level which can be easily seen in the casing pipe to note down the fluctuations of water level. The fluctuations shall be counteracted by varying the quantity of water flowing into the bore hole. The elevation of water shall be observed at every 5 minute interval. When three consecutive readings show constant level of water surface above test depth, diameter of casing pipe, etc. shall be noted and recorded as per the proforma recommended in IS : 5529, Part-I, Appendix-A.

b) **Falling Head Method (in borehole)**

This method shall be adopted for soils of low permeability and which can stand without casing. The test section shall be sealed by the bottom of the boreholes and a packer at the top of test section. If the test has to be conducted at an intermediate section of pre-bored hole then, double packers shall be used. Access to the test section through the packer shall be by means of a pipe which shall extend to above the ground level. Water shall be filled into the pipe upto the level marked just below the top of the pipe and water allowed to drain into the test section. The water level in the pipe shall be recorded at regular intervals as mentioned in IS : 5529, Part-I, Appendix-B. The test shall be repeated till constant records of water level are achieved.

c) **Percolation test (in trial pit)**

Percolation test shall be conducted in the trial pit in areas where effluent is stored / discharged in ground level tanks. The loss of water due to percolation into the soil shall be estimated by the soil absorption capacity. This test shall be conducted in trial pits as per the procedure given in IS : 2470-Part-I, Appendix-A.

5.02.02 **Pump - Out Test**

This test shall be adopted to determine accurate values of permeability of soil below water table. Observation pipes of 50 mm dia shall be installed at regular intervals along three radial lines extending from the borehole at 120 degrees to each other. Length of these pipes shall depend on the ground level and estimated lowering of the ground water table. The test shall be carried out by pumping out the water to a known depth and recording the water levels in the observation pipes at regular intervals of time till the water level is stabilized. The observations shall be recorded as specified in IS : 5529, Part-I, Appendix-D.

6.00.00 **FIELD TESTS**

In situ tests shall be performed as desired by the engineer to meassure properties of soil during the field investigation work.

6.01.00 **Menard Pressuremeter test**

This test shall be carried out as per clause 3.7 of IS:1892 in the bore holes as indicated in approved drawing and/or at such other locations as directed by the Engineer to the full depth of bore holes, to assess the co-efficient of earth pressure at rest and the stress-strain modulus of soil. The tests shall be carried out at every 3.0 m intervals.

The tenderer shall furnish in his tender the complete details of the equipment and method he proposes to follow.

The contractor will submit, for approval of the Engineer detailed arrangement drawings for the tests including the detail of the equipment he proposes to use and satisfy the Engineer about its adequacy. The contractor shall also check and confirm whether the equipment he proposes to use will be suitable for carrying out this test in bore holes of size specified under clause 3.01.00 of this section. If not, separate bore holes of suitable diameter shall be made at locations approved by Engineer for conducting this test.

6.02.00 **Direct Load Tests on Soils**

The direct load tests on soil shall be carried out in the trial pits as indicated in approved drawing and/or at such other locations as directed by the Engineer. This test is to be carried out at 2.5m/3.5m below the natural ground level as indicated in the above drawing/as directed by the Engineer. The plate sizes to be used shall depend on the nature of the soil, a 45 cm square plate will be used in clayey soil and in sandy soils; three plates of size varying between 30 cm to 75 cm will be used. The test shall be carried out in a manner as to give dependable assessment of bearing capacities of the soils at particular level. The results of the test shall also be used for arriving at the modulus of sub-grade reaction and deformation modulus of soil.

The tenderer shall furnish in his tender the complete detail of the equipment and method he proposes to follow.

The excavation and side protection during the test and back- filling after the test shall be carried out by the contractor. If ground water table is at a depth higher than the specified test depth, the ground water table shall be lowered and maintained at the test depth for the entire duration of the test. The cost of dewatering shall be borne by the contractor.

The contractor will submit, for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its adequacy in respect of strength and safety and of its being capable of giving accurate data. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The contractor must get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the direct load tests at the site and produce the certificates of the tests to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The contractor shall bring not less than two dial gauges and one pressure gauge as standby.

In no case settlement observations by means of level and staff shall be accepted.

The tests shall be carried out as described in IS:1888 unless otherwise specifically directed. The application of load may be by gravity or by reaction as detailed out in the above standard.

The test plate shall be preloaded with a load of 700 Kg/ sq.m. retained for a reasonable period and then replaced to take out all slacks of the arrangement. All settlement observations shall start thereafter. Unless the ultimate bearing capacity can be calculated from the available soil data, the contractor shall assess ultimate bearing capacity of the soil under test. Increments of the load shall be of about one fifth of the ultimate bearing capacity. The increments shall continue to an extent that allows locating the 'Yield Value of the Soil' as defined in IS:1888 or upto practicable limit of testing.

While releasing the loads, the rebounds are to be observed in a similar manner as the settlement observations.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed programme of the test and shall also be informed prior to start of releasing the load so that the total settlement can be checked by him.

In addition to carrying out plate load tests, undisturbed/disturbed soil samples shall also be collected at regular intervals during excavation.

The payment shall be lumpsum for each test and shall include all costs inclusive of earthwork in excavation upto 3.5m depth below natural ground level, shoring for side protection, if necessary, and back filling after the test. For the depths over 3.5m extra payments shall be made only for earthwork and shoring, if any. If water table is required to be lowered during the test, necessary diesel operated pumping arrangement will have to be provided by the contractor himself. All expenses in this connection shall be included in his quoted rates.

6.03.00 **Vane Shear Tests**

Vane shear test shall be conducted for measuring the strength of soft clay in-situ at all depths from the surface to at least 30m and at locations as specified. The test shall be conducted by pushing into the clay a small four-bladed vane of suitable size (75mm or 100 mm diameter depending upon the soil condition), attached to the end of a rod and then measuring the maximum torque necessary to cause rotation. This torque is a measure of the moment developed by the shear strength of the clay acting over the surface of the cylinder.

The test can be performed at desired depths either inside boreholes or by direct penetration from ground surface. If cuttings at the test depth in the bore hole show any presence of gravel, sand, shells, decomposed wood etc., which are likely to influence the test results, the test at that particular depth may be ommitted with the permission of the engineer.

The specification for the equipment and accessories required for performing this test procedure, field observations and reporting of results shall conform to IS:4434.

6.04.00 **Determination of Dry-Density of Soils**

In place dry density of soil is required for assessment of bearing capacity of soils analysis for stability of natural slopes and in settlement calculations for estimating overburden pressure at different depths. The following methods depending on the scope of application in different types of soils shall be adopted as directed by the engineer for determination of in-place dry density of soils.

6.04.01 **Sand Replacement Method**

This method is suitable for fine, medium and coarse grained soils. Small sand pouring cylinder should be used when the soil consists of fine to medium size grains while for soils containing stones where difficulties would be encountered with this method, a large sand pouring cylinder should be used. The sand used for filling shall be clean, uniformly graded natural sand; passing 1.00 mm IS sieve and retained on 600 micron IS sieve. It shall be free from organic matter, oven dired and stored for suitable period to allow its water content to reach equilibrium with atmospheric humidity.

Equipment and accessories, test procedure, observations and reporting of results shall conform to IS:2720 (Part XXVIII)

6.04.02 **Core-cutter Method**

The specification for this test shall be as per IS:2720 (Part XXIX). The method should be applied for fine grained soil, free from aggregates. Fine grained soils for the purpose of application of this method is defined as soil with not less than 90 percent passing 4.75 mm IS sieve.

6.04.03 **Ring and Water Replacement Method**

The specification for equipment, test procedure, observation and reporting of results for this test shall conform to IS:2720 (Part XXXIII). The test equipment shall consist of a circular ring placed at the surface of the ground and plastic film inserted in the hole to retain the water. The method should be applied in coarse grained soils including gravels, cobbles, boulders and rock. Density can be determined for either the total material or material smaller than specified or given size.

6.04.04 **Rubber balloon Method**

The equipment, testing method, observations and reporting of results shall be as per IS:2720 (Part XXXIV) . This method should be applied for firmly bonded soils, it is unsuitable for very soft soils which will deform under slight pressure or in which the volume of the hole cannot be maintained at a constant value.

6.05.00 **In-situ Block Shear / Wedge Shear Test**

The test shall be carried out in a manner as to give a dependable assessment of shear resistance of rock, when at a shallow depth, rock is encountered.

The tenderer shall furnish in his tender the complete detail of the equipment and the method he proposes to follow.

The test shall be carried out in the trial pits as indicated in approved drawing and/or at such other locations as directed by the Engineer. The interpretation of test data and report shall be as per the provisions of IS:7746. The set up without an arrangement for direct application of normal load as detailed in the above standard shall be followed.

Regarding the approval of detailed arrangement drawings for the test, adequacy of conducted test, dial gauges to be used for the test and recording of observations for the test the provisions as laid down for direct load tests on soils shall hold good.

The payment terms as indicated for clause 3.02.00 above shall hold good for this test.

6.06.00 **Test for Measurement of soil Resistivity**

For designing the earthing system for the project it is necessary to find out the electric resistivity of the soil at some representative locations of the project site.

Soil resistivity is determined in Ohmmeter by using "WENNER's FOUR ELECTRODE METHOD" . The principle of the above method is generally as under :

Four electrodes are driven into the earth along a straight line at equal intervals of 'S'. This distance 'S' can be varied and different readings taken for electrode spacing S = 5, 10, 15, 20 metres etc. to detect the vertical variations of resistivity at a certain location . A current I is passed through the two outer electrodes and the earth. The voltage difference, V, between the two inner electrodes is measured. The current I flowing into the earth produces an electric field proportional to its density and to the resistivity of the soil. The voltage V measured between the inner electrodes is, therefore , proportional to this field . Consequently , the resistivity will be proportional to the ratio of voltage to current.

If the depth of burial of electrodes in the ground is negligible compared to the spacing between the electrodes , then the soil resisvity.

= 2 X 3.14 X S.V / I

Where , Resistivity of soil in Ohm-meter

S = Spacing between electrodes in metre

V = Voltage difference between two inner electrodes in volts.

= Current flowing through two outer electrodes in amp.

Earth testers normally used for the above purpose comprise the current source and meters in a single instrument and directly read the resistance. Such an instrument is known as four terminal meggar . Using such meggar for measurement , above formula becomes

= 2 X 3.14 X S.R.

where R is meggar reading in Ohms.

Depth of burial of electrodes shall not be more than 1/20 or the spacing between the electrodes.

Correction of the test results should be done, if necessary, using the method outlined in IS:3043.

The location and number of the test points are shown in the plant layout . The number shall be increased if the test results obtained in different locations show a significant difference .

7.00.00 TESTS FOR DYNAMIC PROPERTIES

For evaluation of in-situ dynamic and damping properties of soils, Block Vibration Test, Cyclic Plate Load Test and Wave Propagation Test shall be conducted. The triaxial test method using repeated static loading should also be carried out for arriving at the value of the Young's Modulus.

The Tenderer shall furnish in his tender the complete details of the equipment and method of testing he proposes to follow.

The locations at which such tests are to be carried out shall be as indicated in approved drawing and/or at such locations as directed by the Engineer.If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall exclude such filled-up soil.

The tests shall be carried out as described in IS:5249 or IS:1888 as applicable. The contractor will submit, for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its adequacy in respect of strength and safety and of it being capable of giving accurate data. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed programme of the test and shall also be informed prior to the start of releasing the load so that the total settlement can be checked by him.

The payment shall be lumpsum for each test and shall include all costs inclusive of earthwork in excavation, shoring for side protection (if necessary) construction/curing of plain concrete test block, supply and embedment of foundation bolts etc. and backfilling after the test.

7.01.00 **Block Vibration Test**

Test pits of size 4.5m x 2.75m at the bottom shall have to be made. Then at the bottom of the pit a Plain Cement Concrete block of grade M15 and of size 1.5m x 0.75m x 0.70m shall be constructed. Suitable foundation bolts shall be embedded in the concrete block during casting for fixing the oscillator assembly. The concrete block shall be cured for a minimum of fifteen days and then the following Block Forced/Free vibration Test shall be carried out as per the recommendations of IS:5249 :

a) Vertical Vibration Test

b) Longitudinal Horizontal Vibration Test

c) Free Vertical Vibration Test

d) Horizontal Free Vibration Test.

7.02.00 **Wave Propagation Test**

The wave propagation test for determination of shear modulus shall be conducted both by exciting the block to steady state vibrations in the vertical direction and by making seismic waves to pass through the ground by impact of hammer and determining the time of travel of these waves between two points at a known distance apart.

7.03.00 **Cyclic Plate Load Test**

The test shall be carried out in a manner as to give a dependable assessment of load-deformation characteristics within the soil mass.

The provisions of IS:1888 shall be followed for conducting the test. The application of load may be by gravity or by reaction as detailed out in the above Standard.

The contractor must get the dial gauges and pressure gauges calibrated by an approved testing laboratory before commencing the test at site and produce the certificates of the test to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The contractor shall bring not less than two dial gauges and one pressure gauge as standby.

The contractor shall provide a layer of cement-sand mortar (1:1 mix) below the bearing plate to level-off any uneven parts and interstices on the rock surface. Also to achieve a uniform distribution of pressure over the loaded surface, the contractor shall provide a flexible layer in the form of rubber pad over the loaded surface.

For conducting the load test the contractor shall apply cyclic loading and unloading, with four or five cycles, increasing in successive of 20% to 25% of full load. While releasing the loads the rebounds to be observed in a similar manner as the settlement observations. The range of cyclic loading shall be decided only after the static net bearing capacity is established by conventional plate load tests.

8.00.00 **FIELD DETERMINATION OF CALIFORNIA BEARING RATIO**

The test shall be carried out at locations as shown on the drawing or at locations as directed by the Engineer. The test shall be carried out at a depth of 500 mm below the finished ground level.

The contractor shall submit, for approval of the Engineer complete detail of the equipment and the method he proposes to use. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The surface area to be tested shall be exposed, cleaned of all loose and dried material, levelled and then soaked till saturation with a surcharge weight of 15 kg. After soaking is complete, the test surface shall be drained of all free water and allowed to stand for at least 15 minutes before starting further operations.

The test shall be carried out strictly in accordance with the provisions as laid down is IS:2720 (Part XXXI) latest edition. Surcharge weights of 15 kg including that of the annular weight of 5 kg shall be applied before application of load on the penetration piston. Load shall be applied on the penetration piston such that the penetration is approximately 1.25 mm/min. The load readings shall be recorded at penetrations of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The maximum load and penetration shall be recorded if it occurs for a penetration of less than 12.5 mm.

After completion of the test, a sample of soil shall be taken from the point of penetration for moisture content determination. In place density shall also be determined.

From the plot of load penetration curve, after necessary correction, the bearing ratios shall be calculated for penetrations of 2.5 mm and 5 mm. If the bearing ratio at 2.5 mm penetration is greater than that at 5 mm penetration the former shall be taken as the bearing ratio. If bearing ratio at 2.5 mm penetration is less than that at 5 mm penetration, the test shall be repeated and if the ratio at 5 mm penetration is consistently greater than that at 2.5 mm penetration, the ratio at 5 mm penetration shall be taken.

9.00.00 LABORATORY TESTS ON SOIL SAMPLES/ROCK CORES

The contractor shall carry out the tests as listed out in the Schedule of Items, and/or as decided by the Engineer, in laboratory. He shall furnish the name/s of laboratories where he proposes to have the tests carried out and have them approved by the Engineer.

The owner shall have the right of access to contractor's laboratory and/or any other laboratory where tests have been arranged to be carried out during the progress of this investigation.

Adequate volume of test samples of soil/rock cores shall have to be collected from site and stored, labelled and transported carefully to the approved laboratory for carrying out the tests. The method and procedure of testing to be followed shall be as per the relevant Indian Standard Codes of Practice. The results of the tests shall be submitted to the Engineer in sextuplicate duly signed by the laboratory- in-charge. In tests for rock cores L/D = 1.0 of samples must be maintained.

10.00.00 REPORT ON SUB-SOIL INVESTIGATION

10.01.00 General

a) On completion of all the field and laboratory work, the contractor shall submit a formal report containing geological information of the region, procedure adopted for investigation, field observations, summarised test data, conclusion and recommendations. The report shall include detailed borelogs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculation for the conclusions drawn etc. Initially, the contractor shall submit five copies of the report in draft form for the owner's review.

b) The contractor's qualified geotechnical engineer shall visit the owner's corporate office for a detailed discussion on the owner's comments on his draft report. During the discussions, it shall be decided as to the modifications that need to be done in the draft report. Thereafter the contractor shall incorporate in his report the agreed modifications and after getting the amended draft report approved, five copies of the detailed final report shall be submitted along with one set of reproducibles of the graphs, tables, etc.

c) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different type of structures envisaged in the area under investigations. The contractor shall acquaint himself about the type of structures, foundations loads and other information required from the Engineer.

10.02.00 Data to be furnished

The report shall include the enlisted items but not be limited to them.

a) Purpose and scope of investigation

b) Authorization enabling the contractor to carry out the work at the site.

c) Project description including proposed facilities and construction materials required for the works.

d) Desciption of the site which shall include :

i) Location of the site and existing facilities.

ii) Topography of the site

iii) Drainage Characteristics

e) A plot plan showing the locations and reduced levels of all field tests e.g., boreholes, trial pits, static cone penetration tests, dynamic cone penetration tests, plate load tests etc., properly drawn to scale and dimensioned with reference to the established grid lines.

f) A true cross section of all individual bore holes and trial pits with reduced levels and coordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted and samples collected at different depths and the rock stratum, if met with.

g) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how soil/rock strata is varying vertically and horizontally.

h) **Geological information**

i) Regional geology - geologic province, topographic position of site, processes of formation of subsurface materials at site.

ii) Description of overburden and bedrock at the site (if applicable for the site)

iii) Comments on texture and structure of rock, joints, bedding planes, fissures, weathering condition etc (of applicable for the site)

iv) Effect of geologic features on design.

i) Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.

j) Bore hole & trial pit logs on standard proforma showing the depths, extent of various soil strata etc.

k) Plot of SPT (N) value (both uncorrected and corrected) with depth.

l) Procedure of investigations employed - field tests and laboratory investigation.

m) Results of all laboratory test summarised (i) for each sample as well as (ii) for each layer along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores.

n) For all triaxial shear tests stress vs. strain diagrams as well as Mohr's circle envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elastricity E shall be furnished for all tests along with relevant calculations.

o) For all consolidation tests, the following curves shall be furnished :

e vs. log p
e vs. p and
compression vs. log t or

Compression vs. square root of t (depending upon the shape of the plot for proper determination of co-efficient of consolidation).

The point showing the initial conditions (e, P) of the soil shall be marked on the curves.

p) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.

q) For pressure meter tests, the following curves shall be furnished :

Field pressure meter, creep and air calibration curves indicating Po, Pf and P1.

Corrected pressure meter and creep curves indicating P'o, P'f & P'1.

r) From the pressure meter test results the value of cohesion, angle of internal friction, pressure meter modulus, shear modulus and coefficient of subgrade reaction shall be furnished along with sample calculation. Calculation for allowable bearing pressures and corresponding total settlements, for shallow foundations mentioned below and capacity calculation of piles in various modes shall also be included.

10.03.00 **Recommendations**

Recommendations shall be given areawise duly considering the type of soil, structure and foundation in the area. The recommendations shall include but not be limited to the following :

a) Type of foundations to be adopted for various structures, duly considering the sub soil characteristics, water table, total settlements permissible for structures and equipment. Minimum depth and width of foundation shall also be recommended. The provision in relevant IS codes indicated in clause 2.04.00 shall be considered.

b) For shallow foundations, the following shall be indicated with comprehensive supporting calculations :

i) Net safe allowable bearing pressure for isolated square and continuous strip footings of different sizes at different founding depths below ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculation.

ii) Net safe allowable bearing pressure for mat foundations at different founding depths below ground level considering both shear failure and settlement criteria.

iii) Rate and magnitude of settlement expected of the structure.

iv) Modulus of subgrade reaction, modulus of elasticity, deformation modulus from plate load test results alongwith time-settlement and load-settlement curves for the various footing sizes at different founding levels indicated above. The recommended values shall include the effect of size, shape and depth of foundation.

c) If piling is envisaged, the following shall be indicated with comprehensive supporting calculations :

i) Type of pile and reasons for recommending the same considering soil characteristics.

ii) Suitable founding strata for pile.

iii) Estimated length and diameter of pile for various values of pile capacities. End bearing and frictional resistance shall be indicated separately.

iv) Magnitude of negative skin friction, if any, to be considered in pile design.

d) Recommendations on foundations for special structures like tanks, transformers, sub-station structures, conveyor trestles, silo/stack like structures, etc.

e) Recommendations regarding bases of roads and pavements.

10.04.00 **Additional Recommendations**

a) Co-efficient of permeability of various sub soil and rock strata based on in-situ permeability tests.

b) Cone resistance, frictional resistance, total resistance, relation between cone resistance and SPT(N) value and settlement analysis for different footing sizes based on CPT/SPT.

c) Electricity resistivity of sub-soil based on electrical resistivity tests including electrode spacing vs cumulative resistivity curve.

d) Evaluation of design parameters for design and analysis based on dynamic parameters of soil like Amplitude vs. Frequency curves, co-efficient of elastic uniform compression and elastic uniform shear of soil, co-efficient of elastic non-uniform compression, co-efficient of elastic non-uniform shear, value of damping co-efficient, elastic and shear modulus of soil and Poisson's ratio of soils.

e) Co-efficient of earth pressure at rest and stress strain modulus of soil from Menard pressuremeter test.

f) Recommendations regarding earth pressure as a function of depth below grade as applied to side walls of underground structures. Values of co-efficient of permeability shall be included in the report.

g) Recommendations regarding method and slope of deep excavations.

h) Recommendations regarding stability of slopes, during excavations, etc.

i) Potential of rock slides and methods of stabilisation of slides for very steep cut.

j) If expansive soil is met with recommendation on removal or retainment of the same under the structures/roads etc. shall be given. In the latter case detailed specification of any special treatment required including specification for materials to be used, construction method, equipment to be deployed etc. shall be furnished.

k) Susceptibility of sub soil strata to liquefaction in the event of earthquake and recommendation on remedial measures, if necessary.

l) Information of special significance like dewatering schemes etc. which may have a bearing on design and construction.

m) Aggressiveness of percolating water through sub-soil/ rock fissures to reinforced concrete foundation/sub- structures and also recommended protective measures, if required.

n) Recommendation for the type of cement to be used and any treatment to the underground concrete structures based on the chemical composition of soil and sub-soil water.

o) Recommendation on suitability of the overburden soil as material of construction of earthen embankments and in back filling of excavated pits / trenches.

p) Recommendation on the use of rock available as construction material.

q) Recommendation on the availability of material for use as aggregates at the site.

r) Recommendation for additional investigation beyond the scope of the present work if the contractor considers it necessary.

s) **Plates**

I) General plan showing location of site, and areal geology.

ii) Plan showing existing features, proposed facilities, contours and locations of boring and other investigations.

iii) Geologic sections and soil profiles.

t) **Appendices**

i) Logs of subsurface explorations

ii) Field test results

iii) Laboratory test results

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SECTION-III

TECHNICAL SPECIFICATION FOR AREA GRADING

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SECTION-III

TECHNICAL SPECIFICATION FOR AREA GRADING

1.0.0 **SCOPE**

This specification shall govern all clearing, grubbing, excavating, area filling, grading and compacting soils for areas designated on the drawings. The work shall include excavation, hauling, dumping and spreading of soil, undercutting to remove unstable soil areas, compacting existing soil surfaces and bottom of excavated areas to receive fills, compacting excavated areas for subgrade, placing and compacting soils in fills, pumping to keep excavated areas dry, final grading of designated areas, disposing off unsuitable and excess excavated materials and incidentals thereof.

2.0.0 **GENERAL**

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless specified otherwise, shall include but not be limited to the following :

a) Furnish all labour, supervision, services, earth-moving machineries and equipment, tools and plants, survey instruments, transportation etc. required for the work.

b) Prepare and submit working drawings showing the approaches, slopes, berms, sumps for dewatering, space for temporary stacking of spoils, disposal area, borrow pits, fencing etc. and all other details as may be required by the Engineer.

c) To carry out and submit to the Engineer, results of soil compaction tests whenever required by the Engineer to assess the degree of compaction.

d) If blasting is resorted to, necessary licenses to be procured from the proper authorities.

2.2.0 **Work to be provided for by others**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

However, the Owner reserves the right to award the whole work to one Contractor or to split up the work for awarding to two or more Contractors.

2.3.0 **Codes and Standards**

All work under this specification, unless specified otherwise, shall conform to the latest revision and/or replacements of the following or any other relevant Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not covered specifically by Indian Standard Specification any other standard practice as may be specified by the Engineer shall be followed :

IS : 3764	:	Indian Standard for Safety Code for Excavation Work.
IS : 1200	:	Indian Standard Method of Measurement of Building (Part-I)and Civil Engineering Work Part-I - Earthwork.
IS : 4701	:	Indian Standard Code of Practice for Earthwork on Canals.
IS : 4081	:	Safety Code for Blasting and Related Drilling Operations.

2.4.0 **Conformity with Designs**

The Contractor shall carry out the work as per the drawings issued to him and/or Contractor's drawings which are approved by the Engineer and/or the Engineer's instructions.

2.5.0 **Materials to be used**

2.5.1 **General**

All materials required for the work shall be of best commercial variety and as approved by the Engineer.

2.5.2 **Borrow Material**

Borrow material required for area filling shall be excavated from approved locations and levels and shall consist of selected material, approved by the Engineer, free from roots, vegetations, decayed organic matter, harmful salts and chemicals, free from lumps and clods. If specified, clean graded sand, free from harmful and deleterious materials from approved quarries, shall be used as fill material.

2.6.0 **Quality Control**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. The quality control operation shall include but not be limited to the following items of work :

a) Lines, Levels and Grades :

i) Periodic Surveys

ii) Establishment of markers, Boards etc.

iii) Checking levels and slopes of the graded surface.

b) Area filling :

i) Checking the quality of fill material

ii) Checking moisture content of the fill

iii) Checking the degree of compaction.

2.7.0 **Information regarding Site Conditions**

Boring and sub-surface data regarding the nature of soil, rock, sub-soil water etc. shown on drawings or otherwise furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the Contract. The Contractor must satisfy himself regarding the character and volume of all work under this contract and expected surface, sub-surface and/or sub-soil water to be encountered. He must also satisfy himself about the general conditions of site and ascertain the existing and future construction likely to come up during the execution of the Contract so that he may evolve a realistic programme of execution.

3.0.0 EXECUTION

3.1.0 Setting Out

Within 15 days of award of Contract, the Contractor will prepare and submit to the Engineer, detailed drawings of the excavation and filling work necessary, as proposed to be executed by him, showing the dimensions as per drawings and specification, adding his proposals for slopes, approaches, dewatering sumps, berms etc. On receiving the approval from the Engineer with modifications and corrections if necessary, the Contractor will set out the work from the control points furnished by the Engineer and fix permanent points and markers for future checking. These permanent points and markers will be checked by the Engineer and certified by him after which the Contractor will proceed with the work. Engineer shall be provided with necessary men, material and instruments for such checking. It should be noted that this checking by the Engineer prior to start of the work will in no way absolve the Contractor of his responsibility of carrying out the work to true lines, levels and grades as per drawing and subsequent corrections, if any. In case any errors are noticed in the Contractor's work at any stage, the same shall be remedied by the Contractor at his own cost.

3.2.0 Initial Levels

Initial levels either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross-sections for volume measurement or for cross-checking the depths obtained from tape measurements.

3.3.0 Clearing and Grubbing etc.

The area to be excavated shall be cleared out of fences, trees, logs, stumps, bush vegetation, rubbish, slush, etc. and levelled up. Trees upto 300 mm girth shall be uprooted. Trees above 300mm girth which are required to be cut, shall be got identified by the Engineer and then marked.

Felling of trees shall include taking out roots upto 600 mm below ground level. After the tree is cut and roots taken out, the pot- holes formed shall be filled with good earth in 250 mm layers and compacted to acceptable degree unless directed by the Engineer otherwise. The trees shall be cut in suitable pieces as instructed by the Engineer and then shall be transported to the Owner's store or any other space as directed by the Engineer.

Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be Ash shall be spread or removed as directed by the Engineer. Useful materials, saleable timber, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Engineer.

3.4.0 **Classification**

Materials involved in earthwork shall be classified under the following categories. No distinction will be made whether the material is dry or wet. The Engineer's decision in regard to such classification shall be final and binding on the Contractor :

a) **Ordinary and hard soil**

This shall include clay, silt, sand, moorum, shingle, kankar, gravel, loam, peat, ash and other similar materials in soft, hard or dense state which can generally be excavated with ordinary spade, pick axe, shovel etc. and does not require the use of wedges, pneumatic breaking equipment and/or blasting for removal. It shall also include loose rock boulders present in the soil, with dimensions not exceeding 500 mm in any direction. Breaking of consolidated brick ballast and mud concrete shall be considered equivalent to excavation work under this type of soil.

b) **Soft and Decomposed Rock**

This shall include rocks like chalk, slate, mica schist, laterite and other similar materials which in the opinion of the Engineer is rock, but does not require blasting for removal and could be removed with picks, hammers, crow bars, wedges, pneumatic breaking equipment etc. It shall also include boulders with dimensions greater than 500 mm but not exceeding 1000 mm in any direction. The mere fact that the Contractor resorts to blasting for his own convenience shall not mean that the rock will beclassifiedas hard rock.

Excavation in macadam and tarred roads and pathways, brick work etc. shall be considered at the same rate as excavation of this type of soil.

c) **Hard Rock**

This shall include rocks occuring in large masses which cannot be removed except by blasting. Harder varieties of rock such as trap, with or without veins and secondary mineral which in the opinion of the Engineer require blasting for removal shall also be considered as hard rock. It shall also include boulders bigger than 1000 mm in any direction. Construction in concrete, both reinforced and unreinforced, which is required to be dismantled during earthwork, shall be measured under this item, unless a separate provision is made in the schedule of Quantities for the same.

3.5.0 Earthwork in Excavation

3.5.1 General

All excavation shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Engineer shall be obtained by the Contractor, in each individual case, for the method he proposes to adopt for the excavations including dimension, side slopes, dewatering, disposal, etc.

This approval, however, shall not in any way make the Engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the Engineer.

The rough excavation may be carried upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the Engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the Engineer and the Contractor shall be paid for the extra excavation and the filling at the appropriate item rates.

If the excavation is done to a depth greater than that shown on the drawing, or directed by the Engineer, due to the Contractor's fault, the excess depth shall be filled up to the required level at the latter's cost with selected earth and compacted to 95% of modified Proctor Density or as directed by the Engineer.

The excavation shall be carried out as per the approved proposal, modified and corrected where necessary by the Engineer. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures or works roads, railway tracks, cables, pipelines etc. if any, and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work will be checked by the Engineer thoroughly and the balance work will be carried out carefully to avoid any over-excavation.

On completion, the work will be finally checked and approved by the Engineer. In cases where excavation in soil, soft and decomposed rock and/or hard rock are involved, the soil or soft and decomposed rock layers, shall be removed by turn and levels of the underlying rock surfaces observed to enable measurements. Further work shall be resumed after getting clearance from the Engineer.

3.5.2 Excavation in Hard Rock

Overburden, if any, consisting of top soil, ordinary and hard soil, soft and decomposed rock as per classification of soil, which do not require blasting shall be completely stripped off and the levels of the hard rock surface shall be taken to enable measurement. Further work in hard rock shall be resumed after clearance from the Engineer.

Personnel deployed for rock excavations shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is such that it is not stable against sliding, necessary supports, props, bracings or bulkheads shall be provided and maintained during the period of construction. Where danger exists of loose rock/boulder falling from the excavated surfaces deeper than 2 metres, steel mesh anchored to the lower edge of excavation and extending over and above the rock face, adequate to retain the dislodged material shall be provided and maintained.

In case where blasting, though otherwise required, is prohibited for any reasons, the excavation shall be carried out by chiselling, wedging or any other approved method. All loose or loosened rock in the sides shall be removed by barring, wedging, etc. The unit rate for excavation in hard rock shall include the cost of all these operations.

3.5.3 Blasting

3.5.3.1 General

Excavation shall be continued in hard rock to such widths, lengths, depths and profiles as are shown on the drawings or such other lines and grades as may be specified by the Engineer. As far as possible all blasting shall be completed prior to commencent of construction. At all stages of excavation, precautions shall be taken to preserve the rock below and beyond the lines for the excavation, in the soundest possible condition. The quantity and strength of explosive used, shall be such as will neither damage nor crack the rock outside the limits of excavation. All precautions, as directed by Engineer, shall be taken during the blasting operations and care shall be taken that no damage is caused to adjoining buildings or structure as a result of blasting operations. In case of damage to permanent or temporary structures, Contractor shall repair the same to the satisfaction of Engineer at his cost. As excavation approaches its final lines and levels, the depth of the charge holes and amount of explosives used shall be progressively and suitably reduced.

Unless otherwise stated herein, I.S. Specification IS:4081 "Safety Code for Blasting & Related Drilling Operation" shall be followed.

Specific permission of Engineer will have to be taken by Contractor for blasting rock and he shall also obtain a valid Blasting licence from the authorities concerned.

Contractor shall obtain necessary licence for storage of explosives, fuses and detonators issued to him from owner's stores or from supplier arranged by him, from the authorities dealing with explosives.

The fees, if any, required for obtaining such licence, shall be borne by Contractor. Contractor shall have to make necessary storage facilities for the explosives etc. as per rules of local, State and Central Govt. authorities and statutory bodies/ regulations.

In no case shall blasting be allowed closer than 30 metres to any structure or to locations where concrete has just been placed. In the latter case the concrete must be at least 7 days old.

Contractor shall employ a competent experienced supervisor and licensed blaster in-charge of each set of operation, who shall be held personally responsible to ensure that all safety regulations are carried out.

Before any blasting is carried out, Contractor shall intimate Engineer and obtain his approval in writing for resorting to such operations. He shall intimate the hours of firing charges, the nature of explosive to be used and the precautions taken for ensuring safety.

The blasting of rock near any existing buildings, equipments or any other property shall be done under cover and Contractor has to make all such necessary muffling arrangements. Covering may preferably be done by M.S. plates with adequate dead weight over them. Blasting shall be done with small charges and where directed by Engineer, a trench shall have to be cut by chiselling prior to the blasting operation seperating the area under blasting from the existing structures.

When excavation has almost reached the desired level, hand trimming shall have to be done for dressing the surface to the desired level. Any rock excavation beyond an overbreak limit of 75 mm shall be filled up as instructed by Engineer, with concrete of strength not less than M 100. The cost of filling such excess depth shall be borne by Contractor and the excavation carried out beyond the limit specified above will not be paid for. Stepping in rock excavation shall be done by hand trimming.

Contractor shall be responsible for any accident to workmen, public or Owner's property due to blasting operations. Contractor shall also be responsible for strict observance of rules, laid by Inspector of Explosives, or any other authority duly constituted under the State and/or Union Government.

Storage, handling and use of explosives shall be governed by the current explosive rules laid down by the Central and the State Governments. The Contractor shall ensure that these rules are strictly adhered to. The following instruction, wherever found in variance with the above rules, shall be considered as superceeded by the above rules.

No child under the age of 16 and no person who is in a State of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives.

3.5.3.2 **Storage of Explosive**

Storage of explosives shall be governed by the current Explosive Rules, Explosives shall be stored in a clean, dry, well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400 m of the actual work site or any source of fire. A space surrounding the magazine shall be fenced in. The ground inside the fence shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be by one gate only and no person shall be allowed inside this fence without permission of the Officer-in- charge. The clear space between the fence and the magazine shall not be less than 90m. The megazine shall be perfectly well drained.

Two lightning conductors shall be provided to the magazine, one at each end. The lightning conductors shall be tested once in every year.

Fuses and detonators shall be stored in separate magazines. However, detonators can be kept in an annexe adjoining the magazine provided that their number does not exceed 25,000 and that the annexe is so constructed that not less than 60 cm masonry and 100 cm of air space shall intervene between any detowators in such annexe and the interior of the main magazine. Cases containing explosives are not to be opened in a magazine. Explosive in open cases are not to be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine, but must be removed without delay to a safe distance and destroyed.

Artificial light is not to be allowed in any magazine. No smoking shall be allowed within 100 m of a magazine.

Magazine shoes without nails shall be used while entering the magazine.

The mallets, levers, wedges etc. for opening barrels or cases are to be of wood. Inside a magazine the cases of explosives are to be carried by hand and shall not be rolled or dragged. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been longest in store are to be issued first.

Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides, special care is to be taken to keep the floor free from grains of powder or portions of explosive matter fallen on the floors due to leakage of cases etc.

The magazine shall not be opened during any duststorm or thunderstorm nor any person shall be allowed in the vicinity of the magazine.

All magazines shall be officially inspected at definite intervals and a record kept of the results of such inspections.

3.5.3.3 **Carriage of Explosives**

Dctonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from the direct rays of the sun, naked lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each cage or package is to be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on a vehicle conveying explosives. No carriage or vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosive is likely to come in contact is effectually covered with lead, leather, wood, cloth or other suitable material. No lights shall be carried on the vehicle carrying explosives.

No operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

3.5.3.4 **Use of Explosives**

The Contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with the responsibilities imposed on him.

Holes for charging explosives shall be drilled with Pneumatic drills, the drilling pattern being so planned that the rock pieces after blasting will be suitable for handling.

The hole diameter shall be of such a size that cartridges can easily pass down them and undue force is not required during charging. Charging operations shall be carried out by or under the personal supervision of the shotfirer. Wrappings shall never be removed from explosive cartridges. Only wooden rods shall be used for loading and stemming shotholes. Only one cartridge at a time shall be inserted and gently passed home with the wooden tamping rod.

Only such quantities of explosives as are required for the particular amount of work to be done shall be brought to the works. Should any surplus remain when all the holes have been charged, it shall be carefully removed to a point at least 300 m from the firing point.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges the electric detonators shall be connected with the exploder through the shotfiring cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current and to keep the lead wires short circuited until ready to fire. Any Kinks in detonator leading wire shall be avoided.

For simultaneous firing of a large number of shotholes, use of cordtex may be done. Cordtex shall be initiated by an electric detonator attached to its side with adhesive tape, connecting wire or string.

All connections shall be made by the authorised shotfirer himself. The shotfiring cable shall not be dragged along the ground to avoid possible damage to the insulation. The shotfiring cable shall be tested for continuity and possible short circuiting before it is used each time.

The shotfirer shall always carry the exploder handle on his person until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits.

Before any blasting is carried out, it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300 metres radius from the firing point, or as required by statutory regulations, at least ten minutes before the time of firing by sounding a warning siren. The area shall be encirled by red flags.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations the authorised shotfirer shall return to the blast area and inspect carefully the work and satisfy himself that all charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole not less than 600 mm from the misfired hole and by exploding a new charge. The authorised shotfirer shall be present during removal of the debris liable to contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until atleast half an hour after firing.

Adequate safety precautions as per building bye-laws, safety code, statutory regulations etc. shall be taken during blasting operations.

3.5.4 **Disposal**

The excavated spoils will be disposed off within the specified lead in any or a combination of some of the following manners, as directed by the Engineer :

a) By stacking separately the materials suitable for area filling and materials not suitable.

b) By stacking it temporarily for use in backfilling at a later date.

c) i) By either spreading
or
ii) Spreading and compacting at designated disposal areas.

d) By selecting the useful material and stacking it neatly in areas designated by the Engineer for use in back-filling or other purposes by some other agency.

The rate for excavation in soil should include the cost of filling and compaction in case (c) (ii). The rate for excavation in rock should include the cost of disposal as per (d).

3.5.5 **Dewatering**

All areas shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by the Engineer, any water inclusive of rain water and subsoil water accumulated in the area without any extra cost. Method of dewatering shall be got approved by the Engineer.

3.6.0 **Treatment of Slips**

The Contractor will take all precautions to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides. These precautions along with proper slopes, berms, and control of ground water should cause no slips to occur. If however slips do occur due to causes beyond control of the Contractor, the same shall be removed by him and payment shall be made to him on appropriate item rate of earthwork. Slips caused due to negligence of the Contractor will be cleared and backfilled later by him at his own expenses.

3.7.0 **Earthwork in Filling**

3.7.1 The material to be used for area filling shall be selected material, approved by the Engineer, obtained directly from excavation for area grading, from nearby areas where excavation work by the same agency is in progress, from temporary stacks of excavated spoils or from borrow pits in selected areas designated by the Engineer. The quality of the material shall conform to that mentioned in clause 2.5.2 of this specification.

Where excavated material is mostly rock, the boulders shall be broken into pieces not longer than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill up the voids and the mixtures used for filling.

If any material is rejected by the Engineer, Contractor shall remove the same forthwith from the site at no extra cost of the owner. Surplus fill material shall be deposited/disposed off as directed by the Engineer after the fill work is completed.

No earthfill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by the Engineer.

Before commencement of area filling the existing top soil shall be removed upto a minimum depth of 150 mm, or more, as directed by the Engineer in order to clear the surface of undesirable materials. After this the filling operation shall be performed with earth in layers not exceeding 250 mm, loose thickness. Each layer shall be watered and properly compacted to 95% of modified Proctor Density unless otherwise permitted/directed by the Engineer. Earth shall be compacted with approved machine and usually manual compaction shall not be allowed unless specifically permitted by the Engineer.

Since the degree of compaction depends on the moisture content of the soil, a close watch shall be kept on this aspect and corrections done to optimise the moisture content. The adequacy of the compaction and moisture control of the soil shall be determined by performing field density tests and other tests as and when directed by the Engineer and shall conform to the stipulations laid down in IS:4701.

Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed. This shall hold good for embankments as well.

The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill will be considered as incomplete if the desired compaction has not been obtained.

If so specified, the rock as obtained from excavation may be used for filling and levelling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms. approximately. After rock filling to the approximate level, indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 tonne roller. No less than 12 passes of the roller shall be accepted before subsequent similar operations are taken up.

3.7.2 **Filling in Disposal Areas**

Excavated materials if not used in area filling, will be disposed off in designated disposal areas as directed or as indicated in the drawings. The earth shall not be dumped haphazardly but shall be spread in horizontal layers not exceeding 500 mm in thickness and nominal compaction done to the satisfaction of the Engineer. All clods shall be broken before placing the fill. Earthmoving machinery including dumpers, dozers and trucks shall be allowed to ply over the fill to permit compaction to take place.

In wide areas rollers may be employed and nominal compaction done to the satisfaction of the Engineer. No payment for compaction shall be made for such nominal compaction.

3.8.0 **Approaches and Fencing**

The Contractor shall provide and maintain proper approaches for workmen and for inspection. The roads and approaches around the area shall be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the Project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress, if directed by the Engineer.

3.9.0 **Lighting**

Full scale area lighting is to be provided if night work is permitted or directed by the Engineer. Even if no night work is in progress, red warning lights should be provided at the top in edges of the excavated area and the edges of the fill, unless otherwise permitted by the Engineer.

4.0.0 TESTING AND ACCEPTANCE CRITERIA

4.1.0 Excavation

On completion of excavation, the dimensions of the area will be checked as per the drawings after the area is completely dewatered.

The work will be accepted after all undercuts have been set right and all over excavations filled back to required lines, levels and grades by compacted earth, at the Contractor's cost.

Over excavation of the sides will be made good free of cost by the Contractor. The excavation work will be accepted after the above requirements are fulfilled & all temporary approaches encroaching inside the required dimension of the excavation have been removed.

4.2.0 Area-filling

The degree of compaction required will be as per the stipulations laid down in appropriate sections of this specification. The actual method for measuring the compaction achieved will be as decided by the Engineer. The work of area filling will be accepted after the Engineer is satisfied with the degree of compaction achieved.

5.0.0 INFORMATION TO BE SUBMITTED

5.1.0 With Tender

Following details of Machineries, transport vehicles, equipment proposed to be used for excavation, area-filling and compaction have to be submitted along with the tender :

I) Equipment, machinery & earthmoving vehicles, available with the Contractor and proposed to be used for excavation and haulage giving details regarding make, model, capacity, year of manufacture, numbers available for this contract and general condition.

ii) Equipment proposed to be used for area filling and compaction giving similar details as in item 5.1.0 (i) above.

iii) Method of transportation.

5.2.0 After Award

After award of contract the successful tenderer shall submit the following for approval and adoption :

a) Within 15 days of Award of the contract, the Contractor shall submit a detailed programme of work as proposed to be executed giving completion dates of excavation of the various areas and the time required for area-filling and compaction. The programme should also show how the excavation and area- filling quantities will be balanced, minimising temporary stacking of spoils. It is to be noted that the Engineer even after initial approval of the programme, may instruct to enhance or retard the progress of work during the actual execution, in order to match with overall construction schedule without attracting any claims from the Contractor. The initial programme being submitted by the Contractor should have sufficient flexibility to take care of such reasonable variations.

b) Within 15 days of award, the Contractor shall submit drawings showing details of slopes, approaches, sump pits, dewatering lines, borrow pits,if any, fencing etc. for approval of the Engineer for adoption.

6.0.0 RATES

6.1.0 Excavation and Disposal

The rates of earthwork for all types of soils, soft and decomposed rock and hard rock and leads as listed in the Schedule of Items will include the cost of all materials consumed, hire charges of tools and plants and equipment, cost of labour, insurance, taxes and royalties, security and safety arrangements, power, fuel, lubricants, services, accommodations, supervisions, overheads, profits etc.

The rates of excavation should also include the cost of dewatering. The Contractor will have to give a rebate for non-compaction in case the excavated material is stacked for use in back-fill by some other agency at a later date or dumped and spread in the disposal area with nominal compaction.

6.2.0 Area-Filling by Excavated Earth and Compaction

The rates to be quoted for this item should be complete in all respects including transporting earth available from excavation under Cl. 6.1.0 and include all the components of cost listed under Cl. 6.1.0. No extra will be payable for filling at any depth.

6.3.0 **Area-Filling by Earth brought from Borrow Pits or Stacks left by other Agencies**

In case sufficient earth of proper quality is not available from the excavated spoils, the Engineer may direct area filling to be done by bringing earth from borrow pits or selectively from stacks left by other agencies. The material in the stacks which are considered by the Engineer to be unfit for use in the fill, shall be carted away by the Contractor to the disposal area.

The rate to be quoted against the relevant item of the schedule should be complete in all respects and include all the components of cost listed under Cl.No. 6.1.0 of this specification. No extra will be payable for filling at any depth. Leads will however be paid as per Schedule of Items.

6.4.0 **Dewatering**

The rate for any dewatering of the area during the period of contract, original or extended, shall be deemed to have been included in the unit rate of excavation.

7.0.0 **MEASUREMENT**

7.1.0 **Clearing and Grubbing**

No separate measurement shall be done for this item for the purpose of payment in general, except for cutting of trees, having girth more than 300 mm.

7.2.0 **Excavation and Disposal**

Actual quantity of excavation required and approved by the Engineer shall be measured in Cu.M. No extra shall be paid for keeping the excavations dewatered as required. Necessary disposal of the spoil for filling or stacking as described in the Schedule of Items shall be included in the quoted rate.

The measurement may be done by direct tape measurement or by cross sections derived from initial and final levels.

7.3.0 **Area Filling with Earth from Stacks**

Actual quantity of filling as worked out from the contour drawings or the volume of the stack with a deduction of 30% (thirty percent) for compensating the voids shall be measured in Cu.M. The measurements will be taken before any monsoon passes over the area.

7.4.0 **Area-Filling with Earth from Borrow Pits and Stacks**

Actual quantity of excavation in the Borrow pits, or the volume of the stack with a deduction of 30% percent for voids, in case filling is done from stacks, shall be measured in Cu.M. The lead as mentioned in the Schedule of Items shall be included in the rates quoted.

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SECTION-IV

TECHNICAL SPECIFICATION
FOR
EARTHWORK IN EXCAVATION AND BACKFILLING

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SECTION-IV

TECHNICAL SPECIFICATION FOR EARTHWORK IN EXCAVATION AND BACKFILLING

1.0.0 SCOPE

This specification covers excavation in all types of soil, soft and decomposed rock not requiring blasting and rocks requiring blasting, shoring, dewatering, filling around foundations and to grade, compaction of fills and approaches, protective fencing, lighting, etc. relevant to structures and locations covered under the scope of this contract.

2.0.0 GENERAL

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless specified otherwise, shall include but not be limited to the following :

a) Furnish all labour, supervision, services including facilities as required under statutory labour regulations, materials, scaffolds, equipment, tools and plants, transportation, etc. required for the work.

b) Prepare and submit working drawings showing the approaches, slopes, berms, shoring, sumps for dewatering, including drains and outfall for drainage, space for temporary stacking of spoils, disposal area, fencing, etc. and all other details as may be required by the Engineer.

c) To carry out sampling and testing and submit to the Engineer, results of soil compaction tests Whenever required by the Engineer to assess the degree of compaction.

d) Construction, maintenance and removal after completion of Magazine of proper capacity as well as design for storing of explosives required for blasting work to be carried out under the scope of this tender including procurement of necessary licenses from proper authorities.

2.2.0 **Work to be provided for by others**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

2.3.0 **Codes and Standards**

All works under this specification, unless specified otherwise, shall conform to the latest revision and/or replacement of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not covered specifically by Indian Standard Specification any other standard practice as may be specified by the Engineer shall be followed :

IS:1200	:	Method of Measurement of Building and Civil (Part-I) Engineering work;Part-I Earthwork.
IS:2720	:	Determination of Moisture Content (Part-II)
IS:2720	:	Determination of Moisture content / Dry Relation (Part-VII) using Light Compaction.
IS:2720	:	Determination of Density Index (Relative Density) (Part-xiv) of cohesionless soils.
IS:2720	:	Determination of Dry Density , in place, by core (Part-xxix)cutter method .
IS:2720	:	Determination of Dry Density of soils, in place, xxviii) (Part-by sand replacement methods.
IS:3764	:	Safety code for Excavation work.
IS:4081	:	Blasting and Related Drilling Operations
IS:4701	:	Earthwork on canals

2.4.0 **Conformity with Designs**

The Contractor is to carry out the work as per the drawings issued to him and/or Contractor's drawings which are approved by the Engineer and/or the Engineer's instructions.

2.5.0 **Materials to be used**

2.5.1 **General**

All materials required for the work shall be of best commercial variety and approved by the Engineer.

2.5.2 **Borrow Material**

Borrow material required for back-filling shall be excavated from approved locations and levels and shall consist of material, approved by the Engineer, free from roots, vegetations, decayed organic matter, harmful salts and chemicals, free from lumps and clods. If specified, clean graded sand free from harmful and deleterious material from approved quarries, shall be used as fill material.

2.6.0 **Quality Control**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. The quality control operation shall include but not be limited to the following items of work :

a) Lines, Levels and Grades :

i) Periodic surveys

ii) Establishment of markers, boards etc.

b) Back-filling :

i) Checking the quality of fill material

ii) Checking moisture content of the backfill

iii) Checking the degree of compaction

2.7.0 **Information regarding site conditions**

Surface and Sub-surface data regarding the nature of soil , rock , sub-soil water etc. shown on drawing or otherwise furnished to the Contractor shall be taken as a guidance only and variation there from shall not affect the terms of the contract. The Contractor must satisfy himself regarding the character and volume of all work under this contract and expected surface, Sub-surface and / or sub-soil water to be encountered . He must also satisfy himself about the general conditions of site and ascertain the existing and future construction likely to come up during the execution of the contract so that he may evolve a realistic programme of execution.

3.0.0 EXECUTION

3.1.0 Setting Out

Within 15 days of award of Contract, the Contractor will prepare and submit to the Engineer, detailed drawings of the excavation work as proposed to be executed by him showing the dimensions as per drawings and specification adding his proposals of slopes, shorings, approaches, dewatering sumps, berms, etc. On receiving the approval from the Engineer with modifications and corrections, if necessary, the Contractor will set out the work from the control points furnished by the Engineer and fix permanent points and markers for ease of future checking. These permanent points and markers will be fixed at intervals prescribed by the Engineer and checked by the Engineer and certified by him after which the Contractor will proceed with the work. Engineer shall be provided with necessary men, material and instructions for such checking. It should be noted that this checking by the Engineer prior to start of the work will in no way absolve the Contractor of his responsibility of carrying out the work to true lines and levels and grades as per drawing and subsequent corrections, if necessary, free of cost to the Owner in case any errors are noticed in the Contractor's work at any stage.

3.2.0 Initial Levels

Initial levels of the ground either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross- sections for volume measurement or for cross-checking the depths obtained from tape measurements.

All records of levels, measurements etc. and also any drawing, cross section etc. made therefrom, shall be jointly signed by the authorised respresentative of the contractor and the Engineer before the commencement of work and they shall form the basis of all payments in future.

3.3.0 Clearing and Grubbing, etc.

The area to be excavated or filled shall be cleared outof fences, trees, logs, stumps, bush, vegetation, rubbish, slush, etc. and levelled up. Trees upto 300mm girth shall be uprooted. Trees above 300mm girth to be cut, shall be approved by the Engineer and then marked. Felling of trees shall include taking out roots upto 600mm below ground level or 150mm below formation level whichever is lower. After the tree is cut and roots taken out the pot-holes formed shall be filled with good earth in 250mm layers and consolidated unless directed by the Engineer otherwise. The trees shall be cut in suitable pieces as instructed by the Engineer.

Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burned or removed from the site to approved disposal areas as may be specified. Ash shall be spread or removed. Useful materials, saleable timber, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Engineer.

3.4.0 **Classification**

All earthwork shall be classified under the following categories :

No distinction will be made whether the material is dry or wet.

a) **Ordinary Soil**

This shall comprise vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occuring in such strata shall be deemed to be covered under this category.

b) **Hard Soil**

This shall include :

i) stiff heavy clay, hard shale, or compact moorum requiring grafting tool or pick or both and shovel, closely appllied ;

ii) gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm ;

iii) soling of roads, paths, etc., and hard core ;

iv) macadam surfaces such as water bound, and bitumen/tar bound;

v) lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar, below ground level ;

vi) soft conglomerate, where the stones may be detached from the matrix with picks ; and

vii) generally any material which requires the close application of picks, or scarifiers to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) and (vi) above.

c) **Soft and Decomposed Rock**

This shall include :

i) limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with crowbars ;

ii) unreinforced cement concrete which may be broken up with crowbars or picks and stone masonry in cement mortar below ground level ;

iii) boulders which do not require blasting having maximum diameter in any direction of more than 300 mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin; and

iv) any rock which in dry state may be hard, requiring blasting, but which when wet becomes soft and manageable by means other than blasting.

d) **Hard Rock (requiring blasting)**

This shall include :

i) any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required ;

ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and

iii) boulders requiring blasting.

e) **Hard Rock (blasting prohibited)**

Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

In case of any dispute regarding classification, the decision of the Engineer shall be final.

3.5.0 Excavation for Foundations and Trenches

3.5.1 General

All excavations shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Engineer shall be obtained by the Contractor, in each individual case, for the method he proposes to adopt for the excavations including dimension, side slopes, shoring, dewatering, disposal, etc. This approval, however, shall not in any way make the Engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner.

All excavation in open cuts shall be made true to line, slopes and grades shown on the drawing or directed by the Engineer. No material shall project within the dimension of minimum excavation lines marked. Boulders projecting out of the excavated surfaces shall be removed, if in the opinion of the Engineer they are likely to be a hindrance to the workers.

Method of excavation shall be in every case subject to the approval of the Engineer and the Contractor shall ensure the stability and safety of the excavation, adjacent structures, services and works.

The Contractor shall have full responsibility of the stability of the excavation and safety of the workmen. If any slip occurs, the Contractor shall remove all slipped material from the excavated pit.

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

Prior to starting the excavation, the ground level at the location shall be checked jointly with the Engineer.

The rough excavation may be carried upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the Engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the Engineer and the Contractor shall be paid for the extra excavation and the filling at the appropriate item rates.

If the excavation is done to a depth greater than that shown on the drawing, or directed by the Engineer, due to the Contractor's fault, the excess depth shall be filled up to the required level at the latter's cost (with cement concrete not leaner than 1:4:8 ordinary concrete or richer) as directed by the Engineer in each individual case.

In formation of rock requiring blasting, those overcuts which are unavoidable will be made up by ordinary cement concrete 1:2:4 which will be paid for under appropriate rate, provided this overcut is not due to negligence of the Contractor. The decision of the Engineer as to the admissibility of such overcut for payment will be final. All excavated materials such as hard rock, boulders, bricks, dismantled concrete blocks, etc. shall be stacked separately as directed by the Engineer and shall be the property of the Owner.

3.5.2 Excavation in Ordinary Soil, Hard Soil and Soft and Decomposed Rock

The excavation in ordinary soil, hard soil, soft and decomposed rock will be carried out as per the approved proposal, modified and corrected where necessary by the Engineer. The work will be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work will be checked by the Engineer thoroughly and the balance work will be carried out carefully to avoid any over-excavation. On completion, the work will be finally checked and approved by the Engineer. In certain cases, where deterioration of the ground, upheaval, slips, etc. are expected, the Engineer may order to suspend the work at any stage and instruct the Contractor to carry out the balance work just before the foundation work of the structure can be started. No extra will be paid to the Contractor for such unavoidable temporary suspension of work.

3.5.3 Excavation in Hard Rock

In case where excavation, both in ordinary soil and hard rock, are involved, the ordinary soil comprising of soft, hard and dense soils (including laterite formations) and rock including weathered rocks, lateritic rocks, etc. which can be excavated without blasting, shall be completely stripped off and the levels of the hard rock surface shall be taken to enable measurements. Further work in hard rock shall be resumed after clearance from the Engineer.

Personnel deployed for rock excavations shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is such that it is not stable against sliding, necessary supports, props, bracings or bulkheads shall be provided and maintained during the period of construction. Where danger exists of loose rock/boulder falling from the excavated surfaces deeper than 2 metres, steel mesh anchored to the lower edge of excavation and extending over and above the rock face, adequate to retain the dislodged material shall be provided and maintained.

In case where blasting, though otherwise required, is prohibited for any reasons, the excavation shall be carried out by chiselling, wedging or any other approved method and payment appropriate to blasting shall be made, unless otherwise mentioned in the Schedule.

3.5.4 Blasting

3.5.4.1 General

Storage, handling and use of explosives shall be governed by the current explosive rules laid down by the Central and the State Governments. The Contractor shall ensure that these rules are strictly adhered to. The following instruction, wherever found in variance with the above rules, shall be considered as superceeded by the above rules.

No child under the age of 16 and no person who is in a State of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives.

3.5.4.2 Storage of Explosive

Storage of explosives shall be governed by the current Explosive Rules, Explosives shall be stored in a clean, dry, well ventilated magazine to be specially built for the purpose. Under no circumstances should a magazine be erected within 400 m of the actual work site or any source of fire. A space surrounding the magazine shall be fenced in. The ground inside the fence shall be kept clear and free from trees, bushes etc. The admission to this fenced space shall be by one gate only and no person shall be allowed inside this fence without permission of the Officer-in- charge. The clear space between the fence and the magazine shall not be less than 90m. The megazine shall be perfectly well drained.

Two lightning conductors shall be provided to the magazine, one at each end. The lightning conductors shall be tested once in every year.

Fuses and detonators shall be stored in separate magazines. However, detonators can be kept in an annexe adjoining the magazine provided that their number does not exceed 25,000 and that the annexe is so constructed that not less than 60 cm masonry and 100 cm of air space shall intervene between any detonators in such annexe and the interior of the main magazine. Cases containing explosives are not to be opened in a magazine. Explosive in open cases are not to be received into a magazine. Explosives which appear to be in a damaged or dangerous condition are not to be kept in any magazine, but must be removed without delay to a safe distance and destroyed.

Artificial light is not to be allowed in any magazine. No smoking shall be allowed within 100 m of a magazine.

Magazine shoes without nails shall be used while entering the magazine.

The mallets, levers, wedges etc. for opening barrels or cases are to be of wood. Inside a magazine the cases of explosives are to be carried by hand and shall not be rolled or dragged. Explosives which have been issued and returned to the magazine are to be issued first; otherwise those which have been longest in store are to be issued first.

Cases of explosives must be kept clear of the walls and floors for free circulation of air on all sides, special care is to be taken to keep the floor free from grains of powder or portions of explosive matter fallen on the floors due to leakage of cases etc.

The magazine shall not be opened during any duststorm or thunderstorm nor any person shall be allowed in the vicinity of the magazine.

All magazines shall be officially inspected at definite intervals and a record kept of the results of such inspections.

3.5.4.3 **Carriage of Explosives**

Detonators and explosives shall be transported separately to the blast site. Explosives shall be kept dry and away from the direct rays of the sun, naked lights, steam pipes or heated metal and other sources of heat. Before explosives are removed, each cage or package is to be carefully examined to ascertain that it is properly closed and shows no sign of leakage.

No person except the driver shall be allowed to travel on a vehicle conveying explosives. No carriage or vessel shall be used for transporting explosives unless all iron or steel therein with which a package containing any explosive is likely to come in contact is effectually covered with lead, leather, wood, cloth or other suitable material. No lights shall be carried on the vehicle carrying explosives.

No operation connected with the loading, unloading and handling of explosives shall be conducted after sunset.

3.5.4.4 **Use of Explosives**

The Contractor shall appoint an agent who shall personally superintend the firing and all operations connected therewith. The contractor shall satisfy himself that the person so appointed is fully acquainted with the responsibilities imposed on him.

Holes for charging explosives shall be drilled with Pneumatic drills, the drilling pattern being so planned that the rock pieces after blasting will be suitable for handling.

The hole diameter shall be of such a size that cartridges can easily pass down them and undue force is not required during charging. Charging

operations shall be carried out by or under the personal supervision of the shotfirer. Wrappings shall never be removed from explosive cartridges. Only wooden rods shall be used for loading and stemming shotholes. Only one cartridge at a time shall be inserted and gently passed home with the wooden tamping rod.

Only such quantities of explosives as are required for the particular amount of work to be done shall be brought to the works. Should any surplus remain when all the holes have been charged, it shall be carefully removed to a point at least 300 m from the firing point.

The explosives shall be fired by means of an electric detonator placed inside the cartridge. For simultaneous firing of a number of charges the electric detonators shall be connected with the exploder through the shotfiring cable in a simple series circuit. Due precautions shall be taken to keep the firing circuit insulated from the ground, bare wires, rails, pipes or any other path of stray current and to keep the lead wires short circuited until ready to fire. Any Kinks in detonator leading wire shall be avoided.

For simultaneous firing of a large number of shotholes, use of cordtex may be done. Cordtex shall be initiated by an electric detonator attached to its side with adhesive tape, connecting wire or string.

All connections shall be made by the authorised shotfirer himself. The shotfiring cable shall not be dragged along the ground to avoid possible damage to the insulation. The shotfiring cable shall be tested for continuity and possible short circuiting before it is used each time.

The shotfirer shall always carry the exploder handle on his person until he is ready to fire shots. The number of shots fired at a time shall not exceed the permissible limits.

Blasting shall only be carried out at certain specified times to be agreed jointly by the contractor and the Engineer.

Before any blasting is carried out, it shall be ensured that all workmen, vehicles and equipment on the site are cleared from an area of minimum 300 metres radius from the firing point, or as required by statutory regulations, at least ten minutes before the time of firing by sounding a warning siren. The area shall be encirled by red flags.

At least five minutes after the blast has been fired in case of electric firing or as stipulated in the regulations the authorised shotfirer shall return to the blast area and inspect carefully the work and satisfy himself that all charged holes have exploded. Cases of misfired unexploded charges shall be exploded by drilling a parallel fresh hole not less than 600 mm from the misfired hole and by exploding a new charge. The authorised shotfirer shall be present during removal of the debris liable to contain unexploded explosives near the misfired hole. The workmen shall not return to the site of firing until atleast half an hour after firing.

When blasting is conducted in the neighbourhood of roads, structures, buildings etc. controlled blasting has to be carried out by drilling shallow shotholes and filling the same with light charge of explosives.

Adequate safety precautions as per building bye-laws, safety code, statutory regulations etc. shall be taken during blasting operations.

3.5.5 **Disposal**

The excavated spoils will be disposed of in any or all the following manners :-

a) By using it for backfilling straightway.

b) By stacking it temporarily for use in backfilling at a later date during execution of the Contract.

c) i) By either spreading, Or

ii) spreading and compacting at designated filling areas and / or disposal areas.

d) By selecting the useful material and stacking it neatly in areas designated by the Engineer for use in backfilling by some other agency.

The rate for excavation in soil should include the cost of filling and compaction in case (c) (ii). The rate for excavationin rock should include the cost of disposal as per (d).

3.5.6 **Disposal of Surplus**

All surplus material from excavation shall be carried away from the excavation site to designated disposal area selected by the Engineer.

All good and sound rock excavated from the pits and all assorted materials of dismantled structures shall be the property of the Owner and if the Contractor wants to use it, he shall have to obtain it from the Engineer at a mutually agreed rate for the same.

All sound rock and other assorted materials like excavated bricks, etc. shall be stacked separately and shall be measured in stacks deducting 30% volumetric measure for voids.

3.5.7 **Protection**

The Engineer shall be notified by the Contractor as soon as the excavation is expected to be completed within a day so that it may be inspected by him at the earliest. Immediately after approval of the Engineer, the excavation must be covered up in the shortest possible time. But, in no case the excavation shall be covered up or worked on before approval and measurement by the Engineer. Excavated material shall be placed beyond 1.5 metres from the edge of the pit or trench or half the depth of the pit or trench whichever is more or further away if directed by the Engineer.

Excavation shall not be carried out below the foundation level of structure close by until required precautions have been taken.

Adequate fencing is to be made enclosing the excavation.

The Contractor shall protect all under-ground services exposed by excavation. The Contractor shall also divert all surface drains, etc. affected by the excavation to maintain the working area neat and clean.

3.5.8 **Dealing with Surface Water**

All working areas shall be kept free of surface water as far as reasonably praticable. Works in the vicinity of cut areas shall be controlled to prevent the ingress of surface water.

No works shall commence until surface water streams have been properly intercepted , redirected or otherwise dealt with.

Where works are undertaken in the monsoon period , the Contractor may need to construct temporary drainage systems at his own cost to drain surface water from working areas.

3.5.9 **Dewatering**

All excavations shall be kept free of water and slush. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by the Engineer any water inclusive of rain water and subsoil water accumulated in excavation and keep the trench dewatered until the construction of foundation structure and backfilling are complete in all respects. (except where such dewatering would need installation of well points or deep wells for which separate payment will be made) Sumps made for dewatering must be kept clear of the foundations. Method of pumping shall be approved by the Engineer but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping.

If necessary, the Engineer may direct the Contractor to continue dewatering beyond his original or extended contract period in which case he will be paid separately for dewatering as per terms mentioned elsewhere under payment and measurement, provided the Contractor has completed all the work satisfactorily.

3.5.10 Timber Shoring

Timber Shoring made out of approved quality of timber shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench and the type of timbering shall be determined by the Engineer. It shall be the reponsibility of the Contractor to take all necessary steps to prevent the sides of trenches and pits from collapsing.

3.5.10.1 Close Timbering

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 250 x 40 mm sections as directed by the Engineer. The boards shall generally be placed in position vertically in pairs, one board on each side of cutting, and shall be kept apart by horizontal walers of strong wood at maximum 1.2 metres spacings, cross strutted with ballies or as directed by the Engineer. The length of the bally struts shall depend on the width of the trench or pit.

In case where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical walers, which shall be strutted to similar timber pieces on the opposite face of the trench or pit. The lowest board supporting the sides shall be taken into the ground. No portion of the vertical side of the trench or pit shall remain exposed, so that the earth is not liable to slip out.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

3.5.10.2 Open Timbering

In the case of open timbering, the entire surface of the side of trench pit is not required to be covered. The vertical board of minimum 250 mm width and minimum 40 mm depth shall be spaced sufficiently apart to leave unsupported strips of maximum 500 mm average width. The detailed arrangement, sizes of the timber and the distances apart shall be subject to the approval of the Engineer. In all other respects, specification for close timbering shall apply to open timbering.

3.6.0 Treatment of Slips

he Contractor will take all precaution to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides. These precautions along with proper slopes, berms, shoring and control of ground water should cause no slips to occur. If however slips do occur due to causes beyond the control of the Contractor, the same shall be removed by him and payment shall be made to him on appropriate item rate of earthwork. Slips caused due to negligence of the Contractor will be cleared and back-filled later by him at his own expenses.

3.7.0 **Back-filling**

3.7.1 **General**

The material used for backfilling shall consist of material, approved by the Engineer obtained directly from nearby areas where excavation work by the same agency is in progress, from temporary stacks of excavated spoils or from borrow pits from selected areas designated by the Engineer. The material shall be free from lumps and clods, roots and vegetations, harmful salts and chemicals, organic materials, etc.

In certain locations, the Engineer may direct sand fillings. The sand should be clean, well graded and be of quality normally acceptable for use in concrete.

3.7.2 **Filling and Compaction in Pits and Trenches around Structures**

As soon as the work in foundations has been accepted and measured, the spaces around the foundation structures in pits and trenches shall be cleared of all debris, brick bats, mortar droppings, etc., and filled with earth in layers not exceeding 250 mm in loose thickness each layer being watered, rammed and properly compacted to achieve a dry density of not less that 9o% of proctor's dry density at optimum moisture content as per IS-2720 (Part-VII) where backfilling with cohesive soil and sandy silt containing high percentage of Silt. For back filling with sand having little or no silt, each layer shall be compacted to a relative density of 75% as per IS-2720 part XIV. Earth shall be rammed with approved mechanised compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the Engineer. The final surface shall be trimmed and levelled to proper profile as shown in the drawing and as desired by the Engineer.

Since the degree of compaction depends on the moisture content of the soil, a close watch sould be kept on it and corrections done to optimise the moisture content.

3.7.3 Plinth Filling

The plinth shall be filled with earth in layers not exceeding 250 mm in loose thickness, watered and compacted as stated under clause no. 3.7.2 with approved compaction machine or manually, if specifically permitted by the Engineer. When the filling reaches the finished level, the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and compacted, in order to avoid any settlement at a later stage. The finished level of the filling shall be trimmed to the slope intended to be given to the floor.

3.7.4 Filling in Trenches for Water Pipes and Drains

Earth used for filling shall be free from salts, organic or other foreign matter. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not bigger than 150 mm size in any direction, mixed with fine material consisting of disintearated rock, moorum or earth as available, so as to fill up the voids as far as possible and then the mixture used for filling. The types of bedding & pipe surround material shall be as specified in the drawings .

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed.

Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes in layers not exceeding 150 mm, watered, rammed and compacted taking care that no damage is caused to the pipe below. Filling of trenches shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

In case of excavation of trenches in rock, the filling upto a depth of 300 mm or the diamter of the pipe whichever is more, above the crown of pipe or barrel shall be done with fine material such as earth, moorum, disintegrated rock or ash according to the availability at site. The remaining filling shall be done with rock filling of boulders of size not exceeding 150 mm mixed with fine material as available to fill up the voids, watered, rammed and compacted.

3.7.5 Filling in Disposal Area

Surplus material from excavation which is not required for backfilling will be disposed of in designated disposal areas. The spoils shall not be dumped haphazardly but should be spread in layers approximately 250 mm thick when loose and compacted with the help of compacting equipment. In wide areas rollers will be employed and compaction done to the satisfaction of the Engineer at the optimum moisture content which shall be checked and controlled by the Contractor.

In certain cases the Engineer may direct disposal without compaction which can be done by tipping the spoils from a high bench neatly maintaining always a proper level and grade of the bench.

3.8.0 **Approaches and Fencing**

The Contractor should provide and maintain proper approaches for workmen and for inspection. The roads and approaches around the excavated pits should be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the Project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress.

3.9.0 **Lighting**

Full scale area lighting is to be provided if night work is permitted or directed by the Engineer. If no night work is in progress, red warning lights should be provided at the corners of the excavated pit and the edges of the fill.

4.0.0 **TESTING AND ACCEPTANCE CRITERIA**

4.1.0 **Excavation**

On completion of excavation, the dimensions of the pits will be checked as per the drawings after the pits are completely dewatered the work will be accepted after all undercuts have been set right and all over excavations filled back to required lines, levels and grades by placing ordinary concrete of 1:4:8 proportion and/or richer and/or by compacted earth, as directed by the Engineer, at the Contractor's cost. The choice of grade of concrete will be a matter of unfettered discretion of the Engineer. Over excavation of the sides will be made good free of cost by the Contractor while carrying out the back-filling. The excavation work will be accepted after the above requirements are fulfilled and all temporary approaches encroaching inside the required dimension of the excavation have been removed.

4.2.0 **Back-filling**

The degree of compaction shall be sufficient to achieve a dry density of not less than 90% of proctor's dry density at optimum moisture content as per IS-2720 (Part - vii) or a relative density of 75% as per IS-2720 (Part-xiv)as applicable depending on the nature of back filling material as stated in clause no. 3.7.2 of this specification . The work of back-filling will be accepted after the Engineer is satisfied with the degree of compaction achieved.

5.0.0 INFORMATION TO BE SUBMITTED

5.1.0 With Tender

Details of Equipment proposed to be used for excavation, back-filling and compaction have to be submitted along with the tender.

5.2.0 After Award

After award of the Contract the successful tenderer shall submit the following for approval and adoption :

a) Within 30 days of Award of the Contract, the Contractor shall submit a detailed programme of the work as proposed to be executed giving completion dates of excavation of the various foundations and the time required for back-filling and compaction after completing the foundation for structures. In case the Earthwork Contractor is also the agency for the foundation work, the Earthwork programme is to be connected with the foundation programme. The programme should also show how the excavation and back-filling quantities will be balanced, minimising temporary stacking of spoils. It is to be noted that the Engineer even after initial approval of the programme, may instruct to enhance or retard the progress of work during the actual execution, in order to match with the progress of foundations without attracting any claims from the Contractor. The initial programme being submitted by the Contractor should have sufficient flexibility to take care of such reasonable variations.

b) Within 15 days of award, the Contractor shall submit drawings showing details of slopes, shorings, approaches, sump pits, dewatering lines, fencing etc. for approval of the Engineer for adoption.

6.0.0 RATES

The rates for the items shall include cost of all materials consumed in the works, hire charges of materials, tools and plant, cost of labour, insurance, all transport, taxes, royalties, security and safety arrangements, supervision, profit etc. The rates of excavation shall also include the cost of dewatering (except where such dewatering would need installation of well points or deep wells for which separate payment will be made) and stacking the excavatedspoils properly within a lead of 30M, unless otherwise mentioned in the Schedule of items.

The Contractor will have to give a rebate if the excavated earth is directly used for back-filling.

Where back-filling is to be done with sand, it shall be of good quality from quarries approved by the Engineer. The rate shall include all operations including the cost of sand.

In case the Contractor is required to continue dewatering of the excavated pits beyond the period of the contract, original or extended, he will be paid separately for it as per the schedule of items only for the period beyond the final terminal date of the contract. The rate will be complete in all respects including the cost of consumables, if any.

7.0.0 MEASUREMENTS

7.1.0 Clearing and Grubbing

No separate measurement shall be done for this item for the purpose of payment in general except for cutting of trees having girth more than 30 cms. and works connected to this.

7.2.0 Excavation

Actual quantity of excavation required and approved by the Engineer shall be measured in Cu.M. No extra shall be paid for keeping the excavations dewatered as required for completion of the structure to come in. Necessary disposal of the spoils as described in the schedule of items shall be included in the quoted rate.

7.3.0 Shoring

The actual effective area of shoring as approved by the Engineer, shall be measured in Sq.M. All planks, wallings, verticals, struts, props and all other materials as required for the shoring and subsequent safe dismantling and removal shall be included in the rates quoted.

7.4.0 Back-filling

7.4.1 With Assorted Earth from Excavations for Foundations, Trenches etc.

Actual quantity of consolidated backfill shall be measured in Cu.M. The cost of lead, lift, etc. shall be as per schedule of items and included in the rate quoted.

7.4.2 **With Earth from borrow pits and stacks**

Actual quantity of consolidated back-filling or actual quantity of excavation in the borrow pits, or the excavated volume of the stack with a deduction of 30% for voids, in case filling is done by earth from stack, whichever is less, shall be paid in Cu.M. The lead, lift, etc. as mentioned in the Schedule of Items shall be included in the rates quoted.

7.4.3 **Sand filling**

Actual quantity of consolidated sand filling shall be measured in Cu.M. The rate shall include cost of sand and all necessary works for execution of the items.

7.5.0 **Leads and Lifts**

The leads for excavation and/or back-filling will be measured between the centroid of the actual disposal area and that of the plan of the pit. The distance between these two points will be measured along the shortest practicable haulage path as decided by the Engineer.

Lifts will be measured vertically between the average ground level from where the pit excavation was started and the botton level of the excavated pit. Level lines corresponding to the stages where

lifts become payable will be drawn on the cross section of the pit and the volumes of excavation contained between these horizontal planes will be computed and paid according to the corresponding rates.

7.6.0 **Dewatering**

Dewatering for work beyond the Contract period original or extended will be measured on the basis of horse power - hour which will be obtained by multiplying the estimated requirement of horse power required to run the pumps or actually employed, whichever is less, by the actual hours run, approximated to the nearest half hour.

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SECTION-V

TECHNICAL SPECIFICATION
FOR
CEMENT CONCRETE [PLAIN & REINFORCED]

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SECTION-V

TECHNICAL SPECIFICATION FOR CEMENT CONCRETE [PLAIN & REINFORCED]

1.00.00 SCOPE

1.01.00 General

This specification covers all the requirements, described hereinafter for general use of Plain and Reinforced Cement Concrete work in Structures and locations, cast-in-situ or precast, and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work.

1.02.00 This specification shall also apply to the extent it has been referred to or applicable with the special requirements of structures covered in SCOPE of IS:456.

1.03.00 IS:456 shall form a part of this specification and shall be complied with unless permitted otherwise. For any particular aspect not covered by this Code, appropriate IS Code, specifications and/or replacement by any International Code of practice as may be specified by the Engineer shall be followed. All codes and Standards shall conform to its latest revisions. A list of IS codes and Standards is enclosed hereinafter for reference.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Contractor

The work to be provided by the Contractor, unless otherwise specified shall include but not be limited to the following :

a) Furnish all labour, supervision, services including facilities as may be required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, aids, construction equipment, tools and plants, transportations, etc. required for the work.

b) Except where it is excluded from the Scope of Contract, Contractor shall prepare progressively and submit for approval of detailed drawings and Bar Bending Schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.

c) Design and prepare working drawings of formworks, scaffolds, supports, etc. and submit for approval.

d) Submit for approval of shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedments, hangers, openings, frames etc.

e) Submit for approval of detailed drawings of supports, templates, hangers, etc. required for installation of various embedments like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

f) Submit for approval of detailed schemes of all operations required for executing the work, e.g. Material handling, Concrete mixing, Placement of concrete, Compaction, curing, services, Approaches, etc.

g) Design and submit for approval of concrete mix designs required to be adopted on the job.

h) Furnish samples and submit for approval of results of tests of various properties of the following:

i) The various ingredients of concrete

ii) Concrete

iii) Embedments

iv) Joint seals

i) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings, specifications and Schedule of Items.

j) For supply of certain materials normally manufactured by specialist firms, the Contractor may have to produce, if directed by the Engineer, a guarantee in approved proforma for satisfactory performance for a reasonable period as may be specified, binding both the manufacturers and the Contractor, jointly and severally.

2.02.00 **Work by Others**

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

2.03.00 **Information to be submitted by the Tenderer**

2.03.01 **With Tender**

The following technical information are required with the tender:

a) Source and arrangement of processing of aggregates proposed to be adopted.

b) Type of plant and equipment proposed to be used.

c) Names of firms, if any, with which association is sought for to execute the special items of work in the contract.

d) Types of formwork proposed to be used.

2.03.02 **After Award**

The following information and data including samples, where necessary, shall be submitted by the Contractor progressively during execution of the contract.

a) **Programme of Execution and Requirement of Materials**

Within 30 days of the award of contract, the Contractor will submit a Master Programme for completion of the work giving month-wise requirements of materials, particularly mentioning in details the materials which are to be supplied by the Owner and for the procurement of which the help of the Owner is required as per the terms and conditions of the Contract. In case the Contractor proposes to take on hire any machineries or tools and plants from the Owner, the detailed phased out programme of such hire is also to be submitted.

This Master Programme may have to be reviewed and updated by the Contractor, quarterly or at more frequent intervals as may be directed by the Engineer depending on the exigencies of the work.

Detailed day to day programme of every month is to be submitted by the Contractor before the end of the previous month.

b) **Samples**

Samples of the following materials and any other materials, proposed to be used, shall be submitted as directed by the Engineer, in sufficient quantities free of cost, for approval. Approved samples will be preserved by the Engineer for future reference. The approval of the Engineer shall not, in any way, relieve the Contractor of his responsibility of supplying materials of specified qualities:

i) Coarse and fine aggregates.

ii) Admixtures.

iii) Plywood for Formwork.

iv) Embedded and anchorage materials as may be desired by the Engineer.

v) Joint sealing strips and other waterproofing materials.

vi) Joint filling compounds.

vii) Foundation quality Rubber Pads.

c) **Design Mix**

Design mix as per Clauses 2.1 (g) & 3.4 of this specification giving proportions of the ingredients, sources of aggregates and cement, along with accompanying test results of trial mixes as per relevant I.S. Codes, is to be submitted to the Engineer for his approval before it can be used on the works.

d) **Detail Drawings and Bar Bending Schedules**

Detailed working drawings and Bar Bending Schedules in accordance with Clause 2.1(b) and 3.16.1 of this specification.

e) **Detailed Drawings and Designs of Formworks to be used**

Detailed design data and drawings of formworks to be used as per clause 2.1 (c).

f) **Detailed Drawings for Templates & Temporary Supports for Embedments**

As per Clause 2.1 (e).

g) **Mill Test Reports for Cement & Reinforcing Steel**

Mill Test Reports for Cement and Reinforcing Steel in case these materials are supplied by the Contractor.

h) **Inspection Reports**

Inspection Reports in respect of Formwork and Reinforcement and any other item of work as may be desired by the Engineer in accordance with Clause 2.4 of this specification.

i) **Test Reports**

Reports of tests of various materials and concrete as required under Clause 4.0: SAMPLING & TESTING of this specification.

j) Any other data which may be required as per this specification.

2.04.00 **Conformity with Design**

The Contractor will prepare check lists in approved proforma which will be called 'Pour Cards'. These Pour Cards will list out all items of work involved. The Contractor will inform the Engineer, sufficiently in advance, whenever any particular pour is ready for concreting. He shall accord all necessary help and assistance to the Engineer for all checking required in the pour. On satisfying himself that all details are in accordance to the drawings and specifications, the Engineer will give written permission on the same 'Pour Card' allowing the Contractor to commence placement of concrete. Details of all instructions issued by the Engineer and the records of compliance by the Contractor, deviations allowed by the Engineer and any other relevant information will be written on accompanying sheets attached to the Pour Cards. These sheets, termed as 'Progress Cards', will be prepared by the Contractor on approved proforma. The Pour Cards along with accompaniments will be handed over to the Engineer before starting placement of concrete. One of the mix designs developed by the Contractor as per the I.S. Specifications and established to the satisfaction of the Engineer by trial mixes shall be permitted to be used by the Engineer, the choice being dictated by the requirements of designs and workability. The methods of mixing, conveyance, placement, vibration, finishing, curing, protection and testing of concrete will be as approved or directed by the Engineer.

2.05.00 **Materials to be used**

2.05.01 **General Requirement**

All materials whether to be incorporated in the work or used temporarily for the construction shall conform to the relevant IS Specifications unless stated otherwise and be of best approved quality.

2.05.02 **Cement**

Generally the following type of cement shall be used with prior approval of the Engineer :

a) 43 Grade Ordinary Portland Cement conforming to IS: 8112

b) 53 Grade Ordinary Portland Cement conforming to IS: 12269

c) Portland Slag Cement conforming to IS: 455

d) Portland Pozzolana Cement (fly ash based, by intergrinding Portland Clinker) conforming to IS:1489 (Part-1)

e) Portland Pozzolana Cement (calcined clay based) as per IS: 1489 (Part-2)

In special cases, the following types of cement may be required to be used with prior approval by the Engineer:

a) Rapid hardening Portland Cement conforming to IS: 8041

b) Hydrophobic Cement conforming to IS: 8043

c) Low heat Portland Cement conforming to IS: 12600

d) Sulphate Resisting Portland Cement conforming to IS: 12330

N.B.: Blending of Fly Ash with Ordinary Portland Cement at site is not allowed.

2.05.03 **Aggregates**

Aggregates shall be natural or crushed gravel or crushed rock and free from deleterious materials. It shall comply with the requirements of IS-383. All fine and coarse aggregate shall be tested for susceptibility to Alkali Silicate reaction in a laboratory approved by the Engineer.

a) **Coarse Aggregate**

Aggregate of sizes ranging between 4.75 mm and 150 mm will be termed as Coarse Aggregate. Only Coarse Aggregate from approved quarries and conforming to IS: 383 will be allowed to be used on the works. Aggregates shall be washed to make it free from deleterious materials, if necessary.

The grading of coarse aggregates by sieve analysis shall be as per IS: 383.

b) **Fine Aggregate**

Aggregate smaller than 4.75 mm and within the grading limits and other requirements set in IS: 383 will be termed as Fine Aggregate or Sand. Only Fine Aggregate from approved sources and conforming to the above IS Specification will be allowed to be used on works.

In certain cases there may be two types of sand , one very fine and the other very coarse. In such cases, the two types shall be combined to meet the requirements of a particular zone of IS: 383. In most cases, the preferred zone is Zone - II.

In certain cases crushed stone sand may be added to natural sand in order to achieve the required grading.

Crushed stone sand alone may be used only with the approval of the Engineer.

2.05.04 **Water**

Water for use in Concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts or other impurities. Normally potable water is found to be suitable. Generally, IS: 3550 will be followed for routine tests. Acceptance test for water shall be as per IS: 3025, and Table - 1 of IS: 456.

In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by compressive strength and initial setting time tests as per method of tests in accordance with the requirements of IS: 516 & IS: 4031 respectively. The PH value of water shall generally be not less than 6.

2.05.05 **Admixture**

Only admixture of approved quality will be used when directed or permitted by the Engineer. The different types of admixtures which may be necessary to satisfy the concrete mix and the design requirement shall be as per the following I.S. Standards:

IS: 2645 - Integral cement water proofing compound

IS: 9103 - Indian standard specification for Admixtures for Concrete

Or equivalent American Codes (ASTM C494 and ASTM C260) or British Codes (BS 5075, Part 1 to 3) and may be one of the following:

a) **Accelerating admixtures**

- Set accelerating admixtures like "Sigunit Powder" or "Sigunit LN10" or approved equivalent.

b) **Retarding admixtures**

- Modified lignosulphonate based set retarding concrete admixture like "Plastiment R" or approved equivalent.

c) **Water reducing admixtures**

- Modified sulphonated melamine formaldehyde based water reducing concrete admixture like "Sikament" or approved equivalent.

d) **Air entraining admixtures**

- Modified lignosulphonate based air entraining concrete admixture like “FLOMO AEP " or surface active agents like "Sika AER" or approved equivalent.

e) **Water proofing admixtures**

- Modified lignosulphonate based waterproofing admixture like "Plastocrete Super" or approved equivalent.

However, the Contractor shall furnish following technical information about the admixtures (alongwith the manufacturer's Catalogue) which he is planning to use in different areas within the scope of work for the approval of the Engineer:

i) Type of admixture

ii) Mix proportion & mode of application in concrete/mortar

iii) Manufacturer’s specification & necessary quality assurance certificates (mainly on chloride & sulphate content, PH value, infra red analysis & solid content).

2.05.06 **Reinforcement**

Reinforcement shall be as per relevant IS Specification as mentioned in the Contract/ Drawing/ Instructions. All bars shall be of tested quality.

2.06.00 **Storage of Materials**

2.06.01 **General**

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for concrete and shall be removed from site immediately, failing which, the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The Contractor shall maintain up-to-date accounts of receipt, issue and balance (stack-wise) of all materials. Storage of materials shall conform to IS: 4082.

2.06.02 **Cement**

Sufficient space for storage, with open passages between stacks, shall be arranged by the Contractor to the satisfaction of the Engineer.

Cement shall be stored off the ground in dry, leak proof, well ventilated ware-houses at the works in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter.

Cement shall be stored in easily countable stacks with consignment identification marks. Consignments shall be used in the order of their receipts at site. Sub-standard or partly set cement shall not be used and shall be removed from the site, with the knowledge of the Engineer, as soon as it is detected.

Different types of cement shall be clearly marked with the type & different types of cement shall not be intermixed.

2.06.03 **Aggregates**

Aggregates shall be stored on planks or steel plates or on concrete or masonry surface. Each size shall be kept separated with wooden or steel or concrete or masonry bulk- heads or in separate stacks and sufficient care shall be taken to prevent the material at the edges of the stock piles from getting intermixed. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths as may be directed by the Engineer.

2.06.04 **Reinforcement**

Reinforcing steel shall be stored consignment wise and size wise off the ground and under cover, if desired by the Engineer. It shall be protected from rusting, oil, grease and distortions. If necessary, the reinforcing steel may be coated with cement wash before stacking to prevent scale and rust at no extra cost to the Owner. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage.

2.07.00 **Quality Control**

Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The quality control operation shall include but not be limited to the following items of work:

a) Admixture : Type, quantity, physical and chemical properties that affect strength, workability and durability of concrete

For air entraining admixtures, dosage to be adjusted to maintain air contents within desirable limits

b) Aggregate : Physical, chemical and mineralogical qualities. Tests for grading, moisture content and impurities.

c) Water : Impurities tests.

d)	Cement	:	Tests to satisfy relevant IS Specifications (If Contractor's supply).
e)	Formwork	:	Material, shapes, dimensions, lines, elevations, surface finish, adequacy of form, ties, bracing and shoring and coating.
f)	Reinforcement	:	Shapes, dimensions, length of splices, clearances, ties and supports. Quality and requirement of welded splices. Material tests or certificates to satisfy relevant IS Specification (If Contractor's supply).
g)	Grades of concrete	:	Usage and mix design, testing of all properties.
h)	Batching & Mixing	:	Types and capacity of plant, concrete mixers and transportation equipment.
i)	Joints	:	Locations of joints, water stops and filler materials. Dimension of joints, quality and shape of joint material and splices.
j)	Embedded & Anchorage Items	:	Material, shape, location, setting.
k)	Placing	:	Preparation, rate of pouring, their limitations, time intervals between mixing and placing and between two successive lifts, covering over dry or wet surfaces, cleaning and preparation of surfaces on which concrete is to be placed, application of mortar/slurry for proper bond, prevention of cold joint, types of chutes or conveyors.
l)	Compaction	:	Number of vibrators, their prime mover, frequency and amplitude of vibration, diameter and weight of vibrators, duration of vibration, hand-spreading, rodding and tamping.
m)	Setting of base & Beaming plates	:	Lines, elevations and bedding mortar.
n)	Concrete Finishes	:	Repairs of surface defects, screening, floating, steel trowelling and brooming, special finishes.
o)	Curing	:	Methods and length of time.

Copies of records and tests for the items noted above, as well as, records of corrective action taken shall be submitted to the Engineer for approval as may be desired.

3.00.00 INSTALLATION

All installation requirements shall be in accordance with IS: 456 and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification do not cover all the aspects to the full satisfaction of the Engineer.

3.01.00 Washing and Screening of Aggregates

Washing and Screening of coarse aggregate shall be carried out to remove fines, dirts or other deleterious materials.

Washing of fine aggregate shall not be allowed, Fine aggregates shall be screened only to remove dirt or other deleterious materials.

However, all washing & screening of aggregates shall be carried out by approved means as approved by the engineer to ensure compliance with the aggregate specification.

3.02.00 Admixture

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete. Admixtures may be permitted to be used in accordance with IS: 456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Engineer reserves the right to require laboratory test or use test data, or other satisfactory reference before granting approval. The admixture shall be used strictly in accordance with manufacturer's directions and/or as directed by the Engineer.

3.03.00 Grades of Concrete

Concrete shall be in any of the grades designated in IS: 456. Grade of concrete to be used in different parts of work shall be as shown on the drawing or as per the Engineer's instructions. In case of liquid retaining structures, IS: 3370 will be followed.

3.04.00 Proportioning and Works Control

3.04.01 General

Proportioning of ingredients of concrete shall be made by any of the two following methods as directed by the Engineer.

a) With preliminary tests by designing the concrete mix. Such concrete shall be called 'Design Mix Concrete'.

b) Without preliminary tests adopting nominal concrete mix. Such concrete shall be called 'Nominal Mix Concrete'.

As far as possible, design mix concrete shall be used on all concrete works. Nominal mix concrete, in grades permitted in accordance with IS: 456 may be used if shown on drawings or approved by the Engineer. In all cases the proportioning of ingredients and works control shall be in accordance with IS: 456 and shall be adopted for use after the Engineer is satisfied regarding its adequacy and after obtaining his approval in writing.

3.04.02 **Mix Design Criteria**

Concrete mixes will be designed by the Contractor to achieve the strength, durability and workability necessary for the job, by the most economical use of the various ingredients. In general, the design will keep in view the following considerations:

a) Consistent with the various other requirements of the mix, the quantity of water should be kept at the lowest possible level.

b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.

c) The various fractions of coarse and fine aggregates should be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.

d) Chemical admixtures may be used to modify the rate of hardening, to improve workability (maintaining low water - cement ratio) or as an aid to control concrete quality.

e) The finished concrete should have adequate durability in all conditions, to withstand satisfactorily the weather and other destructive agencies which it is expected to be subjected to in actual service.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete adopted in design and specified on drawings by the Engineer. The Contractor will strictly abide by the same in his design of concrete mix installation.

Notwithstanding anything mentioned in various tables given in IS: 456 giving specific values and degrees of workability for different condition of concrete placing, minimum cement content and maximum water-cement ratio for concrete exposed to sulphate attack and for concrete to ensure durability under different condition of exposure, strength requirement for different grades of concrete, proportion for nominal mix concrete, the following tables are included in the specification. For identical condition if values given in the tables shown herein below are different from those mentioned in IS: 456, the values as indicated in the table shown herein below shall prevail.

Various trials shall be given by the contractor with specific cement content on each trial. In some cases, plasticizers and other admixtures may be necessary to achieve the desired results.

TABLE – I

STRENGTH REQUIREMENT OF CONCRETE

Grade Designation	Specified Characteristic Compressive strength of 150 mm Cube at 28 days **(All values in N/Sq.mm)**
M 10	10
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40

Note - 1 : Nominal mix concrete of proportions M7.5 or M10 may be used as lean concrete for simple foundations for masonry walls, below the reinforced concrete foundations and mass filling.

Note - 2 : Grades of concrete lower than M20 shall not be used in reinforced concrete.

TABLE - II
MIX PROPORTIONS (BY WEIGHT) EXPECTED TO GIVE DIFFERENT DEGREES OF WORKABILITY WITH DIFFERENT VALUES OF WATER - CEMENT RATIO
(FOR GUIDANCE)
CEMENT/TOTAL AGGREGATE RATIOS

WORKABILITY	WATER/ CEMENT RATIO	RATIO BY WEIGHT OF CEMENT TO GRAVEL AGGREGATE		RATIO BY WEIGHT OF CEMENT TO CRUSHED STONE AGGREGATE	
		20 mm Size	38 mm size	20 mm size	38 mm size
Very low Slump 0-25 mm	0.4	1:4.8	1:5.3	1:4.5	1:5.0
	0.5	1:7.2	1:7.7	1:6.5	1:7.4
	0.6	1:9.4	1:10	1:7.8	1:9.6
	0.7	1:10	1:12	1:8.7	1:10.6
Low Slump 25-50 mm	0.4	1:3.9	1:4.5	1:3.5	1:4.0
	0.5	1:5.5	1:6.7	1:5.0	1:5.5
	0.6	1:6.8	1:7.4	1:6.3	1:7.0
	0.7	1:8.0	1:8.5	1:7.4	1:8.0
Medium Slump 50-100 mm	0.4	1:3.5	1:3.8	1:3.1	1:3.6
	0.5	1:4.8	1:5.7	1:4.2	1:5.0
	0.6	1:6.0	1:7.3	1:5.2	1:6.2
High Slump 100-150 mm	0.4	1:3.2	1:3.5	1:2.9	1:3.3
	0.5	1:4.4	1:5.2	1:3.9	1:4.6
	0.6	1:5.4	1:6.7	1:4.7	1:5.7
	0.7	1:6.2	1:7.4	1:5.5	1:6.5

Note - 1 : Notwithstanding anything mentioned above, the cement/Total aggregate ratio is not to be increased beyond 1:9.0 without specific permission of the Engineer.

Note - 2 : It should be noted that such high aggregate cement ratios will be required or concretes of very low slump and high water-cement ratios which may be required to be used in mass concrete work only.

Note - 3 : The above figures are for guidance only, the actual cement/ aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used and from trial mixes.

3.05.00 **Strength Requirements**

The strength requirements of both design mix and nominal mix concrete where Ordinary Portland Cement or Portland Slag Cement is used shall be as per Table-2 of IS: 456. All other relevant clauses of IS: 456 shall also apply.

3.06.00 **Minimum Cement Content**

The minimum cement content recommended for each grade of concrete will be as shown below as per Table 5 of IS: 456.

TABLE - III

MINIMUM CEMENT CONTENT SPECIFIED FOR DIFFERENT GRADES OF CONCRETE

Grade of Concrete	Minimum Cement Content/Cu.M of Finished Concrete
M 15	Kg 240
M 20	Kg 300
M 25	Kg 300
M 30	Kg 320
M 35	Kg 340
M 40	Kg 360

The minimum cement contents mentioned above are for average conditions and for 20 mm size aggregate. For 40 mm size aggregate the cement content may be reduced (Refer Table 6 of IS: 456).

In case the cement content can be reduced due to continuous and consistent favourable conditions, on account of better quality of cement or by the addition of suitable plasticizer / super plasticizers, then the Engineer may instruct lower cement content, and the Contractor shall abide by the stipulations laid down hereunder:

a) The Contractor shall design the mixes for 10% (Ten per cent) higher strength over and above those specified in Table - I under Clause 3.4, for the various grades of concrete and different slump requirements.

b) Sufficient number of trial mixes (to be decided by the Engineer) will be taken at the laboratory for the various designs and graphs of w/c ratio Vs crushing strengths at various ages will be plotted.

c) All tests will be done in presence of the Engineer who shall be the final authority to decide upon the adoption of any revised minimum cement content. The Contractor will always be responsible to produce quality concrete of the required grade as per the acceptance criteria of IS: 456.

d) The Engineer will always have the unquestionable right to revise the minimum cement content as decided above, if, in his opinion, there is any chance of deterioration of quality on account of use of lower cement content or any other reason.

In case there is a downward revision of the minimum cement content from that specified in the contract, the particular unit rate of concrete will be reduced by an amount equal to the cost of cement saved, calculated at the issue rate. The relevant cost of wastage and handling on the cement saved, which is inherent in the total cost of structure, will not be deducted from the unit rate and will thus pass on to the Contractor.

3.07.00 **Water Cement Ratio**

The choice of water cement ratio in designing a concrete mix will depend on

a) The requirement of strength.

b) The requirement of durability.

3.07.01 **Strength Requirement**

In case of 'Design Mix Concrete', the water-cement ratio of such value as to give acceptable test results as per IS: 456 will be selected by trial and error. The values of water- cement ratios for different grade and mix designs will have to be established after conducting sufficiently large number of preliminary tests in the laboratory to the satisfaction of the Engineer. Frequent checks on test will have to be carried out and the water-cement ratios will be revised if the tests produce unsatisfactory results. Notwithstanding anything stated above the Contractor's responsibility to produce satisfactory test results and to bear all the consequences in case of default remains unaltered.

In case of nominal mix concrete, the maximum water-cement ratio for different grades of concrete is specified in Table-9 of IS: 456 and no tests are necessary. The acceptance test criteria for nominal mix concrete shall be as per IS: 456.

3.07.02 **Durability Requirement**

Tables 3, 4 & 5 of IS: 456 give the maximum water-cement ratio permissible from the point of view of durability of concrete subjected to adverse exposure to weather, sulphate attacks, and contact with harmful chemicals. Impermeability may also be an important consideration.

Whenever the water-cement ratio dictated by durability consideration is lower than that required from strength criterion, the former shall be adopted.

The water cement ratio between 0.4 and 0.45 is generally found desirable to satisfy the durability requirement and from the consideration of impermeability of concrete. The contractor may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer / super- plasticizer. However the contractor has to propose specifically along with field trials in the event of lower cement content if found suitable along with a plasticizer. It will be preferable to use Melamine based plasticizer.

3.08.00 **Workability**

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments and to give the required surface finish shall depend on the type and nature of structure and shall be based on experience and tests. The usual limits of consistency for various types of structures are given below:

TABLE - IV

LIMITS OF CONSISTENCY

Degree of Workability	Slump in mm with Standard Cone as per IS: 1199		Use for which concrete is suitable
	Min.	Max.	
Very low	0	25	Large Mass concrete structure with heavy compaction equipments, roads and like
Low	25	50	Uncongested wide and shallow R.C.C. structures
Medium	50	100	Deep but wide R.C.C. structures with congestion of reinforcement and inserts
High	100	150	Very narrow and deep R.C.C. structures with congestion due to reinforcement and inserts.

NOTE Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer.

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. No extra payment will be made for this additional cement.

The workability of concrete shall be checked at frequent intervals by slump tests. Alternatively where facilities exist or if required by the Engineer, the compacting factor test in accordance with IS: 1199 and Clause 7of IS: 456 shall be carried out.

3.09.00 **Size of Coarse Aggregates**

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer:

Very narrow space	-	12 mm
Reinforced concrete except foundation	-	20 mm
Ordinary Plain concrete and Reinforced concrete foundations	-	40 mm
Mass concrete	-	80 mm
Mass concrete in very large structure	-	150 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the specified proportions, strength and consistency that will work readily into position without segregation.

Coarse aggregate will normally be separated into the following sizes and stacked separately in properly designed stockpiles:

150 mm to 80 mm, 80 mm to 40 mm, 40 mm to 20 mm and 20 mm to 5 mm. In certain cases it may be necessary to further split the 20 mm to 5 mm fraction into 20 mm to 10 mm and 10 mm to 5 mm fractions.

This separation of aggregates in different size fractions is necessary so that they may be remixed in the desired proportion to arrive at a correct internal grading to produce the best mix.

3.10.00 **Mixing of Concrete**

Concrete shall always be mixed in mechanical mixer unless specifically approved by the Engineer for concrete to be used in unimportant out of the way locations in small quantities. Water shall not normally be charged into the drum of the mixer until all the cement and aggregates constituting the batch are already in the drum and mixed for at least one minute. Mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall mixing be done for less than 2 (two) minutes and at least 40 (forty) revolutions after all the materials and water are in the drum. When absorbent

aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Engineer. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing.

The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned & when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Owner to allow for loss in the drum.

Regular checks on mixer efficiency shall be carried out as directed by the Engineer as per IS: 4634 on all mixers employed at site. Only those mixers whose efficiencies are within the tolerances specified in IS: 1791 will be allowed to be employed.

Ingredients for design mix concrete shall be measured by weight. For small jobs portable swing weigh Batchers conforming to IS: 2722 may be used.

Batching plant conforming to IS: 4925 shall be used for large jobs. The accuracy of the measuring equipment shall be within ± 1% of the quantity of Cement, water or total aggregates being measured and within ± 3% of the quantity of any admixture being used. The batching equipment shall be fitted with an accurate mechanism for weighing separately the cement, fine aggregate and coarse aggregate. Water may be measured by volume or by weight. All measuring equipment should be maintained in a clean serviceable condition, and their accuracy shall be checked periodically.

Mechanical/electrical control shall be provided on the mixing equipment to ensure the batch cannot be discharged until approved mixing time has elapsed and the entire batch shall be discharged before the mixer is recharged.

Where admixtures are employed, separate containers & measuring devices shall be used.

For minor concreting works, batching by volume according to specific weight may be permitted by the Engineer. In that case the whole bags of cement shall be used and gauge boxes used for measuring aggregates.

When hand mixing is permitted by the Engineer, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand-mixing, 10% extra cement shall be added to each batch at no extra cost to the Owner.

3.11.00 **Conveying Concrete**

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and

compacted in the final position before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation or loss of any of the ingredients. For long distance haulage, agitator cars of approved design will be used. If, in spite of all precautions, segregation does occur during transport, the concrete shall be properly re-mixed before placement. During very hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers which will reduce the rate of loss of water by evaporation or loss of heat. If necessary, the container may have to be covered and insulated. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipments shall be kept free from set concrete.

3.12.00 **Placing and Compacting Concrete**

Where specifically covered, the relevant I.S. Code will be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in the relevant I.S. Code for any particular aspect of work, any other standard Code of practice, as may be specified by the Engineer, will be adopted. Concrete may have to be placed against the following types of surfaces:

a) Earth foundation
b) Rock foundation
c) Formwork
d) Construction joint in concrete or masonry

The surface on or against which concrete is to be placed has to be cleaned thoroughly. Rock or old construction joint has to be roughened by wire brushing, chipping, sand blasting or any other approved means for proper bond. All cuttings, dirt, oil, foreign and deleterious material, laitance, etc. are to be removed by air water jetting or water at high pressure. All excavated areas for foundations, ring beams, plinths, pile caps etc. shall be rammed & consolidated properly before blinding with nominal mix plain concrete, as per drawing and / or direction of the Engineer and shall be allowed to cure prior to setting out, steel fixing, shuttering and concrete pouring for the main structural element.

Formwork, reinforcement, preparation of surface, embedments, joint seals etc., shall be approved in writing by the Engineer before concrete is placed. As far as possible, concrete shall be placed in the formwork by means approved by the Engineer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1500 mm shall have to be approved by the Engineer.

Rock foundation or construction joint will be kept moist for at least 72 hours prior to placement. Concrete will be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution, as directed by the Engineer will have to be adopted.

Formwork will be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.

A layer of mortar of thickness 12 mm of the same or less w/c ratio and the same proportion as that of the concrete being placed and cement slurry will be spread thoroughly on the rock foundation or construction joint just prior to placement of concrete. The cost of application of such cement slurry and mortar will be deemed to be included in the unit rate of concrete.

After concrete has been placed, it shall be spread, if necessary and thoroughly compacted by approved mechanical vibration to maximum subsidence without segregation and thoroughly worked around shape. Vibrators shall not be used for pushing concrete into adjoining areas. Vibrators must be operated by experienced workmen and the work carried out as per relevant IS Code of Practice. In thin members with heavy congestion of reinforcement or other embedments, where effective use of internal vibrator is, in the opinion of the Engineer, doubtful, in addition to immersion vibrators the contractor may have to employ form vibrators conforming to IS: 4656. For slabs and other similar structures, the contractor will additionally employ screed vibrator as per IS: 2506. Hand tamping may be allowed in rare cases, subject to the approval of the Engineer. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or distorted during placing and consolidation of concrete.

The temperature of concrete shall not exceed 40 deg C measured at discharge into the works. However, for STG Top Deck and foundations for rotating equipments the temperature at discharge point of concrete shall not exceed 28 degree C or as per the instruction of the Engineer.

The maximum allowable temperature differential between any two points in the same element is 15 deg Additional temperature control measures during construction (such as use of insulated formwork) shall be required. Contractor to prepare a process control chart and method statement verifying measures to achieve these requirements.
The temperature monitoring of concrete work is required where:

a) the minimum dimension of any casting is 0.8m or more, or

b) where otherwise instructed by the Engineer

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken

in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete.

The size of the concrete pours must be carefully considered prior to commencement to ensure the structural elements are poured in on continuous shift to avoid cold joints.

Slabs, beams and similar members shall be poured in one operation, unless otherwise instructed by the Engineer. Moulding, throating, drip course, etc., shall be poured as shown on the drawings or as directed by the Engineer. Holes shall be provided and bolts, sleeves, anchors, fastenings or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Engineer. Any deviation therefrom shall be set right by the Contractor at his own expense as instructed by the Engineer.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same at the Contractor's expense.

The Engineer shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position, it shall not be distributed.

3.13.00 Construction Joints and Cold Joints

3.13.01 Construction Joints

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete at certain predetermined stages. These joints will be formed in a manner specified in the drawings/Instruction. Vertical construction joints will be made with rigid stop-board forms having slots for allowing passage of reinforcement rods and any other embedments and fixtures that may be shown. Next stage concrete shall be placed against construction joint as per clause 3.12. For water retaining structures and leak-proof buildings suitable approved water bars will be installed at the construction joints.

Where the locations of the joints are not specified, it will be in accordance with the following:

a) In a column, the joint shall be formed 75 mm below the lowest soffit of the beam framing into it.

b) Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and within the middle third of the span.

c) A joint in a suspended floor slab shall be vertical and within the middle third of the span and at right angles to the principal reinforcement.

d) Feather-edges in concrete shall be avoided while forming a joint.

e) A construction joint should preferably be placed in a low-stress zone and at right angles to the direction of the principal stress.

f) In case the Contractor proposes to have a construction joint anywhere to facilitate his work, the proposal should be submitted well in advance to the Engineer for study and approval without which no construction joint will be allowed.

3.13.02 **Cold Joint**

An advancing face of a concrete pour, which could not be covered by fresh concrete before expiry of initial setting time (due to an unscheduled stoppage or delay on account of breakdown in plant, inclement weather, low rate of placement or any other reason), is called a cold joint. The Contractor should always remain vigilant to avoid cold joints.

If, however, a cold joint is formed due to unavoidable reasons, the following procedure shall be adopted for treating it:

a) If the concrete is so green that it can be removed manually and if vibrators can penetrate the surface without much effort, fresh concrete can be placed directly against the old surface. The old concrete should be covered by fresh concrete as quickly as possible and the joint thoroughly and systematically vibrated.

b) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface will be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. A rich mortar layer 12 mm in thickness will be placed on the cold joint, fresh concrete shall be placed on the mortar layer and the joint will be thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not rise inspite of extensive vibration, the joint will be left to harden for at least 12 - 24 hrs. It will then be treated as a regular construction joint, after cutting the

concrete to required shape and preparing the surface as described under clause 3.12.

3.14.00 **Repairs, Finishes and Treatment of Concrete surfaces**

3.14.01 Adequate and sound concrete surfaces, whether formed or unformed, can be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing and consolidation by experienced workmen.

Unsound concrete resulting from improper mix design, incompetent methods, equipment and formwork, poor workmanship and protection will not be accepted and will have to be dismantled, removed and replaced by sound concrete at the Contractor's cost. The Engineer may, at his sole discretion, allow to retain concrete with minor defects provided the Contractor is able to repair it by approved methods at no extra cost to the Owner. All concrete work shall be inspected by the Contractor immediately after the forms are removed and he will promptly report occurrence of any defects to the Engineer. All repair works will be carried out as per the instructions and in the presence of the Engineer or his representative. Generally, repair work will consist of any or all of the following operations:

a) Sack rubbing with mortar and stoning with carborundum stone.

b) Cutting away the defective concrete to the required depth and shape.

c) Cleaning of reinforcement and embedments. It may be necessary to provide an anticorrosive coating on the enforcement.

d) Roughening by sand blasting or chipping.

e) Installing additional reinforcement/welded mesh fabric.

f) Dry packing with stiff mortar.

g) Plastering, guniting, shotcreting etc.

h) Placing and compacting concrete in the void left by cutting out defective concrete.

i) Grouting with cement sand slurry of 1:1 mix.

j) Repairing with a suitable mortar either cement or resin modified mortar.

k) Polymer modified patching and adhesive repair mortar for beams & columns.

3.14.02 **Finishing Unformed Surface**

The Contractor is to include in his quoted rate for concrete, the provision of normal finishes in unformed surfaces which can be achieved by screeding, floating, trowelling etc., as and where required by the Engineer without any extra cost to the Owner. A few typical and common cases of treatment of concrete surface are cited below:

a) **Floor**

Whenever a non-integral floor finish is indicated, the surface of reinforcement concrete slab shall be struck off at the specified levels and slopes and shall be finished with a wooden float fairly smooth removing all laitance. No overtrowelling, to obtain a very smooth surface, shall be done as it will prevent adequate bond with the subsequent finish. If desired by the Engineer, the surface shall be scored and marked without any extra cost to the Owner to provide better bond.

Where monolithic finish is specified or required, concrete shall be compacted and struck off at the specified levels and slopes with a screed, preferably a vibrating type and then floated with a wooden float. Steel trowelling by hand or by rotary power float is then started after the moisture film and shine have disappeared from the surface and after the concrete has hardened enough to prevent excess of fines and water to rise to the surface but not hard enough to prevent proper finishing of aberrations. Steel trowelling properly done will flatten and smoothen sandy surface left by wooden floats and produce a dense surface free from blemishes, ripples and trowel marks. A fine textured surface that is not slick and can be used where there is likelihood of spillage of oil or water can be obtained by trowelling the surface lightly with a circular motion after initial trowelling keeping the steel trowel flat on the surface.

To provide a better grip the Engineer may instruct marking the floor in a regular geometric pattern after initial trowelling.

b) **Beams, Columns & Walls**

If on such or any other concrete structure it is intended to apply plaster or such concrete surfaces against which brickwork or other allied works are to be built, the Contractor shall hack the surface adequately as soon as the form is stripped off so that proper bond can develop. Pattern, adequacy and details of such hacking shall meet with the approval of the Engineer, who shall be informed to inspect such surfaces before they are covered up.

3.15.00 **Protection and Curing of concrete**

Newly placed concrete shall be protected by approved means from rain, sun and wind. Concrete placed below the ground level shall be protected against contamination from falling earth during and after placing. Concrete placed in ground containing deleterious substances, shall be protected from contact with such ground, or with water draining from such ground, during placing of concrete and for a period of at least three days or as otherwise instructed by the Engineer. The ground water around newly poured concrete shall be kept to an approved level by pumping out or other adequate means of drainage to prevent floatation or flooding. Steps, as approved by the Engineer, shall be taken to protect immature concrete from damage by debris, excessive loadings, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently, it shall be covered either with sand, polythene sheet, hessian, canvas or similar materials & kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water will be allowed if the Engineer is satisfied with the adequacy of the arrangements made by the Contractor.

If permitted by the Engineer, curing compound like "ANTISOLE (WP)" or approved equivalent may be used for prevention of premature water loss in concrete and thereby effecting curing of concrete. This type of curing compound shall be sprayed on newly laid concrete surfaces to form thin film barrier against premature water loss without disturbances to normal setting action. The curing compound shall comply with ASTM requirements for acceptance.

The curing compound shall be applied following the final finishing operation and immediately after disappearance of water sheen from concrete surface. It is important not to apply the curing compound when standing water is still present on concrete.

The contractor shall arrange for the manufacturer’s supervision at no extra cost to the owner.

The Contractor shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. The Engineer's decision

regarding the adequacy of curing is final. In case any lapse on the part of the Contractor is noticed by the Engineer, he will inform the Contractor or his supervisor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the Contractor within 3 (three) hours of issuance of such instruction, the Engineer will be at liberty either to employ sufficient means through any agency to make good the deficiency and recover the cost thereof from the Contractor, or pay for the part where adequate curing was not noticed at a reduced rate, entirely at the discretion of the Engineer.

3.16.00 **Reinforcement**

Mild steel round bars, cold twisted and deformed bars as medium tensile or high yield strength steel, plain hard drawn steel wire fabric etc., will be used as reinforcement as per drawings and directions. In an aggressive environment an anti-corrosive coating on the reinforcement may be provided as per IS: 9077, as shown on the drawing or as directed by the Engineer.

3.16.01 **Bar Bending Schedules**

The Contractor shall submit to the Engineer for approval of Bar Bending Schedules with working drawings in triplicate, showing clearly the arrangements proposed by the Contractor to match available stock of reinforcing steel, within one month of receipt of the Letter of Intent or of the receipt of the relevant design drawings, whichever is later. Upon receipt of the Engineer's final approval of the Bar Bending Schedule and drawings, the Contractor shall submit 6 (six) prints of the final drawings with one reproducible print after incorporating necessary modifications or corrections, for final record and distribution. Approval of such detailed drawings by the Engineer shall not relieve the Contractor of his responsibility for correctness nor of any of his obligations to meet the other requirements of the Contract.

3.16.02 **Cleaning**

All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

3.16.03 **Cutting & Bending of Reinforcement**

Unless otherwise specified, reinforcing steel shall be bent in accordance with the procedure specified in IS:2502 or as approved by the Engineer. Bends and shapes shall comply strictly with the dimensions corresponding to the approved Bar Bending Schedules. Bar Bending Schedules shall be rechecked by the Contractor before any bending is done.

No reinforcement shall be bent when already in position in the work, without approval of the Engineer, whether or not it is partially embedded in concrete.

Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Engineer. Reinforcing bars

above 16 mm diameter shall be bent by machine producing a gradual and even motion. Bars of 16 mm or below may be bent by hand. All the bars shall be cold bent unless otherwise approved. Bending hot at a cherry-red heat (not exceeding 845 Deg.C) may be allowed under very exceptional circumstances except for bars whose strength depends on cold working. Bars bent hot shall not be cooled by quenching.

Reinforcing bars, whether high yield or mild steel shall be cut using either hand held shears, guillotines or foot operated pneumatic cutters. Cutting bars using cold chisels may be allowed by the Engineer at exceptional cases.

3.16.04 **Placing in Position**

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings by such approved and adequate means like mild steel chairs and/or concrete spacer blocks irrespective of whether such supports are payable or not. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by No. 20 G annealed soft iron wire. Tack welding of bars should not be done unless permitted by the Engineer. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be spaced such that the main bars do not sag perceptibly between adjacent spacers. Before actual placing, the Contractor shall study the drawings thoroughly and inform the Engineer in case he feels that placement of certain bars is not possible due to congestion. In such cases he should not start placing any bar before obtaining clearance from the Engineer.

3.16.05 **Welding**

Normal bond laps in reinforcement may be placed by lap or butt welding reinforcement bars, if asked by the Engineer, under certain conditions. The work should be done with suitable safeguards in accordance with relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction as per IS:2751 and IS:456. Welded mesh fabrics conforming to IS: 1566 may also be used if specified in the Schedule of Items and Drawings.

3.16.06 **Control**

The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be examined by the Engineer for accuracy of placement and cleanliness. Necessary corrections as directed by him shall be carried out. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length. The laps shall be staggered as far as practicable and as directed by the Engineer. Arrangements for placing concrete shall be such that reinforcement in position does not have to bear extra load and get disturbed.

The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Engineer. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar not leaner than 1 (one) part cement to 2 (two) parts sand by volume and cured in a pond for at least 14 (fourteen) days. The type, shape, size and location of the concrete blocks shall be as approved by the Engineer.

3.17.00 **Cold Weather Concreting**

When conditions are such that any operation of concreting may be expected to be done at 5 Deg.C atmospheric temperature or below the work shall conform to the requirement of Clause 14 of IS: 456 and IS: 7861(Part II).

3.18.00 **Hot Weather Concreting**

When depositing concrete in very hot weather, the Contractor shall take all precautions as per IS:7861 (Part-I) and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 40 Deg.C while placing. Positive temperature control by precooling, postcooling or any other method, if required, will be specified and paid for separately.

3.19.00 **Concreting under water**

When it is necessary to deposit concrete under water it shall be done in accordance with the requirements of clause 14.2 of IS: 456.

3.20.00 **Form Work**

3.20.01 **General**

The formwork shall be designed and constructed as per clause 11 of IS 456. Formwork shall conform to the shape, grade, lines, levels and dimension as shown on the drawings. The contractor shall prepare design & working drawings for formwork & temporary support system for important structures and get them approved by the Engineer prior to commencement of actual work.

Materials used for the formwork inclusive of the supports and centering shall be capable of withstanding the working load and remain undistorted throughout the period it is left in service. All supports and scaffolds should be manufactured from structural or tubular steel except when specifically permitted otherwise by the Engineer.

The centering shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rakers are to be used where forms are to support inclined members. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as a liquid as well as the

working load. In case the Contractor wishes to adopt any other design criteria, he has to convince the Engineer about its acceptability before adopting it. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of slurry or mortar.

To achieve the desired rigidity, tie bolts, spacer blocks, tie wires and clamps as approved by the Engineer shall be used but they must in no way impair the strength of concrete or cause stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Alternatively, except in case of water retaining structures through rods and the tie bolts shall be sleeved with PVC conduits to allow retraction of the ties on removal of the shutters. Where required, the annulus of the conduits will be filled with expanding mortar to seal the void. Bolts passing completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork shall not be used.

The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Engineer immediately and rectified free of charge as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion- resistant devices. Rigid care shall be exercised in ensuring that all column forms are plumb and true and thoroughly cross braced to keep them so. All floor and beam centering shall be crowned not less than 8 mm in all directions for every 5 metres span. Unless specifically described on the drawings or elsewhere to the contrary, bevelled forms 25 mm by 25 mm shall be fixed in the form-work at all corners to provide chamfering of the finished concrete edges without any extra charge. The formwork should lap and be secured sufficiently at the lift joints to prevent bulges and offsets.

Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where they are necessary and as may be directed by the Engineer. The temporary openings shall be so formed that they can be conveniently closed when required, during pouring operations without leaving any mark on the concrete.

3.20.02 **Cleaning and Treatment of Forms**

All parts of the forms shall be thoroughly cleaned of old concrete, wood shavings , saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish, loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Compressed air jet and/or water jet along with wire brushes, brooms etc. shall be used for cleaning. The inside surface of the formwork shall be treated with approved non-staining oil based shutter release agent like "Separol/Sika form oil/ Siparol Concentrate" or approved equivalent before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork. The oiling of the formwork will be inspected just prior to placement of concrete and redone wherever necessary.

3.20.03 **Design**

The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns and walls are independent of the soffits of beams and can be removed without any strain to the concrete already placed or affecting the remaining formwork. Removing any props or repropping shall not be done except with the specific approval of the Engineer. If formwork for column is erected for the full height of the column, one side shall be left open and built up in sections, as placing of concrete progress. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment and alignment of the formwork and to allow it to be removed gradually without jarring the concrete.

The design of formwork shall take into account all vertical and lateral loads that the forms will carry or be subjected to during the construction process. Besides weight and pressures of reinforced concrete and weight of the forms themselves, the design shall consider loading due to unsymmetrical placement of concrete; impact from dumping of concrete; movement of men and construction equipment; wind action and any other imposed load during construction. The contractor shall assess the magnitude of vertical live load to be taken for design of formwork duly considering his method, sequence and rate of pour of concrete. However, minimum design vertical live load to be considered shall be 750 kg/sqm excluding weight of concrete. Regarding design and detailing of formwork, reference may be made to IS 14687.

3.20.04 **Inspection of Forms**

Casting of Concrete shall start only after the formwork has been inspected and approved by the Engineer. The concreting shall start as early as possible within 3 (three) days after the approval of the formwork and during this period the formwork shall be kept under constant vigilance against any interference. In case of delay beyond three days, a fresh approval from the Engineer shall be obtained.

3.20.05 **Removal of Forms**

Before removing any formwork, the Contractor must notify the Engineer well in advance to enable him to inspect the concrete if he so desires.

The Contractor shall record on the drawing or in any other approved Banner, the date on which concrete is placed in each part of the work and the date on which the formwork is removed there from and have this record checked and countersigned by the Engineer regularly. The Contractor shall be responsible for the safe removal of the formwork and any work showing signs of damage through premature removal of formwork or loading shall be rejected and entirely reconstructed by him without any extra cost to the Owner. The Engineer may, however, instruct to postpone the removal of formwork if he considers it necessary.

Forms for various types of structural components shall not be removed before the minimum periods specified herein and the removal after the minimum periods shall also be subject to the approval of the Engineer in each case.

TABLE – V

SCHEDULE OF REMOVAL OF FORM

	Ordinary Portland Cement Concrete				Rapid Hardening Portland Cement Concrete			
Part of Structure	Temperature Deg. C				Temperature Deg. C			
	> 40	40 -20	20 - 5	< 5	> 40	40 -20	20 - 5	< 5
	Days	Days	Days	Days	Days	Days	Days	Days
a)Columns & Walls	2	1	1	Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength	1	1	1	Do not remove forms until site cured test specimen develop at least 50% of the specified 28 days strength
b)Beam sides	3	2	3		2	1	1	
c)Slabs, 125 mm	10	7	8		7	4	5	
d)Slabs over 125 mm thick and soffit of minor beams	18	14	16		12	8	9	
e)Soffit of main beams	24	21	22		14	10	12	

Wherever exposed surfaces of concrete can be effectively sealed to prevent loss of water, the periods specified for temperature above 40 Deg.C can be reduced to those of the temperature range of 20 Deg.C to 40 Deg.C subject to approval of the Engineer.

Construction joints in beams, if required to be provided, will be located within the middle third of span according to clause 3.13.1(b) of this specification. In such cases, however, entire span of beam shall have to be kept supported by formwork till its removal for the portion of beam, cast at a later date, is due and so approved by the Engineer.

If any type of cement other than ordinary Portland cement and Rapid hardening Portland cement is used the time of removal or forms shall be revised as approved by the Engineer such that the strength of this cement at the time of removal of forms match with strength of Portland cement at the time of removal of form as mentioned above. This has to be supported by regular tests.

3.20.06 **Tolerance**

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as shown on the drawings subject to the following tolerances unless otherwise specified in this Specification or drawings or directed by the Engineer:

For -	a)	Sectional dimension	-	± 5 mm
	b)	Plumb	-	1 in 1000 of height
	c)	Levels	-	± 3 mm before any deflection has taken place

The tolerance given above are specified for local aberrations in the finished concrete surface and should not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which should be as accurate as possible to the entire satisfaction of the Engineer. Any error, within the above tolerance limits or any other as may be specially set up by the Engineer, if noticed in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

3.20.07 **Re-use of Forms**

Before re-use, all forms shall be thoroughly scraped, cleaned, joints and planes examined and when necessary repaired, and inside surface treated as specified herein before. Formwork shall not be used / re-used if declared unfit or unserviceable by the Engineer.

3.20.08 **Classification**

Generally, the 'ordinary' class formwork shall be used unless otherwise directed by the Engineer:

a) **Ordinary**

These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) **Plywood**

These shall be used in exposed surfaces, where a specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. Re-use may only be permitted after special inspection and approval by the Engineer. He may also permit □hosphate□n of used plywood for the 'ordinary' class, if it is still in good condition.

c) **Ornamental**

These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

d) **Metal Decking**

The metal decking shall consist of cold rolled light gauge mild steel sheets conforming to IS: 513 having a troughed profile and a minimum thickness of 0.8 mm. The troughed profile of the sheet shall be such that the depth of the valley is minimum 44 mm and center to center of the valley is about 130 mm. The decking sheets are to be □hosphate on both sides conforming to IS: 3618. The phosphating shall be medium duty B class conforming to the above code. Over the phosphating the decking sheets shall be coated with one coat of chlorinated rubber paint applied on outside face at the manufacturer's work. Metal deck shall be installed strictly in accordance with manufacturer's recommendations.

3.21.00 **Opening, Chases, Grooves, Rebates, Blockouts etc.**

The Contractor shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings or as specified by the Engineer.

3.22.00 **Anchor Bolts, Anchors, Sleeves, Inserts, Hangers, Conduits, Pipes and other Miscellaneous Embedded Fixtures**

The Contractor shall build into concrete work all the items noted below and shall embed them partly or fully as directed and secure the same as may be required. The materials, if required to be supplied by the Contractor, shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Engineer. Exposed surfaces of embedded materials are to be painted with one coat of approved anti- corrosive paint and/or bituminous paint without any extra cost to the Owner. If welding is to be done subsequently on the exposed surface of embedded material the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be required or directed by the Engineer, free of cost to the Owner.

Items to be embedded -

a) Inserts, hangers, anchors, frames around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.

b) Anchor bolts and plates for machinery, equipment and for structural steel work.

c) Steel structures to be left embedded for future extension, special connection etc.

d) Lugs or plugs for door and window frames occurring in concrete work.

e) Flashing and jointing in concrete work.

f) Any misc. embedments and fixture as may be required.

Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Contractor.

3.23.00 **Expansion and Isolation Joints**

3.23.01 **General**

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as may be specified on the drawings or as directed by the Engineer. All materials are to be procured from reliable manufacturers and must have the approval of the Engineer. Where it is the responsibility of the Contractor to supply the material, the Engineer may demand test certificates for the materials and/or instruct the Contractor to get them tested in an approved laboratory free of cost to the Owner. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints should be obtained from the Engineer before starting the work.

3.23.02 **Bitumen Board/Expanded Polystyrene Board**

a) **Bitumen Board**

Bitumen impregnated fiber board of approved manufacturer as per IS: 1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and possess a high degree of rebound. The dimensions of the board should be equal to that of the joint being formed. It should, preferably be manufactured in one piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

b) **Expanded Polystyrene Boards**

If required, commercial quality of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material will have to be procured from reliable manufacturers as approved by the Engineer. The method of installations will be similar to that recommended by the manufacturers for fixing on cold storage walls. A coat of Bitumen paint may have to be applied on the board against which concrete will be placed.

3.23.03 **Joint Sealing Strips**

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure. The sealing strips will be non-metallic like rubber or P.V.C.

Sealing strips will not have any longitudinal joint and will be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs. The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Engineer. The Contractor is to supply all labour and material for installation including the material and tools required for jointing, testing, protection, etc. If desired by the Engineer, joints in rubber seals may have to be vulcanized.

Non-metallic sealing strips will be normally in Rubber or P.V.C. Rubber or P.V.C. joint seals can be of shape having any combination of the following features:

i) Plain

ii) Central bulb

iii) Dumb-bell or flattened ends

iv) Ribbed and Corrugated Wings

v) V shaped

As these types of seals can be easily handled in very large lengths, transverse joints will be allowed only under unavoidable circumstances and with the specific approval of the Engineer.

The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or as approved by the Engineer taking particular care to match the central bulbs and the edges accurately.

a) **Rubber Sealing Strips**

The minimum thickness of Rubber sealing strips shall be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings/schedule of items and/or as directed by the Engineer. The material will be natural rubber and be resistant to corrosion, abrasion and tear and also to attacks from the acids, alkalis and chemicals normally encountered in service. The physical properties will be generally as follows. The actual requirements may be slightly different as decided by the Engineer:

Specific Gravity	:	1.1 to 1.15
Shore Hardness	:	65A to 75A
Tensile Strength	:	25 – 30 N/Sq.mm
Max. Safe Continuous Temperature	:	75 Deg.C
Ultimate Elongation	:	Not less than 350%

b) **P.V.C. Sealing Strips**

The minimum thickness of P.V.C. sealing strips will be 3 mm and the minimum width 100 mm. The actual size and shape will be as shown in drawings/schedule of items and/or as directed by the Engineer. The material should be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows. The actual requirements, which will be directed by the Engineer, may vary slightly:

Specific Gravity	:	1.3 to 1.35
Shore Hardness	:	60A to 80A
Tensile Strength	:	10 – 15 N/Sq.mm
Max. Safe Continuous Temperature	:	70 Deg.C
Ultimate Elongation	:	Not less than 275%

3.23.04 **Joint Sealing Compound**

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS: 1834.

Alternatively, when directed, the expansion Joints may be filled with joint sealing compound like "Sikalastic" or approved equivalent and shall be applied as per manufacturer's specification.

3.23.05 **Isolation Joints**

Strong and tough alkathene or PVC sheet or equivalent, about 1 mm in thickness and as approved by the Engineer shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

3.23.06 **Rubber Pad**

Hard foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings or as directed by the Engineer. The rubber shall have a unit weight of 1500 Kg/Cu.m, a shore hardness – 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

3.24.00 **Grouting under Machinery or Structural Steel Bases**

If required, grouting under base plates of machines or structural steel etc. shall be carried out by the Contractor. In general, the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Engineer, 6 mm down stone chips may have to be used in the mix. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. Finished grout shall be cured to ensure proper strength. If desired by the Engineer, admixtures like Aluminium powder, 'Ironite' etc. may have to be added with the grout in proportions to be decided by the Engineer. Admixture, if directed to be added, without any extra cost to the owner.

Alternatively non-shink, free flow, cementious grout like "Sikagrout 214 / Ankor NSG" / Masterflow 918 or approved equivalent specifically selected for the type of equipment to be located (vibrating , static etc.) may also be used for grouting as per manufacturer's specification with necessary approval of the Engineer.

3.25.00 **Concrete for Special Work**

3.25.01 **Precast Concrete**

The Specification for precast concrete will be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose.

This yard shall be dry, properly leveled and having a hard and even as well as well drained surface to prevent excessive uneven settlement due to softening of soil during casting & curing. If the ground is to be used as a soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportions) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Engineer, casting will have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 10 (Ten) days of curing and can be removed for erection after 28 (twenty eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal and must be rigid enough to prevent distortion during placing and compaction of the concrete.

Other than normal curing by applying water through spray nozzles or perforated hose curing by high pressure steam, steam vapour or other accepted processes may also be employed to accelerate the hardening of the concrete and to reduce the curing time.

Lifting hooks, where necessary or as directed by the Engineer, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

All members shall be indelibly marked with a unique identification mark on a surface which will not be permanently exposed to show on which production line they were manufactured, their type, the class of concrete, the data of casting and if they are of a symmetrical section the face which will be uppermost when the member is in its correct position after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Engineer. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, leveling and plumbing shall be done as per instructions of the Engineer. The Contractor shall render all help with instruments, materials and men to the Engineer for checking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Engineer. If centering have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar where called for in the drawings.

3.25.02 **Construction by Slip/Jump/Climb form Method**

Slip/Jump/Climb form method of construction when considered by the Bidder, type of process proposed for formwork should be indicated in the bid along with sketches, drawings and construction methods statement as explained hereinafter. Number, type and capacities of jacks, the control system and achievable rate of progress (in case of slip form) in mm/hour should also be indicated. The chosen scheme shall be of a past proven design. A certified performance record of the scheme should be submitted with the offer to guarantee workability of the scheme both from execution time and safety point of view.

The Bidder should furnish a brief but comprehensive report indicating the planning and method of work to be followed at the time of submitting the Bid. This report shall include the following items :

Type and description of (Slip/Jump/Climb) formwork proposed along with Equipment and its accessories.

i) Design of scaffolding and staging.

ii) Description of materials including admixtures to be used for construction.

iii) Manpower planning, construction spaces required and standby arrangement.

iv) Temporary Lightning arrestor arrangement.

v) Rate of Slip-forming/average rate of Jumps/Climbs per week.

vi) Proposed workability requirement of concrete and type of cement & admixture to be used.

vii) Quality and safety assurance programme.

viii) Method of Transportation of material

ix) Planned interruption, if proposed and activities during planned interruption.

x) Treatment of construction joints.

xi) Contingency solution for unplanned interruptions.

xii) Time of completion.

While selecting the Contractor, due consideration will be given to the merit of the above mentioned method statement proposed by the Bidder and minimum time of completion, apart from his past experience in such types of work and also his technical and financial resources.

Notwithstanding what have been specified in earlier clauses, following guidelines are being presented which should be kept in view by intending Bidders, while quoting for Slip/Jump/Climb form method of construction:

1. Care to be taken to prevent dragging of concrete alongwith upward movement or removal of the shuttering. For this purpose following steps are advisable:

    a) Shutter plates have to be smooth and should be thoroughly clean.

    b) In areas where concrete thickness is 750 mm or more rate of pouring should be such that the minimum slipping rate of slip form is 100 mm per hour.

    c) Mix design should be so done that it will be self-lubricant at the contact face of shutter and concrete and thus reduce friction. Suitable cement of approved manufacturer (conforming to relevant I.S. Specification) may be used for the purpose. An optimum ratio of coarse/fine aggregate should be established to suit the purpose depending on the type of aggregates used.

    d) Mix design also should be so done that it has a slump of minimum 50 mm at the point where concrete is placed under the ambient temperature conditions. This will also keep the required vibration by needle vibrators to minimum. Slump should not drop down to zero in less than 45 minutes. Suitable retarding agent and plasticizer of approved manufacture may be added in the mix to achieve this purpose. These admixtures to be properly identified by preliminary tests both for performance and for compatibility with particular type of cement and aggregates proposed to be used. The admixtures shall be used strictly as per the manufacturer's Specification.

    Additional steps like spraying of water over the shutters and keeping down the temperature of coarse aggregates by continuous spraying of water over those may be resorted to if ambient temperature is higher than 40 Deg.C.

2. Care must be taken to prevent twist, which predominantly occurs in the initial stages because of low slipping rate, in the horizontal plane of Slip-form assembly. A thorough check on this aspect must be kept at every 15 minutes interval. One person should exclusively be assigned this work together with rectifying any defect.

3. Every endeavor has to be made to eliminate any tilt in the shutter assembly. To achieve this following steps need be taken:

   a) Performance of jacks has to be closely observed and any defective one needs immediate replacement. Difference in levels of opposite jacks at any instant of time should not exceed 5 mm.

   b) Loading on Slip-form truss/yokes or A-Frame and hoist has to be fairly equal.

   c) Sleeves, through which the jacking rod passes for slip form shuttering, has to be of sufficient length so that the latter gets a uniform clearance and does not get any chance to tilt. Sleeves should have a minimum wall thickness of 3.25 mm and should be such that jacking rod gets a maximum clearance of 1 mm to 1.5 mm around.

4. In designing the mix following aspects should be borne in mind:

   a) Cement used should have an initial setting time of not less than 50 minutes and preferably should have a specific surface around 3700 Sq.Cm./gramme.

   b) Coarse and fine aggregates should be well graded and rounded aggregates offer better performance in Slip-form technique. These help to keep down water/cement ratio and also offer better lubrication between concrete and shutter surface. 40 mm down size of coarse aggregates should preferably be used unless reinforcement detailing calls for lesser size aggregates.

   c) From the point of view of creep, shrinkage as well as initial setting property of concrete, cement content should not preferably be more than 400 Kg. per Cu.M of concrete.

   d) Minimum compressive strength (after 4 to 6 hours of mixing) of concrete immediately below the shutter as slipform proceeds should not be less than 0.1 MPa.

   e) It is advisable to use cement from a single source during the entire operation of shell casting using slip form technique since once the operation starts, there might not be any time left for conducting further trial for design mixes if the source of procurement of cement changes.

5. Large diameter vibrator needles should not be used for vibrating concrete. Sizes of these needles should preferably be restricted to 25 mm diameter. 40 mm diameter may be used only in exceptional cases. Sufficient numbers (at least two) of standby vibrator units should always be maintained on top of working deck at all times during the entire period of shell casting operation.

6. Proper arrangement has to be made for adequate supply of curing water for continuous spraying on both inside and outside surfaces with spraying equipment. Necessary length of pipelines and pumps of adequate capacity and head to serve the purpose shall be made available with Stand-by arrangements.

   Membrane curing compounds may be allowed on fresh surfaces emerging out of shutter panels for curing. The applied compound has to be removed suitably before further surface treatment. If curing compound is to be used then the compound to be applied should be such that it may be removed easily without leaving any stain on the concrete surfaces.

7. Exact number and capacity of jacks as well as spacing of yoke frames are to be determined taking into account various loadings including self weight of the system, dead and live loads on working and other platforms, horizontal load on formwork, wind load etc.

   It is desirable that the jacking system, based on which the slip/climbing form system works, should consist of jacks 3 Tonne to 6 Tonne capacity and hydraulic pump with necessary pipe connections.

   Spacing of yoke legs should preferably be kept within 2 metres to prevent overloading on jacks and consequent failure resulting in twist of the formwork.

   Jacking rods should be of 25 mm diameter for 3 Tonne Jacks and 32 mm diameter for 6 Tonne Jacks.

8. At least 30% spare jacks and jacking rods should be kept ready during the entire operation. It is obligatory to maintain spare hydraulic pump along with a set of loose pipes in perfect working condition on top of working deck.

9. In sections where thickness is 500 mm or more it is prudent to go in for two nos. of jacks for each slipform yoke.

10. For effective utility of this technique following areas need careful attentions at the very conceptual stage :

a) Detailed quality assurance programme.

b) Advance Planning and preparations.

c) Arrangement for on-site supervision and adequate access facilities.

11. Construction methods including description and types of different equipment proposed to be used, structural arrangement and analysis of the system, description and type of different materials, planned interruptions, description and frequency of various checks and tests for Slipform/climbing technique as well as for material, method of preparing, transporting and pouring of concrete, solution for probable defects during slipping, sequence of operations during planned interruptions etc. should be prepared beforehand by executing agency and to be approved by Engineer before starting the actual work.

12. Placing and binding of reinforcement is also a very critical item and needs special attention. From practical considerations not more than two or three layers of horizontal steel can be tied at a time and this causes a definite limitation in placement of reinforcement.

    Vertical reinforcements should be kept vertical by providing suitable holders within the formwork system.

13. For Slip form process, in particular, it is desirable to have a planned break of at least one day for every two weeks of continuous operation. Such break should be utilized for various maintenance activities, removal of jack rods etc.

14. Numbers and locations of hoists for lifting concrete, reinforcement and other materials have to be planned well in advance. Capacity of hoists should be such as to match with hourly requirement of concrete and reinforcement. If felt necessary one hoist may be exclusively earmarked for transporting concrete. For movement of personnel supervising the work a separate hoist must be arranged for.

15. If concrete is to be placed using concrete pumps then the complete operation such as mix design, transportation and placing of concrete, availability of sufficient equipment such as truck mixers, concrete pumps, placer booms etc. should be well planned and ensured before the concreting activities commence.

16. The slipform system being operative round the clock it is obligatory to have adequate lighting arrangement both on various platform levels as well as on ground below. Arrangement has to be made for facilitating continuous upward movement of the entire system along with slipform.

17. The vertical alignment must be checked constantly using laser equipment. Further manual checks should be performed using plumb bobs, theodolites or other means.

18. In case of interruption in the course of slipping of formwork following measures should be taken :

    a) Provision of a key and additional reinforcement at the junction of new and old concrete.

    b) Formwork system should be brought up freely to have a minimum overlap of 100 mm or so over previously cast concrete.

    c) Washing of old concrete surface with compressed air and water jet and thereafter pouring a layer of neat cement grout.

    d) Clearing of shuttering panels of loose materials, concrete etc. by compressed air and applying a coat of epoxy paint, if felt necessary by Engineer.

    e) Neatly finishing the interface of old and new concrete as soon as it comes out of shutter panel.

19. It is preferable to suspend the construction work under high wind condition and high lightning frequency.

20. It is of utmost importance that for effective implementation of this system an Engineer fully conversant with Slip/Jump/Climb form technique with enough experience in planning and control of formwork should be in overall command of the site and he should be ably supported by well trained mid level supervisory staff, skilled workers and operators.

21. Operation of slip/Jump/Climb form method of construction is practically a continuous/continual operation and demands continuous and intermittent inspection of accuracies in line, level, dimensions and position and immediate rectification of any noticed deviation. All these ask for personnel of high quality having constant vigilance over the construction activity.

22. While all the activities in effective implementation of the work needs utmost care keeping safety of men and material in mind it is obligatory that all activities should be carried out under the guidance of a qualified and trained safety Engineer.

    Safety measures as listed below must be adhered to but should not be limited to only these :

    a) Safety helmets and belts to be provided to a supervising staff and workers.

    b) Safety nets to be provided below both inside and outside platforms as instructed by Engineer.

    c) Handrailing & toe guard to be provided around all openings & platforms.

    d) Regular maintenance of equipment, checking of hoists, scaffoldings etc.

    e) Passenger hoist must have multiple ropes.

    f) Emergency lights, coloured lamps to be provided in accordance with relevant Indian Standards and as supplemented in the Specification and to be operative in case of sudden power failure Emergency standby generator must be kept ready during the entire period of slipform method of construction.

    g) Emergency vehicles, first aid facilities must be kept ready during the entire period of work.

23. Permissible construction tolerances should be limited to the following: Variation in wall thickness : (-) 5 mm, (+) 25 mm

    Variation from Design Diameter : (+_) 12.5 mm per 3 m dia., but in no case more than (+_) 75 mm.

    Out of Plumb in General: 1 in 1000 of height subject to a maximum of 200 mm.

3.26.00 Waterproofing of Concrete Structure

3.26.01 General

Waterproofing of concrete structures shall be done by either suitable extraneous treatments like applying waterproofing paints like “Sikatop Seal” or approved equivalent, fixing bitumen felts etc. or internally by suitable design of the concrete mix, addition of suitable admixtures conforming to IS: 2645 and equivalent American or British codes in the concrete or mortar at the time of mixing and/or installing water bars at the joints.

The design, material and workmanship shall conform to the relevant I.S. Codes where applicable. The Engineer’s approval of the materials shall be obtained by the Contractor before procurement. If desired by the Engineer, test certificates for the materials and samples shall be submitted by the Contractor free of charge. The materials shall be of best quality available indigenously, fresh clean and suitable for the duties called upon.

3.26.02 Water Bar/Seal/Special Treatment of Construction Joint

Water bearing structures and underground structures may have water bar/seals installed at the joints. They may be rubber or P.V.C. The materials and installation will be as described under Clause 3.23.3. Construction joint should be provided as per clause 3.13.1 with or without water bar / Seal as shown on the drawing. In case of water bars being used at the construction Joint, fixing of the same has to be done carefully so that the water bar is not disturbed during concreting. The construction joint shall also be treated by any one of the following methods:

Method 1: A surface retarder in the form of a thixotropic gel shall be applied on the joint surface of the previous pour in case of joint on the wall and in case of floor the same shall be applied on the formwork against which previous pour of concreting shall be done. The retarder may be liquid or paste form depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting in case of walls. The above bonding agent will be mixed with water which will be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer’s specification. In case of floor joint, however, after washing of retarder a solvent free two component epoxy resin bonding agent will be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days:

Compressive strength	-	55 to 60 N / Sq. mm
Flexural Strength	-	25 to 30 N / Sq. mm
Tensile strength	-	15 N / Sq. mm (approx)
Bonding strength to concrete	-	3 N / Sq. mm (approx)
Bonding strength to steel	-	20 N / Sq. mm (approx)

The whole operation shall be done as per manufacturer's specification. The contractor shall provide manufacturer's supervision at no extra cost to owner.

Method 2 : One row of threaded nozzles at regular intervals not exceeding 1.5 m centre to centre shall be placed in concrete along the construction joint during casting. Injection of cement water together with a suitable waterproof expanding grouting admixture of approved quality shall be done through the nozzles after the construction joint in walls and slabs. The injection shall be done under pressure of approximately 2 to 4 Kg/Sq cm. The nozzles shall be sealed off with suitable admixture after the injection is over. The whole operation shall be carried out as per manufacturer's specification and supervision. The cost of such manufacturer's supervision shall be borne by the contractor.

3.26.03 **Waterproofing Admixtures**

The waterproofing admixture for concrete and cement mortar / plaster shall conform to relevant IS code. The admixture shall not cause decrease of strength of concrete / plaster at any stage and it is free from chlorides and sulphates. The admixture shall not affect the setting time by more than 5 %.

The maximum permissible dosage of admixture will be 3 % (three percent) by weight of cement but a lower dosage will always be preferred.

The product shall be stored in strong moisture proof packings.

However, in case of important structures where M25 or higher grade concrete is specified, the use of melamine based, high range water resistant concrete admixture shall be used as per manufacturer's specification to provide a waterproof concrete.

a) In concrete : The approved admixture shall be based on modified lignosulphonate like "Plastocrete – N/Super" or approved equivalent. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer. The Contractor shall have the services of the manufacturer's supervisor at no extra cost to the Owner to supervise the work, if desired by the Engineer.

b) In Plaster : The concrete surface, to be plastered, shall be hacked to Engineer's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture like "No leek CP/ Sika Latex" or approved equivalent and laid in appropriate thickness and in layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by Engineer. If desired by the Engineer, the Contractor shall have the work supervised by the manufacturer's supervisor at no extra cost to the Owner. On completion, the plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

3.26.04 **Bituminous or Tar Coating on External Surface**

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacturer and quality as per IS: 216 (not heated above 375 Deg.F) using not less than 2 Kg. per Sq.M. or with hot asphalt i.e., bitumen according to IS:73 (not heated above 400 Deg.F) using not less than 1.5 kg. per Sq.M. When the first coat has completely dried up and approved by the Engineer, the second coat shall be applied in the same manner using not less than 1.25 Kg. per Sq.M. in case of coal tar and 1 Kg. per Sq.M. in case of asphalt. Immediately after application of the second coat and before it is dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before backfilling is done in order to allow the final coat to dry up completely. In place of hot application by coal tar / asphalt the coating of the outside surfaces of walls may be carried out using a ready to use liquid, bituminous emulsion/ rubber protective coating of approved manufacturer.

3.26.05 **Protective Coating on Inside Surface**

Two coats of cement based two-components polymer modified flexible protective and waterproofing slurry having 1 mm thickness for each coat shall be applied on the walls/ floor after proper surface preparation as per manufacturer's specification. The slurry shall be applied by brush.

3.26.06 **Bitumen Felt : Application for Tanking**

This specification shall cover laying the waterproof course on the outside and inside of the walls and bases of structures.

The materials shall conform to IS: 1322, and the workmanship to IS: 1609. The bitumen felt shall be hessian base and/or fibre base as specified in Drawing/Schedule of Items. If required by the Engineer, tests as specified in relevant IS Codes shall be arranged by the Contractor without charging any extra to the Owner.

The Contractor shall execute this work in direct collaboration with one of the well known □pecialized firm approved by the Engineer.

Cleaning the surface, keeping it dry, providing necessary corner fillets and cement rendering and cutting chases, etc. shall be included in the rate for this item. If any protective brickwork on/against concrete sub-bases or walls is required, these will be paid extra under suitable items in the contract. A 10 (ten) years' guarantee for satisfactory performances shall be given by the Contractor as well as his specialist sub-contractor jointly and severally, for this item of work. Free rectification of any defects noted in the work within this guarantee period will be carried out by the Contractor even if it is beyond the specified maintenance period of the contract as a whole.

3.26.07 **Polyethylene Films : Application in Walls or Base of Structures**

Waterproof treatment shall be applied as outlined and as per sequence given hereunder:

i) the concrete surface shall be made smooth with 12 mm cement plaster 1:6

ii) apply hot bitumen 80/100 grade (IS:73-1961) @ of 1.0 Kg/Sq.m minimum

iii) lay black polyethylene film 250 micron (IS:2508-1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed, taking care not to puncture the film.

Alternatively, the overlaps shall be heat sealed by an electric iron having three parallel sealing bars. A long piece of plywood is to be placed below the polyethylene film to be heat sealed. On the plywood a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a cellophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another cellophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat sealing, the cellophane tape is to be removed and the joints are to be tested for leaks.

iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen

v) Lay hot bitumen 80/100 grade (IS:73-1961) at 1.0 Kg/Sq.m minimum.

vi) Lay 250 micron polyethylene film as second layer similar to (iii) above.

vii) Lay second layer of 100 gm. Brown craft paper laminated as (iv) above.

viii) Apply hot bitumen (straight run grade) to IS:73-1961 at 1.0 Kg/Sq.m dusted with fine sand.

ix) Protecting with a layer of 75 mm plain cement concrete M10 or a layer of brick laid in cement mortar 1:6. In case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

3.27.00 **Protective coating on Concrete Surface**

3.27.01 **On Foundation**

The outside faces of foundation of important structures will be protected from adverse effect of soil/ underground water, if shown on drawing or instructed by the Engineer, by using rubber / bitumen emulsion protective coating of approved manufacturer.

3.28.00 **Waterproofing by Pressure / Chemical Grouting**

Where required, waterproofing for underground concrete structure shall be done by injecting high polymer based non- shrink waterproof grouting compound through nozzle under pressure as per manufacturer's recommendation. The pressure during injection shall not be less than 2.5 kg/Sq.m and the thickness of epoxy resinous emulsion □aterproof paint (to be applied on the external surface of walls/ slabs) shall not be less than 700 microns.

4.00.00 **SAMPLING AND TESTING**

4.01.00 **General**

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in this specification. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

4.02.00 **Cement**

Representative samples will be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths. Soundness Tests may also be required to be carried out if required by the Engineer. The tests shall be carried out free of charge by the Owner if cement is supplied by him. In case the Contractor is directed to arrange for the supply of cement as per the terms and conditions of the Contract the tests shall be carried out by him without any expense to the owner. In case due to any circumstances, the agency of supply is changed in the middle of the Contract, the party who bore the original contractual obligation will carry on with the test, free of charge to the other, till the end of the job. No cement from a particular consignment/batch will be used on the works unless satisfactory 3 (three) days and 7 (seven) days test results for compressive strength are known. The Owner, Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the Owner or the Contractor. These tests are of great importance as their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

4.03.00 **Aggregates**

The Contractor shall carry out any or all the tests for aggregates as may be required by the Engineer in accordance with IS: 2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

4.04.00 **Water**

Sampling and Testing of water being used for concrete works as per IS: 3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The final acceptance criteria in case of doubt will be as per IS: 3025 & IS: 456.

4.05.00 **Admixture**

4.05.01 **Air Entraining Agents (A.E.A)**

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cube crushing strength vis-à-vis quantity of A.E.A. used for all types of concrete will be established by the Contractor free of charge by carrying out sufficiently large number of tests. Thereafter, the tests shall be carried out at regular intervals and whenever directed by the Engineer, the Contractor will check up free of charge, the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

4.05.02 **Other Admixtures**

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Contractor free of charge to the Owner.

4.06.00 **Concrete**

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS: 516 and IS: 1199 the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Engineer may require other tests to be performed in accordance with IS: 516.

Sampling procedure, frequency of sampling and test specimen shall conform to Clause 15 of IS: 456.

To control the consistency of concrete from every mixing plant, slump tests and/or compacting factor tests in accordance with IS: 1199 shall be carried out by the Contractor every two hours or as directed by the Engineer. Slumps corresponding to the test specimens shall be recorded for reference.

The acceptance criteria of concrete shall be in accordance with Clause 16 of IS: 456.

Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor without any extra cost to the owner. No payment for the dismantled concrete, the relevant formwork and reinforcement, embedded fixtures, etc. wasted in the dismantled portion shall be made. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Engineer.

5.00.00 **ACCEPTANCE CRITERIA**

5.01.00 **Standard Deviation**

Standard deviation shall be based on test results and determination of Standard deviation shall conform to clause 9.2.4 of IS: 456.

5.02.00 **Acceptance Criteria**

The strength requirements and acceptance criteria shall conform to Clause 16 of IS: 456.

5.03.00 **Inspection and Core Tests**

Inspection of concrete work immediately after stripping the formwork and Core Test, Non-destructive Tests of structures shall conform to Clause 17 of IS: 456.

5.04.00 **Load Test**

Load tests of structural members may be required by the Engineer, when the strength of test specimen results fall below the required strength, as per 'Load Tests for flexural members', Clause 17.6 of IS: 456. If load testing is decided by the Engineer, the member under consideration shall be subjected to a test load equal to full dead load of the structure plus 1.25 (one and a quarter) times the specified live load used for design and this load shall be maintained for a period of 24 (twenty four) hours before removal. The detailed procedure of the test is to be decided by the Engineer. Load tests shall not be made until the structure is at least 28 days old.

If the member shows evident failure, such changes as are necessary to make the structure adequately strong shall be made by the Contractor free of cost to the Owner. Alternatively, if permitted under Statutory Regulations and at the discretion of the Engineer, the structure under test or a portion thereof may be retained as such without any modification by derating its load bearing capacity, provided the design criteria allows such derating.

A reinforced concrete beam, floor or roof shall be deemed to have passed the test if the maximum deflection at the end of 24 hours does not exceed the deflection given in Clause 17.6 of IS: 456.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per the specification. The entire cost of dismantling and replacement and restoration of the site shall be borne by the Contractor.

If, in the course of dismantling, any damage is done to the embedded items and or other adjacent structures, the same will be made good, free of charge by the Contractor to the satisfaction of the Engineer.

6.00.00 **LIST OF IS CODES AND STANDARDS FOR REFERENCE**

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not specifically covered by Indian Standard Specifications, any other standard practice, as may be specified by the Engineer, shall be followed:

IS : 73 - Indian Standard Specification for Paving Bitumen

IS : 216 - Indian Standard Specification for Coal Tar Pitch

IS : 383 - Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete

IS : 432 - Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement - Part 1 & 2

IS : 455 - Indian Standard Specification for Portland Slag Cement

IS : 456 - Indian Standard Code of Practice for Plain and Reinforced Concrete

IS : 457 - Indian Standard Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive Structures

IS : 513 - Indian Standard Code of Practice for Cold Reduced Low Carbon Steel Sheet and Strip

IS : 516 - Indian Standard Specification for Methods of Test for Strength of Concrete

IS : 737 - Indian Standard Specification for Wrought Aluminium and Aluminium Alloy sheet and strip for general Engineering purpose

IS : 1199 - Indian Standard Specification for Methods of Sampling and Analysis of Concrete

IS : 1200 (Part-II) - Indian Standard Specification for Method of Measurement Cement Concrete Works

IS : 1200 (Part-V) - Indian Standard Specification for Method of Measurement of Formwork

IS : 1322 - Indian Standard Specification for Bitumen Felts for Waterproofing and Damp-proofing

IS : 1489 - Indian Standard Specification for Portland - Pozzolona Cement - Part 1 & 2

IS : 1566 - Indian Standard Specification for hard drawn steel wire fabric for concrete reinforcement

IS : 1609 - Code of Practice for Laying Damp-proof Treatment using Bitumen Felts

IS : 1786 - Indian Standard Specification for high strength deformed Bars & wires for Concrete Reinforcement

IS : 1791 - Indian Standard Specification for Batch Type Concrete Mixers

IS: 1834 - Indian standard specification for hot applied sealing compound for joint in concrete.

IS : 1838 - Indian standard specification for Preformed Fillers for Expansion Joint in Concrete Pavement and Structures (Non Extruding and Resilient Type)

IS : 2062 - Steel for general structural purpose.

IS : 2185 - Indian Standard Specification for Hollow and solid/ solid light wt. Cement Concrete Blocks - Part - 1 & 2

IS : 2210 - Indian Standard Specification for Design of Reinforced Concrete Shell Structures and Folded Plates

IS : 2386 - Indian Standard Specification for Methods of Test for Aggregates for Concrete - Part-I to VIII

IS : 2430 - Indian standard specification for method of sampling of Aggregate for concrete.

IS : 2502 - Indian Standard Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement

IS : 2505 - Indian Standard Specification for Concrete Vibrators Immersion Type

IS : 2506 - Indian Standard Specification for Screed Board Concrete Vibrators

IS : 2508 - Indian Standard Specification for Low Density Polyethylene Films

IS : 2514 - Indian Standard Specification for Concrete Vibrating tables

IS : 2645 - Integral Cement water proofing compound

IS : 2722 - Indian Standard Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket type)

IS : 2751 - Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction

IS : 2770 - Indian Standard Specification for Method of Testing Bond in Reinforced Concrete. Part - 1: Pull out Test

IS : 3025 - Indian Standard Specification for Methods of Sampling and Test (Physical and Chemical) for Water & waste water - part - 1 to 37

IS : 3201 - Indian Standard Specification for Design and Construction of Precast Concrete Trusses and purlins.

IS : 3370 - Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids Part 1 to 4

IS : 3384 - Indian standard specification for / Bitumen primer for use in waterproofing and Damp proofing

IS : 3414 - Code of practice for Design and Installation of joints in Buildings

IS : 3550 - Indian Standard Specification for Method of Test for Routine Control for Water used in Industry

IS : 3558 - Code of Practice for use of Immersion Vibrators for Consolidating Concrete

IS : 3618 - Indian Standard Specification for Phosphate Treatment of Iron and Steel for Protection against Corrosion

IS : 3696 - Safety Code for Part-1: Scaffolding and Part 2: Ladders

IS : 3812 - Indian Standard Specification for Fly Ash for Use as Pozzolana & Admixture

IS : 4031 - Indian Standard Specification for Method of Tests for Hydraulic Cement - Part - 1 to 14

IS : 4082 - Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site

IS : 4090 - Indian Standard Specification for Design of Reinforced Concrete Arches

IS : 4634 - Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixers

IS : 4656 - Indian Standard Specification for Form Vibrators for Concrete

IS : 4925 - Indian Standard Specification for Concrete Batching and Mixing Plant

IS : 4926 - Indian Standard Specification for Ready Mixed Concrete

IS : 4990 - Indian Standard Specification for Plywood for Concrete Shuttering work

IS : 4991 - Indian Standard Specification for Blast Resistant Design of Structure for Explosion above ground

IS : 4995 (Part-I&II) - Indian Standard Specification for Design of Reinforced Concrete Bins for the Storage of Granular and Powdery Materials

IS : 4998 (Part - I) - Indian Standard Specification for Design of Reinforced Concrete Chimneys

IS : 5512 - Indian Standard Specification for Flow Table for use in Tests of Hydraulic Cement and Pozzolanic Materials

IS : 5513 - Indian Standard Specification for Vicat Apparatus

IS : 5515 - Indian Standard Specification for Compaction Factor Apparatus

IS : 5751 - Indian Standard Specification for Precast Concrete Coping Blocks

IS : 5816 - Indian Standard Specification for Method of Test for Splitting Tensile Strength of Concrete Cylinders

IS : 5891 - Indian Standard Specification for Hand Operated Concrete Mixers

IS : 6452 - Indian Standard Specification for High Alumina Cement for Structural Use

IS : 6909 - Indian Standard Specification for Supersulphated Cement

IS : 6923 - Indian Standard Specification for Method of Test for performance of Screed Board Concrete Vibrators

IS : 6925 - Indian Standard Specification for Method of Test for Determination of Water Soluble Chloride in Concrete Admixtures

IS : 7242 - Indian Standard Specification for Concrete Spreaders

IS : 7246 - Indian Standard Specification for Table Vibrators for Consolidating Concrete

IS : 7251 - Indian Standard Specification for Concrete Finishers

IS : 7320 - Indian Standard Specification for Concrete Slump Test Apparatus

IS : 7861 (Part-I&II) - Indian Standard Specification for Recommended Practice for hot and cold Weather Concreting

IS : 7969 - Safety Code for Storage and Handling of Building Materials

IS : 8041 - Indian Standard Specification for Rapid Hardening Portland cement

IS : 8043 - Indian standard specification for hydrophobic cement

IS : 8112 - Indian Standard Specification for 43 grade Ordinary Portland Cement

IS : 8142 - Indian Standard Specification for Determining Setting time of Concrete by Penetration Resistance

IS : 8989 - Safety Code for Erection of Concrete Framed Structures

IS : 9013 - Indian Standard Specification for Method of Making, Curing and Determining Compressive Strength of Accelerated - cured Concrete Test Specimens

IS : 9077 - Code of Practice for Corrosion Protection of Steel Rails in RB and RCC Construction

IS : 9103 - Indian Standard Specification for Admixtures for Concrete.

IS : 9417 - Recommendation for welding cold worked bars for reinforced concrete construction

IS : 10262 - Recommended Guideline for concrete Mix Design

IS : 12269 - Indian standard specification for 53 grade ordinary Portland cement

IS : 12330 - Indian standard specification for sulphate resting Portland cement

IS : 12600 - Indian standard specification for low heat Portland cement

IS : 14687-Indian Standard Guidelines For Falseworks For Concrete Structures

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SECTION-VI

TECHNICAL SPECIFICATION FOR DRIVEN PRECAST CONCRETE PILE

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SECTION-VI

TECHNICAL SPECIFICATION FOR DRIVEN PRECAST CONCRETE PILE

1.00.00 SCOPE

This Specification deals with the requirements regarding materials, workmanship, casting, curing, handling, transportation and driving of precast concrete piles (both vertical and raker) and all related items of work like surveying, layout of piles, sand filling in holes (considering driving of precast piles into the ground using follower) after driving of the piles, lengthening of the piles, redriving of the piles, jetting, and load testing of the piles, etc.

IS:2911 (Part I/Sec.3) shall form a part of this Specification and shall be complied with unless they are at variance with the Specification where the latter will prevail.

2.00.00 GENERAL

2.01.00 Work to be Provided by the Contractor

Work to be provided for by the Contractor, unless otherwise specified, shall include but not be limited to the following :

a) Furnish all labour, supervision, services, materials, forms, templates, supports, approaches, aids, construction equipment, tools and plants, transportations, etc. required for the work.

b) Prepare and submit for approval detailed drawings and bar bending schedules for reinforcement bars showing the positions and details of spacers, supports, etc.

c) Submit for approval detailed scheme of all operations required for executing the work e.g. Material handling, casting, curing, handling, transporting, driving, testing, services, approaches, sand filling of holes etc.

d) Design and submit for approval concrete mix designs required to be adopted for the job.

e) Furnish samples and submit for approval results of tests for various properties e.g. various ingredients of concrete, concrete cubes etc.

f) Supply & install the pile shoes made of chilled cast iron of approved design.

g) Supply and paint Bitumen coating, if required, on the outer surfaces of the piles prior to their driving, as per schedule of items.

h) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings, specifications and schedule of items.

2.02.00 **Work to be Provided by Others**

No work under this specification shall be provided by any agency other than the Contractor, unless specifically mentioned otherwise elsewhere in the contract.

2.03.00 **Codes and Standards**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specifications and Codes of Practices.

IS-269 : I.S. Specification for ordinary, and Low Heat Portland Cement.

IS-383 : I.S. Specification for Coarse and Fine Aggregates from Natural Source for concrete.

IS-432 : I.S. Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement.

IS-456 : I.S. Code of Practice for Plain and Reinforced Concrete.

IS-516 : I.S. Specification for Methods of Test for Strength of Concrete.

IS-1199 : I.S. Specification for Methods of Sampling and Analysis of Concrete

IS-1786 : I.S. Specification for Cold-twisted Steel Bars for Concrete reinforcement.

IS-2386	:	I.S. Specification for Methods of Test for Aggregates for Concrete - Part - I to VIII.
IS-2502	:	Codes of Practice for Bending and Fixing of Bars for concrete Reinforcement.
IS-2751	:	Code of practice for welding of mild steel bars used for Reinforced concrete construction.
IS-2911 (Part-I/ Sec.3)	:	Code of practice for Design and Construction of Pile Foundations. Driven Precast Concrete Piles.
IS:2911 (Part-IV)	:	Code of Practice for Design and Construction of Pile Foundations - Load Test of Piles.
IS:3558	:	Code of Practice for use of immersion Vibrators for Consolidating Concrete.
IS-6999	:	I.S. Specifications for super-sulphated cement.
IS-8112	:	I.S. Specification for high strength Ordinary Portland Cement.

2.04.00 **Conformity with Design**

The Contractor will prepare check lists in approved proforma which will be called "Pile Installation Cards". At each important stage of the work as decided by the Engineer, the work will be checked and approved by the Engineer for Correctness and conformity with the design, Specifications and drawings, before allowing the next phase of the work to commence. The intermediate checks and approval by the Engineer will not, however, absolve the Contractor from his total responsibility to execute the work as per the specification and drawings and remove and/or rectify all work which is defective or inaccurate.

2.05.00 **Materials**

2.05.01 **Cement**

Cement used shall conform to IS:269 (or Portland Cement), IS:455 (Slag cement), IS:6909 (Supper-sulphated cement) or any other I.S. Specification as indicated in the schedule of items.

2.05.02 **Aggregates**

Aggregates both fine and coarse shall comply with requirements of IS:383. Size of coarse aggregates shall be selected considering the size of section. Generally 20 mm down coarse aggregate shall be used.

2.05.03 **Steel**

Reinforcement Steel shall conform to IS:432 (Part-I) and IS:1786.

2.05.04 **Concrete**

Controlled concrete grade M30 shall be used for the piles, unless specified otherwise in the schedule of items. Water/cement ratio including water contained in aggregates shall not be more than 0.45. However, minimum cement content and corresponding W/c ratio shall be determined by trial mix design and as approved by the Engineer. Materials and methods of manufacture of concrete shall be in accordance with IS:456. In addition, the materials shall have special resistance against sulphate attack where subsoil conditions warrant it.

2.05.05 **Water**

Clear water, free from acids and other impurities, shall be used for the manufacture of concrete. Normally potable water is found to be suitable.

2.06.00 **Storage of Materials**

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer shall not be used, failing which, the Engineer shall be at liberty to get the materials removed and the cost increased thereof shall be realised from the Contractor's dues.

2.07.00 **Quality Control**

The Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The requirements will include but not be limited to the following :

a) Casting of piles

b) Inspections of piles

c) Location and Plumb : Control survey for accuracy in plan and check for verticality.

d) Driving : Correlation of weight of hammer, length of stroke, number of strokes per minute and rate of penetrations.

e) Load tests.

3.00.00 INSTALLATION

All installation requirements shall be in accordance with IS:2911 (Part-I/ Sec. 3) latest edition and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification might not have covered all this aspects to the full satisfaction of the Engineer.

3.01.00 General

The tenderer shall furnish complete information about the type of piles offered, method of driving of piles, details and availabilities of driving equipment, formula or data curve on which the tenderer bases the load carrying capacity of piles as well as the criteria for determining suitable and sufficient`founding'of individual piles and any other relevant details.

The Contractor shall acquaint himself fully about the nature of the soil encountered from bore hole logs or any other data as available with the owner. All piles will have to be driven to the required set and/or based on load tests, as decided by the Engineer. In case the Contractor is required to drive piles to greater or shallower depths than that is envisaged the rates will be adjusted as per relevant items in Schedule of Items and no other extra claims will be entertained. The tenderer should, in his own interest, investigate the site thoroughly and take additional bore holes if he feels it necessary to assess the type of equipment to be used and the depths to which the piles may have to be driven finally.

3.02.00 Casting and Curing

Precast concrete piles shall be square with chamfered edges. (25mm x 25mm) and conical bottom. The top edges of all piles shall also be chamfered (25mm x 25mm).

Before placing in moulds, the steel skeletons shall be accurately fabricated and assembled away from the moulds, complete with metal shoe if specified, accurately fitted so that the point is truly on the axis of the pile.

Care shall be taken to ensure that the binders are perfectly tight and main reinforcements straight and true. Spacer fork of approved design are to be inserted throughout and spacing shall not be more than 1.5 m apart.

Longitudinal bars shall be in one length. In cases where laps in reinforcement bars cannot be avoided, the bars shall be staggered. Welded joints in reinforcement may be used with prior approval of the Engineer. Welding of reinforcements shall be done in accordance with the recommendations of relevant IS Code of practice. The cages shall be rigidly fixed straight and parallel to the moulds and held correctly as to maintain cover by spacer blocks. Care shall be taken to ensure correct and uniform cover throughout.

Formwork to be used for casting of the piles must be strong and level so that the outer faces of the piles are smooth and free from undulations. The prefabricated steel formwork with proper fasteners shall be used. Deformed and out of alignment formwork will be rejected.

The Casting Yard shall be so located that the piles can be lifted directly from their beds and transported to the piling frame with a minimum of handling. The casting yard should have a well drained surface to prevent excessive uneven settlement due to softening of soil during manufacturing and curing. The contractor shall submit layout drawing of the casting yard to the Engineer for approval prior to its construction.

Each pile shall be cast in continuous operation from end to end. The concrete shall be thoroughly compacted against the forms and around the reinforcement by means of immersion and/or shutter vibrators. Care shall be taken to ensure that the heads of the piles are formed plane and square to the axis. Particular attention must be paid to compaction at head and toe having regard to the more closely spaced reinforcement and the need for the densest possible concrete.

Immediately on completion of the casting the top surface shall be finished level without excess trowelling. Care shall be taken to ensure that vibration from adjacent work does not affect the previously placed concrete for piles during the setting period.

Side shutters shall be stripped off only after 24 hours of concreting. The piles shall be kept continuously wet for at least 7 days and protected from rapid drying by sheltering them from the wind and direct sunlight by covering the stacks.

3.03.00 **Storing and Handling**

Storage area shall be of firm ground free from liability to unequal subsidence or settlement under weight of the stack of piles. The piles shall be placed on timber supports which are truly level and spaced so as to avoid undue bending in the piles. The supports shall be vertically one above the other. Space shall be left round the piles to enable them to be lifted without difficulty. The order of stacking shall be such that the older piles can be withdrawn for driving without disturbing the new piles.

Great care shall be taken at all stages of transporting, lifting and handling of the piles that they are not damaged and cracked. Piles shall be lifted only by means of bolts or shackles inserted through the lifting holes provided and in no other way. Any pile damaged in handling shall be replaced free of charge by the Contractor.

All lifting and toggle holes shall be formed by casting in pieces of steel pipe for the full length of the concrete section. In places where lifting holes have not been provided in the piles, the points of lifting shall be clearly marked on the surface of the pile over at least half the perimeter. If the piles are put down temporarily after being lifted, they shall be placed on trestles or blocks located at lifting points. Lifting shall be by two points i.e. at 1/5th length of pile from either end so as to keep the handling stress minimum. Single point lifting is not permitted.

Piles must not be taken for driving before 28 days have passed after casting.

3.04.00 **Driving**

The proposed arrangement for driving, the equipment and accessories shall be to the approval of the Engineer.

The equipment and accessories are to be selected considering the hardness of driving, the capacity suitable for the size and weight of the pile to be handled. Piles may be driven with any type of hammer provided they penetrate to the prescribed depth or attain the specific resistance without being damaged. A hammer may be 'single acting' or 'double acting'. The hammer, dolly, helmet and the pile should be co-axial and sit squarely one upon the other. For a single acting or drop hammer, the fall should be limited to 1.2m, preferably 1m.

The head of precast concrete piles shall be protected with packing of resilient material, evenly spread and held securely in place. A helmet should be placed over the packing and provided with dolly of hardwood or equivalent not thicker than the width of pile.

Any sudden change in rate of penetration which cannot be explained due to normal change of nature of the ground should be noted and the cause ascertained before driving is continued.

Jetting may be used in case of sand, gravel and fine grained soils provided percentage of clay is small, after approval of the Engineer, as a means of minimizing the to resistance and skin resistance along the pile shaft. Jetting shall not be used in case of clay soils. The pressure of jetting should be from 6 Kg./Sq.cm. to 10 Kg./Sq.cm. Proper arrangement shall be made for taking away water that emerge at the ground so that the stability of the piling equipment is not endangered by softening of the ground. Special care should be taken to ensure that pile penetrates vertically.

Jetting shall be stopped prior to completing the driving which should always be made by ordinary methods. Jetting shall also be stopped if there is any tendency of the pile tip to be drawn towards the piles already driven owing to disturbance of the ground.

Piles should be installed as accurately as possible as per the drawings. As a guide, for vertical piles a deviation 1.5% and for raker piles a deviation of 4% shall not be exceeded. Piles shall not deviate more than 75 mm from their designed position. Spacing of the piles shall be as per the drawings.

In case of piles deviating beyond these limits, the piles shall be replaced or, supplemented by one or more piles as instructed by the Engineer at no extra cost to the owner.

In a group the sequence of installation shall be from the centre to the periphery of the group or from one side to the other, such that the carrying capacity of previously installed pile is not reduced. The driving shall not cause appreciable upheaval of the ground or cause unusual soil resistance to rest of the pile driving. It shall be ensured that soil is not flowing out literally during driving operation.

Set criteria shall be same as those used when the sets of test piles were obtained under identical driving conditions.

3.05.00 **Stripping of Pile Heads**

If specified in the schedule of items the concrete shall be stripped to the cut-off levels shown on the drawings. Reinforcements shall be exposed for the full bond length appropriate to the diameter of the bar and projected in the pile cap. All concrete and cement shall be removed from the bars which shall also be wire brushed to remove any loose rust, dirt and scale. Any cracked or defective concrete shall be cut away and made good with new concrete properly bonded to the old concrete.

3.06.00 **Lengthening of Piles**

Length of individual piece of precast pile is generally restricted from handling point of view. Considering the required total length of pile and the length of individual piece as mentioned above, the contractor shall develop standard splicing detail using studs, dowels, keys etc. at the spliced end of the piles and get it approved by the Engineer. The splice shall be as strong as the pile segments.

If due to unforeseen site conditions over and above the preplanned splicing mentioned above, further lengthening of pile is required during driving the longitudinal reinforcement shall be exposed by stripping of head and jointed properly either by welding or lapping as directed by the Engineer. The exposed surface of the concrete shall be hacked to form a key, brushed to remove loose material and covered with 25 mm thick cement mortar (1:2 mix) immediately before the new concrete is placed.

3.07.00 **Risen Piles**

In places where the piles may rise due to ground heaving, levels of the tops of the piles should be measured at interval while nearby piles are being installed. Piles which have risen as a result of driving adjacent piles should be redriven to the original depth as per the direction of the Engineer.

3.08.00 **Defective Piles**

Defective piles shall be removed or left in place without affecting performance of the adjacent piles as per direction of the Engineer. Additional piles shall be provided by the Contractor free of charge.

3.09.00 **Idle Period**

The phasing of construction and movement of plant shall be done as desired by the Engineer. The phasing may involve some extra movement of the plant or some idle period, but the Contractor will not be entitled for any claim due to this reason.

During the actual testing of the piles, the Contractor's plant and personnel may remain temporarily idle. Again, during the period of redesign, if any, (based on the pile test results), the plant personnel of the contractor may remain idle for any reason whatsoever.

For such idle periods mentioned above, the Contractor will not be entitled to any claim and rates quoted by him shall include the same. However, during the testing of piles and other hold ups, pile driving operation may be allowed on other piles wherever possible, if decided by the engineer with a view to minimise idle times.

If due to change in loading, elevations or any other alteration, some amendments become necessary in the design of foundations, the Contractor shall not be entitled to any claim whatsoever for such amendments in the pile layout during the progress of work including claims for any idle labour or tools and plant on this account.

3.10.00 **Test Pile**

The Contractor may have to construct test piles, if desired by the Engineer, before he starts systematic piling operation at locations indicated. For this purpose, the pile construction process shall be the same as in usual piling process to be followed on this job. Load test on such piles shall be as per the provisions under "Procedure for Initial Load Test" in IS:2911.

4.00.00 **TESTING AND ACCEPTANCE CRITERIA**

4.01.00 **General**

The Contractor shall carry out all sampling and testing for the components of reinforced concrete in accordance with the relevant Indian Standards at his own cost unless otherwise specified in the Contract. Whenever directed, the Contractor shall get the specimens tested in a laboratory approved by the engineer and submit to the Engineer the test results in triplicate within three (3) days of completion of the test.

Initial tests and/or routine tests as indicated in the Schedule of Items or as directed by the Engineer shall be carried out on single pile or pile groups to ascertain the capacities of the piles and their behaviour.

Any or all of the following tests shall be carried out as indicated in the Schedule of Items and as directed by the Engineer.

a) Vertical load test on pile (Compression)

b) Lateral load test on pile

c) Pull out test on pile

All the above tests are to be performed as per requirements of IS:2911 (Part-IV) - latest revision and as supplemented herein.

4.02.00 **Static Load Test on Working Piles**

In order to determine the carrying capacity of piles, static load tests shall be undertaken by the Contractor on single pile or pile groups, as indicated on drawings. Before any load test is made, the proposed arrangement of the structure, dead load to be used in making the load test, and method of application of load to the pile shall have to be approved by the Engineer. All load tests shall be made under the supervision of the Engineer. All responsibilities for conducting the test safely and properly lie with the Contractor.

The test load to be applied on pile or piles shall be one and a half times the proposed load value of the pile or piles as claimed by the Contractor. The test load shall be applied in 6 increments equal to one fourth, half, three fourth, one, one and one fourth and one and one half times the proposed working load. Readings of settlements and rebounds shall be referred to a constant elevation bench mark and shall be recorded with the help of three dial gauges of 0.02 mm sensitivity each positioned at equal distance around the pile. Each stage of loading, except the final test load of one and one half times the working load, shall be maintained till the rate of movement of the pile top is not more than 0.02 mm per hour. The final test load shall be maintained for 24 hours and hourly readings of settlements are to be recorded. The total test load shall be removed in decrements not exceeding 1/5 of the total test load with intervals of not less than one hour. The rebounds shall be recorded after each decrement is effected and the final rebound shall be recorded 24 hours after the entire test load has been removed. A complete record in triplicate shall be filed with the Engineer on the loads and readings obtained duly verified and countersigned by the Engineer.

The tested piles shall be used as usual foundation piles if they satisfy the acceptance criteria and no extra payment shall be made except for load tests on the piles.

If so desired by the Engineer, special test caps may have to be cast and subsequently dismantled at no extra cost.

4.03.00 **Acceptance Criteria**

The piles shall be accepted as satisfactory only when the work has been executed in order with this Specification to the satisfaction of the engineer and satisfy the following requirements :

a) Deviations shall be within the prescribed limit of tolerance specified in this specification.

b) Results of the load tests satisfy the specification and IS Code requirements.

4.04.00 **Recording Data**

The Contractor shall maintain a separate register, signed jointly by him and the Engineer, giving the following information during installation of the piles:

a) The sequence of installation of piles in each group with dates of starting and completion

b) The dimensions of the pile including the reinforcement details of the piles

c) The depth driven

d) The final set for the last ten blows or as may be specified by the Engineer

e) Cut-off levels

f) The type and size of hammer and its stroke, or with double acting hammers, the number of blows per minute

g) The type and condition of the packing on the pile head and the dolly in the helmet; and

h) Any other important observation

5.00.00 **INFORMATION TO BE SUBMITTED**

5.01.00 **With Tender**

The tenderer shall submit the following information along with his tender.

5.01.01 **Programme of Construction**

The tenderer will submit the details of the method of construction and the construction equipment that he will employ. A proposed construction programme, matching with the capacity of the equipment and taking into consideration the various idle and non production periods on account of shifting of equipment, testing and possible delays due to modifications of design should be drawn up and submitted along with the tender, keeping in view the completion dates stipulated in the tender.

5.02.00 **After Award**

After award of the contract, the successful tenderer is to submit the following details.

5.02.01 **Execution Plan**

Within 15 days of the receiving the Letter of Intent the Contractor will submit 6 (six) copies of drawings showing the sequence of driving. The drawings will be prepared on the basis of a master plan giving identification number of the piles, which will be furnished by the Engineer.

5.02.02 **Detailed Construction Programme**

Within 30 (thirty) days of the award of contract, a detailed construction programme for completion of the work is to be submitted. This master programme will be reviewed and updated every month or at more frequent intervals as directed by the Engineer, incorporating the various factors which have caused or are likely to cause changes in the programme.

5.02.03 **Requirement of Materials, Tools and Plants and Equipment**

In accordance with the master programme, a detailed material, tools and plants and equipment requirement schedule, particularly for those items which the Owner is to supply or is to help in procurement as per the terms and conditions of the Contract, is to be submitted within 30 (thirty) days of the contract.

5.02.04 **Test Results**

The test data and result for the various ingredients of R.C.C., concrete cubes and cylinders, driving of the pile, static load test on single piles and group will be submitted regularly and as and when directed by the Engineer.

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SECTION-VII

TECHNICAL SPECIFICATION
FOR
DRIVEN CAST IN SITU CONCRETE PILE

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SECTION-VII

TECHNICAL SPECIFICATION FOR DRIVEN CAST IN SITU CONCRETE PILE

1.00.00 SCOPE

This specification covers driven reinforced cement concrete cast in situ piles including movement of pile driving equipment as per drawings as made available from time to time, and all related items of work like sand filling in the holes left after casting the piles, testing the load bearing capacity of individual piles and group of piles, etc. The relevant clauses of the "Technical Specification for Cement Concrete (Plain or Reinforced)" appearing in this document elsewhere, fall within the Scope of this Specification.

IS : 2911 (Part-I/Sec-2) shall form a part of this specification and shall be complied with unless they are at variance with the specification where the latter will prevail.

Other items of work like, excavation, casting pile caps, beams etc. which in most cases, will be required to be executed in connection with piling, will fall under the Scope of other relevant sections of the Technical Specifications which appear separately in this document.

2.00.00 GENERAL

2.01.00 Work to be provided by the Contractor

The work to be provided for by the Contractor, unless otherwise specified, shall include but not be limited to the following :

a) Furnish all labour, supervision, services, materials, equipment, tools, plants, transportation etc. required for the supply and installation of piles of desired capacity.

b) Mark the proposed sequence of driving on six (6) copies of identification plan. The identification plan will be prepared by the Contractor as per the basic plan furnished by the Engineer, if so desired by him.

c) Furnish detailed drawings in six (6) copies of the pile driving equipment giving all salient dimensions and loads.

d) Submit detailed daily report of pile driving incorporating information as required by the Engineer.

e) Carry out load tests to the satisfaction of the Engineer including casting and dismantling of test caps if necessary and submit the test results in approved proforma.

f) Make necessary earthwork and approaches for movement of the pile driving rig.

g) Provide all necessary work mentioned under the "Technical Specification for Cement Concrete (Plain or Reinforced)" , as may be applicable.

2.02.00 **Work to be provided by others**

No work under this Specification will be provided by any agency other than the Contractor unless specifically mentioned otherwise elsewhere in the Contract.

2.03.00 **Codes and Standard**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standards Specifications and codes of Practice. In case any particular aspect of work is not specifically covered by Indian Standard Specifications, any other Standard Practice as may be specified by the Engineer shall be followed :

IS : 269 - Indian standard Specifications for 33 Grade ordinary Portland Cement

IS : 383 - Indian Standard Specifications for Coarse and fine Aggregates from Natural sources for concrete.

IS : 432 - I.S. specification for Mild Steel and Medium (Part -I)Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement : Part I Mild Steel and Medium Tensile Steel Bars.

IS : 455 - Indian Standard Specification for Portland Slag Cement.

IS : 456 - Code of Practice for Plain and Reinforced concrete.

IS : 516 - Indian Standard Specification for Methods of test for Strength of concrete.

IS : 1199 - Indian Standard Specification for Method of sampling and Analysis of Concrete.

IS : 1786 - Indian standard Specification for Cold worked steel High strength Deformed Steel Bars and Wires for Concrete Reinforcement.

IS : 2502 - Code of practice for bending & Fixing of Bars for Concrete Reinforcement.

IS : 2722 - Indian Standard Specification for Portable Swing Weight Batches for Concrete (Single and Double Bucket Type).

IS : 2751 - Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction.

IS : 2911 - Code of Practice for Design and (Part-I/Construction of Pile Foundations - Driven Sec-2)Cast-in-situ Concrete Piles.

IS : 2911 - Code of Practice for Design and Construction (Part-IV) of Pile Foundations - Load Test on Piles.

IS : 4926 - Indian Standards Specification for Ready Mixed Concrete.

IS : 5121 - Safety Code for Piling and other Deep Foundations.

2.04.00 **Conformity with design**

The Contractor will prepare check lists in approved proforma which will be called "Pile Installation Cards". At each important stage of the work as decided by the Engineer, the work will be checked and approved by the Engineer for correctness and conformity with the design, specifications and drawings, before allowing the next phase of the work to commence. The intermediate checks and approvals by the Engineer will not, however, absolve the Contractor from his total responsibility to execute the work as per the specification and drawings and to remove and/or rectify all work which is defective or inaccurate.

2.05.00 **Materials**

2.05.01 **General**

All materials whether incorporated in the works or used temporarily as aids or for executing enabling works will be of best approved quality conforming to the latest Indian Standard Specification.

2.05.02 **Pile Shoes and Shells**

Piles shoes, where used, should be manufactured out of best quality cast Iron or Steel with proper treatment, the composition and thickness of the materials being of special importance where they are likely to be in contact with harmful chemicals and organic materials causing deterioration in service. The shell tubes which are to be left in place should also receive similar consideration in selection.

2.05.03 **Cement**

Cement used shall conform to IS : 269, IS : 8112 or IS : 12269 (Portland Cement), IS : 6909 (Super-sulphated cement), IS : 12330 (Sulphate resisting Portland Cement) or any other I.S. specification as indicated in the schedule of items.

2.05.04 **Aggregates**

Aggregares both fine and coarse shall comply with the requirements of IS : 383. Size of coarse aggregates shall be selected considering the size of the section. Generally, 20 mm down coarse aggregares shall be used.

2.05.05 **Steel**

Reinforcement steel shall conform to iS : 432 (Part - I) (Mild Steel plain bars) or IS : 1786 (High yield strength deformed bars).

2.06.00 **Storage of Materials**

2.06.01 **General**

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Engineer shall not be used, failing which, the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The relevant clauses pertaining to storage of material under "Technical Specification for Cement Concrete (Plain & Reinforced)" will apply.

2.06.02 **Cast Iron or Steel Shoes and Shells**

All cast iron or steel shoes and shells will be painted with two coats of anticorrosive paint or smeared with protective layer of grease and kept stored in weatherproof sheds, off the ground, on sturdy racks in such a manner as to enable quick and easy inspection.

2.07.00 **Quality Control**

The Contractor shall establish and maintain quality control for different items of work and materials as may be directed by the Engineer to assure compliance with contract requirements and maintain and submit to the Engineer records of the same. The Quality Control requirements stipulated under the "Technical Specifications for Cement Concrete (Plain and Reinforced)" will apply wherever relevant. In addition, the requirements will include but not be limited to the following :

a) Location and Plumb :Control survey for accuracy in planand check for verticality.

b) Driving : Correlation of wt. of hammer, length of stroke,number of strokes perminute and rate of penetration.

c) Casting of Piles : Check inside casing, reinforcement cage,concrete mix, placing, conso- lidation and curing.

d) Inspection of Pile

e) Load Tests

2.07.01 **Non-conformance**

Any work which fails to conform to the specification will be subject to the issue of a non-conformance report in line with the quality control procedures to be implemented at site. Corrective or remedial action, design modification or product rejection will be reviewed in accordance with site quality plan.

3.00.00 **INSTALLATION**

All installation requirements shall be in accordance with IS:2911 (Part I) and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification might not have covered all the aspects to the full satisfaction of the Engineer.

3.01.00 **General**

The Tenderer shall furnish complete information about the type of piles offered with sketches of pile sections showing reinforcement, method of driving the piles, details and availability of driving equipment, formula or data curve on which the Tenderer bases the load carrying capacity of piles as well as the criteria for determining suitable and sufficient 'founding' of individual piles and any other relevant details.

The Tenderer will be supplied with bore hole logs or any other data indicating the nature of the soil expected to be encountered. The information furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the Contract. All piles will have to be driven to the required set and/or based on load tests, as decided by the Engineer. In case the Contractor is required to drive piles to greater or shallower depths than that is envisaged the rates will be adjusted as per relevant items in the Schedule of Items and no other extra claims will be entertained. The tenderer should, in his own interest, investigate the site thoroughly and take additional bore holes if he feels it necessary to assess the type of equipment to be used and the depths to which the piles may have to be driven finally.

3.02.00 **Type of Pile**

All piles shall be adequately reinforced cast in situ concrete piles driven as specified on the drawing/s. The reinforcement and diameters of piles should be exactly as indicated in the drawing and specification. Only cast in situ piles with complete reinforcement for the total length and casing driven to total depth required for pouring controlled concrete mixture shall be accepted.

Inspite of different methods of driving, concreting, etc. of different types of cast in situ piles, the allowable vertical load carrying capacity of piles shall be as follows:

Nominal diameter of pile Max. allowable loadcarrying capacity of single pile

450 mm : 60 M.T.

550 mm : 100 M.T.

3.03.00 **Identification of Piles**

A plan, in triplicate, showing clearly the designation of all piles by an identifying system shall be filed with the Engineer before installation of piles is started if so desired by the Engineer.

3.04.00 **Sequence of Construction**

The piles shall be installed in such a sequence that the carrying capacity of previously installed pile is not reduced. The driving shall not cause appreciable upheaval of the ground or cause unusual soil resistance to rest of the pile driving. It shall be ensured that the soil is not flowing out laterally during driving operation. The Engineer shall decide on the sequence of the groups of piles and the Contractor shall have to follow this sequence.

3.05.00 **Driving of Piles**

Piles shall be installed with due consideration to the adjacent structures and by a method which leaves their strength unimpaired and which develops and retains the required bearing resistance. Equipment and the method of driving the pile shall be such that the pile is installed in its proper position and alignment. The pile shall not be out of plumb by more than 2% of the pile length. If any pile goes out of plumb by more than 2% of the pile length, the design of the foundation shall have to be modified in a manner approved by the Engineer to support the resulting vertical and lateral forces properly. The cost of modification, however, has to be borne by the Contractor at no extra cost to the Owner. A maximum positional deviation of 7.5 cm at the cut off level from the designed location of pile may be permitted, beyond which modification in the design shall become necessary.

Jetting shall not be done except when permitted in writing by the Engineer. The driving shall start from the existing ground level. After completion of driving, concrete shall be placed and compacted to fill up the hole left by the driving up to 300 mm above the cut of level. The balance depth between the G.L. and the top of concrete shall be filled up with sand so that the next pile does not move out of place during construction. To construct the pile cap, the ground will be excavated to expose the top portion of the piles, which will be dismantled neatly upto the cut off level removing all cracked , loose and unsound concrete. the top surface of the piles will be kept rough to ensure bond with the pile cap in which they will be ultimately embedded. The reinforcement rods of the pile should project out of the top by at least the value of bond length for the bar depending on its diameter and grade of concrete in pile cap. This length of bar will be later on bent and embedded in the pile cap concrete.

During the process of driving, should an obstruction be encountered, through which piling tube can not penetrate, the Contractor shall be compensated for the cost of removal of such obstruction at actual cost plus 20%.

Liquefaction of soil or localised compaction of soil due to driving of piles, if occurring, may create conditions when determination of load bearing capacity by the usual method of 'set' sometimes gives erroneous results. The pile, in such cases, shall be driven to the set desired or the desired strata based on the experience gained on the various load tests as desired by the Engineer.

The Contractor shall ensure that any green concrete in the nearby piles or any pile loaded in testing operation is not disturbed by driving the tube adjacent to it.

3.06.00 **Concrete in Pile**

This shall conform to the requirements of "Technical Specification for Cement Concrete (plain and reinforced)" enclosed herewith, to the extent it has been referred to or as applicable to this Specification. The concrete shall be of controlled grade and approved quality preferably M 20 and M 25 but in no case shall it be less than M 15 grade. The stipulation laid down in IS:2911 (Part I), regarding selection of mix shall be generally followed unless otherwise specified by the Engineer.

Concreting shall start as soon as possible after the hole is completed. Concrete shall be so placed as to fill the entire volume of the hole without segregatopm and formation of voids caused by faulty consolidation or entrapped air. The volume of concrete placed shall be observed in the initially cast piles and the average figure obtained shall be used to check whether there is undue deviation in concrete consumption for the subsequent piles.

Where the concrete is cast in place in a tube, its consistency shall be suitable to the method of compaction employed in the formation of piles. If necessary, concrete shall be as dry as possible to minimise shrinkage and to minimise the possibility of cement being washed down by flow of subsoil water while casing is withdrawn. Care shall be taken against seggregation of concrete while passing

the reinforcement cage, and against inflow of soil and water during withdrawal of the tube by maintaining sufficient head of concrete inside the tube. The extraction of casing shall not cause any shearing or necking of the poured concrete thereby reducing the capacity of piles.

The method of concreting shall strictly conform to the above specification and no deviation shall be allowed.

As mentioned in Section 3.5, concreting of the pile shall have to be done at least 300 mm above the cut off level of the pile. The remaining part of the hollow formed by the withdrawal of driving tube from ground down to the top of the concreted pile shall be filled up with sand.

3.06.01 **Trimming of Pile Heads**

Completed piles shall be trimmed to the cut-off levels shown on the drawings or until sound concrete is found. In the event of trimming being carried below the cut-off level, the pile shall be made up to the correct cut-off level, with concrete of the same quality as used in the piles at the contractor's expense. A 'non-conformance' will be raised in such circumstances. Reinforcement shall be exposed for the full bond length appropriate to the diameter of the bar and projected in the pile cap as per drawing. All concrete and cement shall be removed from the bars, which shall also be wire-brushed to remove any loose rust, dirt and scale.

3.06.02 **Lengthening of Piles**

Where it is necessary to increase the length of any pile after it has been installed, the head of the pile shall be cut-off to expose the reinforcement for a full bond length of the bars to lap with the new bars. The exposed surface of the concrete shall be chiselled to form a key brushed to remove loose material and covered with 25 mm thick cement mortar (1 : 2 mix) immediately before the new concrete is placed.

3.07.00 **Reinforcement in Piles**

Steel Reinforcement conforming to IS:432, IS:1139 or IS:1786 grade suitable for reinforced cement concrete for general building work shall be applicable for the specification to the extent it has been referred to or applicable.

Pile has to be reinforced throughout its length. In spite of different methods of driving, concreting, etc. of different types of cast-in-situ driven piles, the minimum area of longitudinal reinforcement within the pile shaft shall be 0.4 percent of the sectional area calculated on the basis of outside diameter of the casing of the shaft when mild steel plain bars conforming to IS : 432 Grade I are used. For other grades of steel noted above, the area of reinforcement may be adjusted suitably, but in no case shall the number of vertical reinforcing bars be less than six and the bar diameter less than 16 mm. The minimum diameter of the links or spirals shall be 6 mm and their spacing shall not be less than 150

mm. In addition to the binders/links, spacer bars of 8 mm diameter shall be welded at the inside face of the cage of suitable intervals.

Reinforcement used in cast in situ piles shall be made up into cages sufficiently well wired or spot welded to withstand handling without damage. The bars shall be so spaced as not to impede the placing of the concrete. Care shall be taken to preserve correct cover and alignment of reinforcement throughout the whole operation of placing the concrete by means of concrete rollers or by any other means approved by the Engineer. Any distortion or displacement of reinforcement, during the compaction of concrete or while extracting the tube, shall be avoided. The reinforcement in the pile shall be exposed for a minimum length of the anchor length in tension above cut off level to permit it to be adequately bonded into the pile cap. All reinforcement in piles including the dowels projecting above the piles, shall be measured and paid separately.

3.08.00 **Dowels**

The Contractor shall provide necessary dowels as directed by the Engineer. In case of inadequate length of dowels, the same shall be extended by welding or by mechanical devices, if necessary as per direction of the Engineer. The expenditure on this account shall be borne by the Contractor. The extra reinforcement thus required shall be taken into consideration during reconciliation if the same is supplied by the Owner.

3.09.00 **Inspection**

Before placing the reinforcement and concrete in the driven pile, the same shall be inspected by lowering a battery or flash lamp or by any other method approved by the Engineer to ensure water tightness of the tube. In case of water in any bore or damage to any cast iron shoe, the tube shall be extracted and redriven after earthfilling of the hole, with a fresh shoe at the cost of the Contractor.

3.10.00 **Record for driving of Piles**

A joint record of the entire penetration shall be maintained by the Contractor in a proforma approved by the Engineer for every pile for the behaviour of such pile during its entire process of construction. Such records shall be submitted to the Engineer regularly as the job progresses. Any sudden change in the rate of penetration which can not be ascribed to the nature of the ground or any deviation from the designed location, alignment or load carrying capacity of any pile or any upheaval or subsidence noticed on any pile driven under this Contract shall be promptly reported to the Engineer and adequate corrective measures shall be taken free of any charge as decided by the Engineer.

Upon completion of the pile driving, all records together with the records of such additional borings or other subsurface information that were obtained during the process of driving shall also be filled with the Engineer in triplicate.

3.11.00 **Defective Piles**

Piles that are defective or piles with deviation in alignment of the tube or position of the base more than that permissible under this specification shall be pulled out or left in place as per the direction of the engineer. Additional piles shall be driven to replace them and/or the pile cap shall be redesigned in consultation with the engineer. All the additional costs associated with the corrective action shall be borne by the Contractor. However, the extra reinforcement and cement that will be required for such work shall be taken into consideration during reconciliation of Owner's material, if the same are supplied by the Owner.

3.12.00 **Idle Period**

The phasing of construction and movement of plant shall be done as desired by the Engineer. The phasing may involve some extra movement of the plant or some idle period, but the Contractor will not be entitled for any claim due to this reason.

During the actual testing of the piles, the contractor's plant and personnel may remain temporarily idle. Again, during the period of redesign, if any, (based on the pile test results), the plant personnel of the contractor may remain idle for any reason whatsoever.

For such idle periods mentioned above, the Contractor will not be entitled to any claim and rates quoted by him shall include the same. However, during the testing of piles and other hold ups, pile driving operation may be allowed on other piles wherever possible, if decided by the engineer with a view to minimise idle times.

If due to change in loading, elevations or any other alteration, some amendments become necessary in the design of foundations, the Contractor shall not be entitled to any claim whatsoever for such amendments in the pile layout during the progress of work including claims for any idle labour or tools and plant on this account.

In case of extra rolling of rig arising out of a decision taken by the Engineer due to non-availability of drawings or site, or priority consideration, the same shall be paid under the relevant item in the schedule of items.

3.13.00 **Test Pile**

The Contractor may have to construct test piles, if desired by the Engineer, before he starts systematic piling operation at locations indicated. For this purpose, the pile construction process shall be the same as in usual piling process to be followed on this job. Initial test shall be carried out on such piles as per the relevant provision in IS : 2911 (Part - IV).

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 General

The Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in the Contract. Whenever directed, the Contractor shall get the specimens tested in a laboratory approved by the engineer and submit to the Engineer the test results in triplicate within three (3) days of completion of the test.

4.02.00 Components of R.C.C

The testing and acceptance criteria for the components of Reinforced Cement concrete shall be as stipulated in the relevant clauses of the Technical Specification for Cement concrete (Plain and Reinforced) appearing in the document elsewhere.

4.03.00 Static Load Test on Working Piles

In order to determine the carrying capacity of piles, static load tests shall be undertaken by the Contractor on single pile or pile groups, as indicated on drawings. Piles to be tested shall be cast at least 30 days before loading unless otherwise directed by the Engineer. Before any load test is made, the proposed arrangement of the structure, dead load to be used in making the load test, and method of application of load to the pile shall have to be approved by the Engineer. All load tests shall be made under the supervision of the Engineer. All responsibilities for conducting the test safely and properly lie with the Contractor.

The test load to be applied on pile or piles shall be one and a half times the proposed load value of the pile or piles as claimed by the Contractor. The test load shall be applied in 6 increments equal to one fourth, half, three fourth, one, one and one fourth and one and one half times the proposed working load. Readings of settlements and rebounds shall be referred to a constant elevation bench mark and shall be recorded with the help of minimum two dial gauges of 0.02 mm sensitivity and resting on diametrically opposite sides. Each stage of loading, except the final test load of one and one half times the working load, shall be maintained till the rate of movement of the pile top is not more than 0.02 mm per hour. The final test load shall be maintained for 24 hours and hourly readings of settlements are to be recorded. The total test load shall be removed in decrements not exceeding 1/5 of the total test load with intervals of not less than one hour. The rebounds shall be recorded after each decrement is effected and the final rebound shall be recorded 24 hours after the entire test load has been removed. A complete record in triplicate shall be filed with the Engineer on the loads and readings obtained duly verified and countersigned by the Engineer.

The tested piles shall be used as usual foundation piles if they satisfy the acceptance criteria, and no extra payment shall be made except for load tests on the piles.

If so desired by the Engineer, special test caps may have to be cast and subsequently dismantled at no extra cost.

4.03.01 **Acceptance Criteria**

The pile or piles tested shall be accepted to carry the proposed working load provided that the total settlement of the pile top under the load does not exceed 12 mm.

4.04.00 **Lateral Load Tests/Pull out Tests**

If desired by the Engineer lateral load tests on piles will be carried out by the Contractor as per IS:2911. Pull out tests will be carried out in special cases if required by either cantilever or fulcrum loading as may be approved by the Engineer. The quantum and nature of test loading will be as approved by the Engineer.

4.05.00 **Non-destructive Dynamic Testing on Working Piles**

In addition to the above load tests, the Contractor may also have to carry out testing of piles by non-descructive dynamic testing methods before or during piling work as desired by the engineer.

4.05.01 **"Low Strain" Method for Integrity Investigation of Concrete Piles**

The method of testing shall conform to ASTM D4945. All equipment including small impact device, 16 lbs nylon tipped hand held hammer accelerometer pile integrity tester and pile driving analyser shall be arranged by the Contractor. Analysis shall be carried out by exponential amplification of the signal with line and the average velocity curve obtained by numerically integrating the acceleration record to be submitted. From analysis of the results any defect like necking, honey-combing, segregation or weakness in concrete, when detected shall be reported in detail.

4.05.02 **"High Strain" Method for Determination of Pile Capacity**

The method of testing shall conform to ASTM D 4945. All equipment including piezoelectric transducers, strain gauges, pile driving analyser, two track oscilloscope for displaying data and contractor for every hammer below the analyser shall determined the following data :

a) Pile bearing capacity

b) Transferred energy

c) Maximum compression force

d) Maximum tension force

e) Maximum impact velocity

f) Maximum acceleration

g) Maximum displacement

which are to be properly recorded and analysed and submitted in detailed report form.

4.06.00 **Lateral Dynamic Load Test on Piles**

Two types of tests, namely, free and forced vibration lateral tests shall be carried out to observe response of soil-pile system under horizontal dynamic loads and for the evaluation of soil pile stiffness, soil modulus, natural frequency, time period and damping characteristics of soil- pile system.

A minimum of three representative piles of same type in almost similar soil conditions shall be tested. Two adjacent piles shall be subjected first to free vibrations and then to forced vibrations, the third pile shall only be tested under forced vibrations.

The equipment and accessories for the test, setting up and test procedure and recording of observations shall be as described in relevant sections IS : 9716 (Guide for Lateral Dynamic Load Test on Piles).

The tests shall normally be carried out without sustained vertical load other than that of the oscillator assembly. However, sustained weight can be used to increase dynamic force to obtain resonance or nearly resonance condition.

From analysis of test data, the following parameters shall be determined :

i) Frequency of vibrations

ii) Amplitude of vibrations

iii) Imparted dynamic force

iv) Natural frequency

v) Damping coefficient

vi) Soil-pile stiffness

vii) Coefficient of horizontal soil modulus variation

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 With Tender

The Tenderer should submit the following information alongwith his tender :

5.01.01 Design Data

The Contractor will submit full details of method of construction, design data and drawings for the type of piles he wishes to adopt.

5.01.02 Programme of construction

The Contractor will also submit the details of the construction equipment that he will employ. A proposed construction programme, matching with the capacity of the equipment and taking into consideration the various idle and non production periods on account of shifting of equipment, testing and possible delays due to modifications of design should be drawn up and submitted along with the tender, keeping in view the completion dates stipulated in the tender.

5.02.00 After Award

After award of the contract, the successful tenderer is to submit the following details.

5.02.01 Execution Plan

Within 15 days of receiving the letter of Intent the Contractor will submit 6 (six) copies of drawings showing the sequence of driving. The drawings will be prepared on the basis of a master plan giving identification number of the piles, which will be furnished by the Engineer.

5.02.02 Detailed Construction Programme

Within 30 (thirty) days of the award of contract, a detailed construction programme for completion of the work is to be submitted. This master programme will be reviewed and updated every month or at more frequent intervals as directed by the Engineer, incorporating the various factors which have caused or are likely to cause changes in the programme.

5.02.03 Requirement of Materials, Tools and Plants and Equipment

In accordance with the master programme, a detailed material, tools and plants and equipment requirement schedule, particularly for those items which the Owner is to supply or is to help in procurement as per the terms and conditions of the Contract, is to be submitted within 30 (thirty) days of the contract.

5.02.04 **Test Results**

The test data and result for the various ingredients of R.C.C., concrete cubes and cylinders, driving of the shell, static load test on single piles and group and non- destructive dynamic test on working piles will be submitted regularly and as and when directed by the Engineer. For testing the ingredients of R.C.C. the relevant clauses of the "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply.

6.00.00 **RATES**

The rate for the item of installation of piles shall include the cost of all materials consumed in the work or incidental to it as well as testing of materials, the cost of plants and equipment, labour, supervision, transport, taxes, insurances, royalties and revenue expenses, securities and safety measures, approaches, power, fuel, lubricants, services, preliminary and enabling works, camps, stores, etc. and overheads and profits complete. The rate shall include the entire cost of driving, supplying and installing concrete including the cost of providing extra concrete above cut off level and subsequent dismantling and removing the same. Rate for providing reinforcement including cutting, bending, binding and placing in position shall be quoted separately. The work to be provided for by the Contractor for installing cast in situ piles is given under clause 2.1 and elsewhere in this specification. In case no specific items is provided in the schedule to cover any particular item of work, it is implied that the Contractor will include the cost of executing such work in the rates quoted for connected items in the schedule.

7.00.00 **METHODS OF MEASUREMENT**

7.01.00 **Installation of Piles**

a) Measurement of length for payment will be done by letting down a tape with a heavy weight attached at the end, through the hole left by driving, before the reinforcement cage is lowered and concreting commences. The additional depth driven and covered with the shoe or any other materials like aggregates or concrete will not be considered for payment.

b) Unless specified otherwise in the schedule of items, piles of specific size and length will be measured in numbers. For any addition or reduction over the above specified lengths, the extra/rebate for specific sizes will be measured in length. Reinforcement in piles shall be measured in weight.

7.02.00 **Sand Filling**

The theoretical volume of sand required to fill the hole left by driving and casting the pile, upto the original ground level or the actual volume of sand used whichever is less, will be measured for payment.

7.03.00 **Load Test**

Measurement will be taken for static / dynamic, lateral load or pull out tests on single pile or groups as per specification and schedule of items on each occassion of test.

7.04.00 **Other Items**

The mode of measurement of the other connected item of work like excavation, casting pile caps and beams etc. will be governed by the relevant clauses of the Technical Specification for earthwork, concrete etc.

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SECTION-VIII

TECHNICAL SPECIFICATION
FOR
BORED CAST-IN-SITU CONCRETE PILE

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SECTION-VIII

TECHNICAL SPECIFICATION FOR BORED CAST-IN-SITU CONCRETE PILE

1.00.00 SCOPE

This specification deals with the requirements regarding materials, workmanship and installation of bored cast- in-situ reinforced concrete piles and all related items of work like sand filling in the holes after casting the piles, testing the load bearing capacity of individual piles and group of piles, etc. The relevant clauses of the "Technical Specification for Concrete Work", appearing elsewhere in this document, fall within the scope of this specification.

IS:2911 (Part-I/Sec-2) shall form a part of this specification and shall be complied with unless they are at variance with the specification where the latter shall prevail.

2.00.00 GENERAL

2.01.00 Work to be provided by the contractor

The work to be provided for by the contractor, unless otherwise specified, shall include but not be limited to the following :

a) Furnish all labour, supervision, services, materials, equipment and accessories, tools, plants transportation including consumables and temporary works required for the supply and installation of piles of desired capacity.

b) Mark the proposed sequence of installation on six (6) copies of identification plan. The identification plan will be prepared by the contractor as per the basic plan furnished by the Engineer, if so desired by him.

c) Furnish full details of the proposed piling equipment, accessories, temporary works and method of pile construction for approval of the engineer.

d) Submit detailed daily report of boring and pile casting incorporating information as required by the Engineer.

e) Carryout load tests to the satisfaction of the engineer including casting and dismantling of test caps if necessary and submit the test results in approved proforma.

f) Make necessary earthwork and approaches for movement of pile installation equipment.

g) Provide all necessary work mentioned under "Technical Specification for Cement Concrete (Plain and Reinforced)", as may be applicable.

2.02.00 **Work to be provided by others**

No work under this specification will be provided by any agency other than the contractor unless specified elsewhere in the Contract.

2.03.00 **Codes and Standards**

All work under this specification shall, unless specfied otherwise, conform to the latest revisions and/or replacements/amendments of the following or any other Indian Standard Specifications and Code of Practice.

IS : 269 - Indian Standard Specifications for 33 Grade Ordinary Portland Cement.

IS : 383 - Indian Standard Specifications for Natural Sources for Concrete.

IS : 432 - Indian Standard Specification for (Part - I)Mild Steel & Medium Tensile Steel Bars and Hard drawn Steel Wire for Concrete Reinforcement : Part I Mild Steel and Medium Tensile Steel Bars.

IS : 455 - Indian Standard Specifications for Portland Slag Cement.

IS : 456 - Indian Standard Code of Practice for Plain and Reinforced Concrete.

IS : 516 - Indian Standard Specifications for Methods of Test for Strength of Concrete.

IS : 1199 - Indian Standard Specifications for Methods of Sampling and Analysis of Concrete.

IS : 1786 - Indian Standard Specifications for high strength deformed steel bars and wires for concrete reinforcement.

IS : 2062 - Steel for General Structural Purposes

IS : 2386 - Indian Standard Specification for Methods of Test for Aggregates for Concrete Part - I to VIII.

IS : 2502 - Code of Practice for Bending & Fixing of Bars for Concrete Reinforcement.

IS : 2722 - Indian Standard Specifications for Portable Swing Weight Batches for Concrete (Single and Double Bucket Type).

IS : 2751 - Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction.

IS : 2911 - Code of Practice for Design and Cons-truction of Pile Foundations - Bored Cast-in-situ piles. (Part-I/Sec.2)

IS : 2911 - Code of Practice for Design and (Part - IV)Construction of Pile Foundations - Load Test on Piles.

IS : 4926 - Indian Standard Specifications for Ready Mixed Concrete.

IS : 9716 - Guide for Lateral Dynamic Load Test on Piles.

2.04.00 **Conformity with design**

The contractor will prepare check lists in approved proforma which will be called "Pile Installation Cards". At each important stage of the work as decided by the engineer, the work will be checked and approved by the engineer for correctness and conformity with the design, specification and drawings, before allowing the next phase of work to commence. The intermediate checks and approvals by the engineer will not, however, absolve the contractor from his total responsibility to execute the work as per the specification and drawings and to remove and/or rectify all work which is defective or inaccurate.

2.05.00 **Materials**

2.05.01 **General**

All materials whether incorporated in the works or used temporarily as aids or for executing enabling works will be of best approved quality conforming to the latest Indian Standard specification.

2.05.02 **Casing**

Casing in boreholes where used, should be manufactured out of best quality mild steel with proper treatment, the composition and thickness of the materials being of special importance where they are likely to be in contact with harmful chemicals and organic materials causing deterioration in service. Casing to be left in place like in offshore piling should also receive similar consideration in selection. They shall have sufficient strength and rigidity to permit their being driven and not to be distorted by soil pressure or driving of adjacent tubes. They shall be sufficiently water-tight to exclude water during placing of concrete.

2.05.03 **Concrete**

Concrete type M-15/M-20 grade shall be used for piles as indicated in drawings. Materials and method of manufacture for cement concrete shall in general be in accordance with IS : 456. The concrete cube strength on 15 cm. cubes at 28 days shall satisfy the acceptance criteria as per IS : 456. Concrete cubes will be cast as per instruction of the Engineer. These will be cast and cured by the Contractor at site for testing. The concrete shall be of such consistency as to give a slump of 100 to 150 mm. Cement used for the concrete shall be Portland Blast Furnace Slag or 33 Grade ordinary Portland cement conforming to IS:455 & IS:269 respectively. The minimum cement content should be 350 kg/m3 and 385 kg/m3 for M-15 & M-20 grade concrete respectively based on subsoil condition requirement besides that required from strength and other considerations.

2.05.04 **Reinforcement**

Reinforcement shall be mild steel bars conforming to IS: 432. If instead of mild steel, Tor steel bars are used, they shall conform to IS : 1786.

2.06.00 **Storage of Materials**

2.06.01 **General**

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the engineer shall not be used, failing which, the engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the contractor's dues. The relevant clauses pertaining to storage of material under "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply.

2.06.02 **Casing**

Mild steel casing will be painted outside with two coats of anticorrosive paint or smeared with protective layer of grease and kept stored in weather proof sheds, off the ground, on sturdy racks in such a manner as to enable quick and easy in spectrum. Epoxy painting on outside surface shall be provided if so specified in the drawing.

2.07.00 **Quality Control**

The contractor shall establish and maintain quality control for different items of work and materials as may be directed by the engineer to assure compliance with contract requirements and maintain and submit to the engineer records of the same. The quality control requirements stipulated under the "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply wherever relevant. In addition, the requirement will include but not be limited to the following.

a) Location and plumb : Control survey for accuracy in plan and check for verticality.

b) Driving of casing : Correction of weight of hammer, length of fall, number of strokes per minute and rate of penetration.

c) Boring : Boring method to suit soil profile.

d) Casting of piles : Check inside casing, reinforcement cage, concrete mix, placing, consolidation and curing.

e) Inspection of pile

f) Load tests

2.07.01 Any work which fails to conform to the specification will be subject to the issue of a `non-conformance report' in line with the quality control procedures to be implemented at site. Corrective or remedial action, design modification or product rejection will be reviewed in accordance with site quality plan.

3.00.00 **INSTALLATION**

All installation requirements shall be in accordance with IS : 2911 (Part - I/ Sec.2) and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification might not have covered all the aspects to the full satisfaction of the engineer.

3.01.00 **General**

The tenderer shall furnish complete information about the type of piles offered with sketches of pile sections showing reinforcement, method of boring, details and availability of equipment and accessories formula or data curve on which the tenderer bases the load carrying capacity of piles as well as the criteria for determining suitable and sufficient founding of individual piles and any other relevant details.

The tenderer will be supplied with bore hole logs or any other data indicating the nature of the soil expected to be encountered. The information furnished to the contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. Piles should be founded on suitable continuous hard strata. In case the contractor is required to drive piles to greater or shallower depths than that is envisaged, the rates will be adjusted as per relevant items in the schedule of items and no other extra claims will be entertained. The tenderer should, in his own interest, investigate the site thoroughly and take additional bores if he feels it necessary to assess the type of boring equipment to be used and the depth to suitable founding strata.

3.02.00 **Design of Pile**

The contractor shall satisfy the engineer as to the boring procedure and equipment which he proposes to use for the particular conditions of the site. If the engineer desires, sufficient test piles shall be installed to prove the adequacy of the pile, at the places indicated by the engineer and a load test shall be performed on each pile.

The Contractor shall satisfy the Engineer as to the boring procedure and equipment which he proposes to use for the particular conditions of the site. If the Engineer desires, sufficient test piles shall be driven to prove the adequacy of the pile, at the places indicated by the Engineer, and a load test shall be performed on each pile.

Piles have to be reinforced throughout their length. Main longitudinal reinforcement in the length of the piles as well as links or spirals shall be provided as shown in the drawings. Longitudinal bars shall preferably be in one length. Reinforced cage shall be handled and installed carefully without damaging its shape. All other requirements of reinforcement bars i.e., qualilty, workmanship, etc. shall be as specified for reinforced concrete work in Technical Specification for Concrete work.

The average basic length of the piles shown in the drawing/schedule of items is tentative and is to be assumed from cut-off level to the tip of the pile, but the final length will be decided by the Contractor with approval of the Engineer on the basis of boring resistance actually observed at site at the particular location. It will be the responsibility of the Contractor to prove by subsequent load tests/pull-out tests that the adopted length of the pile shall carry the safe loads, in compression and tension with the resulting

deflections being within permissible limits. To ensure this, the length of the pile actually installed will be subject to change if considered necessary from the abovementioned basic length and payment shall be made to the Contractor on the basis of the actual lengths of pile installed at the rates quoted by the Contractor for deviation in length above or below the stipulated basic length.

If the load test is satisfactory and the Engineer accepts the type of the pile as suitable, payment shall be made for the pile. If the piles by reasons of defective workmanship or failure of one or more load tests, are found to be unsatisfactory, the cost of the test piles shall be borne by the Contractor.

3.03.00 **Identification of Piles**

A plan in triplicate, showing clearly the designation of all piles by an identifying system shall be filed with the engineer before installation of piles is started if so desired by the engineer.

3.04.00 **Sequence of Piling**

Individual piles and pile groups shall be constructed in such a sequence that the adjacent piles already installed are not disturbed, nor their carrying capacity reduced by subsequent boring/driving operation. The Contractor shall submit the sequence order and programme chart to the Engineer and get his confirmation before starting the work.

3.05.00 **Boring**

3.05.01 **With Casing**

Boring equipment and accessories shall generally conform to IS:2911 - relevant section. Boring may be done by either rotary or percussion equipment or grabbing equipment using reversed or direct mud circulation method. In case of unstable soils the boring tools used should be such that suction effects are minimised. Stabilisation of the sides of bore hole shall be done by use of casing. The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm.

The casing should be used from the ground level and shall be kept ahead of boring in case where there is danger of caving-in due to subsoil water entering into the bore hole or where the soil is loose. While boring below subsoil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to difference in hydrostatic head.

Boring shall proceed by alternatively driving the casing and extracting the bored material with the boring tools. While boring in soft material liable to cavitation boring tools shall not be operated at a level below the toe of the casing. Care shall be taken to ensure that the volume of water added to the bore shall be not more than the minimum necessary for the operation of the boring tools. The casing shall be driven down through the soft material to

penetrate a hard stratum not subjected to cavitation and shall be sealed in this material as far as possible. Thereafter the boring shall be continued by means of the boring tools until the approved bearing layer is reached.

Criteria for approval of the bearing layer will be agreed between the Engineer and the Contractor based on visual inspection of recognisable samples, recovered from the pile bore in the upper levels of the compact layer. The approved samples shall consist of sound material shall be consistent in quality for a depth of 300 mm in the pile bore. A sample of this material shall be supplied by the Contractor to the Engineer duly labelled for maintaining records of the founding strata.

The piles shall be installed with due consideration for safety of adjacent structures by a method which leaves their strength unimpaired and which develops and retains the required bearing resistance.

Where the soil is such that driving of a pile causes previously installed piles to heave, load test shall be conducted at the expense of the Contractor on such pro- portion of the heaved piles which shall be ordered by the Engineer.

3.05.02 **With Drilling Fluid**

Alternate to the boring with casing, stabilisation of the sides of bore hole can be effected by the use of drilling fluids.

In such cases the drilling fluid must be used at least from the level of subsoil water, as the hole, should then be always kept almost full with the fluid. The density and composition of the fluid shall be such as to suit the requirements of ground conditions and to maintain the fine materials from the boring in suspension. At the last stage of boring or in inter- mediate hard layers chisel or a chopper may be used. The rate for piling work should be inclusive of any chiselling, chopping of hard strata, clearing of bottom of pile borehole etc. complete as per specifications and necessary penetration test as may be required to prove the soundness of the founding strata. A five per cent bentonite suspension would be generally suitable and its quality shall conform to specification given in Appendix 'A' of IS : 2911 (Part-I/Sec.2).

3.06.00 **Spacing of Piles**

In general, all piles shall have a minimum spacing on centres of 3 d (where 'd' is the diameter of the pile) unless shown otherwise in the drawings.

3.07.00 **Placing of Reinforcement**

Reinforcement as required shall be made into stiff cages sufficiently wired or welded to withstand handling without any damage or distortion. Reinforcement shall be placed immediately after cleaning and inspection of the bottom of bore holes. The reinforcement should be supported away from the sides of the shaft by means of suitable space block to ensure concentric

alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion.

Nominal lap between reinforcement cages shall be 60 cm and the main reinforcing steel shall project for a length sufficient to develop bond (45 times the diameter of reinforcing bar) above the level of the underside of the pile cap.

The concrete cover to main reinforcement shall not be less than 5 cm and suitable spacer blocks shall be provided at intervals not exceeding 2 metres and wired to the main reinforcement.

3.08.00 **Concreting**

Immediately before concreting the bottom of the hole shall be cleaned very carefully. The cleaning of the hole shall be ensured by careful operation by air lifting process unless otherwise allowed by the Engineer. To lift the spoil at founding level before concreting, borehole shall be agitated by jetting with fresh drilling mud with relatively higher pressure than that used during boring or air through tremie pipe. While boring by use of drilling mud, the specific gravity of the mud suspension in the vicinity of the bottom of the borehole shall be determined by suitable slurry sampler in a first few piles and at suitable interval of the piles and recorded. Consistency of the drilled mud suspension shall be controlled throughout the boring as well as concreting operation in order to keep the hole stabilised and to avoid concrete mixed up with the thicker suspension of the mud.

Concreting of boreholes shall start as soon as possible after the completion of boring. If a borehole, be left unconcreted for more than two hours, it shall be cleaned thoroughly as directed by the Engineer before concreting. Concrete shall be so placed as to fill the entire volume of the tube or bore without the formation of voids caused by faulty consolidation or entrapped air. Great care shall be taken to ensure that the fluid alluvial soil does not penetrate between batches of the concrete. Concreting under water shall be done in one operation. Concrete shall be placed by means of a tremie pipe. It shall, however, be ensured that concrete ente- ring the tremie pipe does not get mixed up with the slurry and 1/4 kg of granulated vermiculite shall be poured in the tremie pipe before pouring concrete as directed by the Engineer.

3.08.01 **Tremie Method of Concreting**

The tremie pipes and funnel shall be filled and lifted just 15 cm above bottom before releasing the concrete column to facilitate flushing out the bottom. The concrete levels in the tremie shall be checked every few centimetres in order to note the difference, if any, between the theoritical quantity that should have been placed and actual quantity that has gone in. This is to locate the position of over cut during boring.

In addition to the normal precautions to be taken in tremie concreting as per relevant section of IS:2911 the following specifications shall be particularly applicable for the use of tremie concrete in pipes :

a) The concrete shall be coherent, rich in cement (not less than 400 kg/m3) and of slump not less than 100 mm.

b) The hopper and tremie shall be closed system embedded in the placed concrete, through which water cannot pass.

c) The tremie shall be large enough with due regard to the size of the aggregate. For 20 mm aggregate the tremie pipe shall be of diameter not less than 200 mm, aggregates more than 20 mm shall not be used.

d) The first charge of concrete shall be placed with a sliding plug pushed down the tube ahead of it or with a steel plate of adequate charge to prevent mixing to concrete and water. However, the plug shall not be left in the concrete as a lump.

e) The tremie pipe shall always penetrate well into the concrete with an adequate margin if safety against withdrawal of the pipe is required while discharging the concrete.

f) The pile shall be concreted wholly by tremie and the method of deposition shall not be changed part way up the pile, to prevent the laittance from being entrapped within the pile.

g) All tremie tubes shall be scrupulously cleaned after use.

Normally concreting of the piles shall be uninterrupted. In exceptional cases interruption of concreting may be allowed but it will be resumed within 1 or 2 hours. The tremie shall not be taken out of the concrete, instead it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting should be resumed by introducing a little richer concrete with a higher slump for taking care of the partly set concrete in the bore.

If the concreting cannot be resumed before final setting of concrete already placed, the pile so cast may be rejected.

In case of withdrawal of tremie out of the concrete, either accidentally or to remove a choke in the tremie, the tremie may be reintroduced in the following manner to prevent impregnation of laittance or scum lying on the top of the concrete already deposited in the bore.

The tremie shall be gently lowered on to the old concrete with very little penetration initially. A ver- miculite plug shall be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm shall be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing laitance/scum. The tremie will be pushed further in steps making fresh concrete sweep away laitance/scum in its way. When tremie is buried by about 60 to 100 cm, concreting may be resumed.

3.08.02 **Concreting in Cased Holes**

In case of cased holes, after the required founding level is encountered, the bottom shall be sealed with concrete and the reinforcement cage shall be lowered. If the borehole is dry, concrete shall be deposited by direct pour from the top followed by gradual withdrawal of casings. If water is present in the borehole, it shall be bailed out by bailer.

If it is difficult to dewater by the bailer, concrete shall be placed under water by means of a placer. After the head of water has been neutralised by the head of the concrete, excess water shall be bailed out and concrete shall then be deposited by direct pouring from the top, as is done, if the borehole is dry.

Extraction of casing shall be done in such a way that no necking or shearing of the concrete in the shaft takes place.

During the extraction of casing, slumping of concrete shall be observed and when required, additional quantity of concrete shall be poured so that the pile is formed above the cut-off level as per the requirements indicated below.

3.08.03 **Cut-off Level**

The top of concrete in a pile shall be brought above the cut-off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut-off level for proper embedment into the pile cap.

Where cut-off level is less than 1.5 m below the working level concrete shall be cast to a minimum of 500 mm above cut-off level. For each additional 0.3 m increase in cut-off level below the working level additional coverage of 50 mm minimum shall be allowed. Higher allowance may be necessary depending on the length of the pile as directed by the Engineer. When concrete is placed by tremie method, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of one metre above cut-off level. In the circumstances where cut-off level is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above cut-off level shall be determined and allowed in Works.

3.09.00 **Steel Pipe or Casing tube**

This item shall be fabricated with mild steel plates conforming to IS : 2062 and/or steel tubes for structural purpose conforming to IS : 1161 & IS : 1239 as shown on drawings and/or described in the schedule of items.

Fabrication work and welding of steel shall be done in accordance with IS : 800 and IS : 9595. Welding of pipes shall be done by experienced and good welder who have been qualified by tests in accorance with IS : 817.

3.10.00 **Trimming of Pile Heads**

Completed piles shall be trimmed to the cut-off levels shown on the drawings or until sound concrete is found to the satisfaction of the Engineer. In the event of trimming being carried below the cut-off level, the pile shall be made upto the correct cut-off level, with concrete of the same quality as used in the piles at the Contractor's expense. Reinforcement shall be exposed for the full bond length appropriate to the diameter of the bar and projected in the pile cap. The minimum distance of keying of pile into pile cap shall be 75 mm unless noted otherwise. All concrete and cement shall be removed from the bars, which shall also be wire-brushed to remove any loose, rust, dirt and scale.

Manual chipping shall be permitted after three (3) days of pile casting. Pneumatic chipping, if permitted by the Engineer, shall not be started before seven (7) days. In case Portland Pozzolana cement is used, chipping shall only be started as directed by the Engineer.

3.11.00 **Lengthening of Piles**

Where it is necessary to increase the length of any pile after it has been driven, the head of the pile shall be cut-off to expose the reinforcement for a full bond length of the bars to lap with the new bars. The exposed surface of the concrete shall be hacked to form a key, brushed to remove loose material and covered with 25 mm thick cement mortar (1:2 mix) immediately before the new concrete is placed.

3.12.00 **Removal of Spoil**

The Contractor shall be responsible for the prompt removal from the site of all spoil due to the boring to places indicated by the Engineer. The cost of such disposal shall be deemed to have been included in the cost of piling.

3.13.00 **Back-Filling of Abandoned Borings**

The Contractor shall backfill all the abandoned borings between the concrete pile and the surface level after setting of concrete of the piles, by sand or by other materials as directed by the Engineer.

All permanently abandoned boreholes generally shall be backfilled with selected materials and for a depth of 5 M below cut-off level with plain concrete of mix 1:4:8 so that resistance to lateral forces on neighbouring piles are developed.

3.14.00 **Record for Installation of Piles**

The Engineer and the Contractor shall maintain separate registers, signed jointly by both the parties, giving the following information for each pile or any other proforma as agreed between Engineer and Contractor. These data shall be submitted to the Engineer, in triplicate, on completion of installation of each pile.

a) Date of completion, pile number & sequence of installation of piles in a group.

b) Bored depth, concreted depth, empty boring and nature of stratum at founding level.

c) Pile diameter, details of reinforcement and details of mild steel liner where provided along with stiffener.

d) Volume of concrete poured, time taken, cement bag consumption, slump of concrete and RL of top of concrete.

e) Time taken for penetration of every 15 cm during last 2 M depth before founding level.

f) Method of cleaning bottom of hole at founding level before concreting.

g) Records of additional borings or other subsurface information obtained during the process of boring.

h) Any other relevant important information.

Any sudden change in the rate of boring which cannot be ascribed to the nature of the ground or any deviation from the designed location, alignment or load carrying capacity of any pile or any upheaval or subsidence noticed on any pile shall be promptly reported to the engineer and adequate corrective measures shall be taken free of any charge as decided by the engineer.

The data for pile load test (load, displacement, time, etc.) are to be recorded sequentially for the test under consideration in a suitable proforma as agreed between Engineer and Contractor. These data along with the load-displacement curve shall be submitted to the Engineer, in triplicate, on completion of each load test.

3.15.00 **Defective Piles**

Any pile which is shown to be defective under load test shall not be accepted and the Engineer will relate such failure to the acceptance of other piles in the area.

If an individual pile should fail to meet the requirements specified in Clause 16.00.00 above such piles may be deemed to be defective and the Engineer may order such investigation to be made as he considers appropriate.

When any pile is found defective, the Contractor shall perform at his own expense one or more of the following remedial measures as directed by the Engineer.

i) Replacement of defective piles.

ii) Providing additional piles.

iii) Alteration in design of pile caps.

3.16.00 **Idle Period**

The phasing of construction and movement of plant shall be done as desired by the engineer. The phasing may involve some extra movement of the plant or some idle period, but the contractor will not be entitled to any claim due to this reason.

3.17.00 **Test Pile**

The contractor may have to construct test piles, if desired by the engineer, before he starts systematic piling operation at locations indicated. For this purpose, the pile construction process shall be the same as in usual piling process to be followed on this job. Load test on such piles shall be as per the provisions under "Procedure for Initial Load Test" in IS : 2911 (Part - IV) or as directed by the engineer.

3.18.00 **Offshore Piles**

Offshore piles, subjected to high horizontal forces and having large unsupported height above the bed level are to be installed under structures to be constructed on river/sea bed. Installation shall be done with the help of floating rig/crane from the river or by cantilever method from land using moving gantry or similar other equipment. Temporary filling of the area for movement of the piling rig will, however, be allowed to the extent that such filling does not encroach on the flow of the river and also no hindrance is caused to adjoining work. The cost of building such temporary gangway/filling, embedment and removal of the same shall be included in the cost for relevant items related to installation of offshore Piles in the schedule of items.

The piles adopted are in general large diameter bored piles with mild steel liner retained for a height as indicated in the related drawings. The liner shall be of 6 mm mild steel plates fabricated to true shape and be provided with protective surface treatment. The concreting shall be done by tremie method as described earlier and according to the other stipulation as described in the Technical Specification.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 General

The contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in the contract. Whenever directed, the contractor shall get the specimens tested in a laboratory approved by the engineer and submit to the engineer test results in triplicate within three (3) days of completion of the test.

4.02.00 Components of RCC

The testing and acceptance criteria for components of reinforced cement concrete shall be as stipulated in the relevant clauses of the Technical Specification for Cement Concrete (Plain and Reinforced).

4.03.00 Components of Steel

Testing and acceptance criteria for the component of steel pipe material and fabrication work shall be as stipulated in relevant clauses of IS : 800 and IS : 9595.

4.04.00 Load Tests

4.04.01 General

Initial tests and/or routine tests as indicated in the schedule of items or as directed by the engineer shall be carried out on single pile or pile groups to ascertain the capacities of the piles and their behaviour.

Any or all of the tests described below shall be carried out as indicated in the schedule of items and as directed by the engineer. The tests shall be performed as per requirements of the relevant Indian Standards and as supplemented herein.

4.04.02 Vertical Load Test [as per IS : 2911 (Part-IV)]

Load tests shall be carried out on single piles to check the bearing capacity or the quality of piles in the manner specified below :

From among the completed piles the Engineer at his discretion shall select piles for the purpose of testing.

At least 1% of the piles driven shall be tested to an overload of 50% above the working load of the pile and 0.1% of the piles driven shall be tested to an over load of 100% above the working load of the pile.

Load shall be applied in increments of about one-fifth of the design load till the design load is reached and thereafter in increment of 10 tonnes till the test load is reached.

Each increment of load shall be maintained for minimum of half an hour upto design load and thereafter for one hour till the test load is reached. Test load shall be maintained for 24 hours.

For each increment of load, readings of settlement at every ten minutes shall be taken. The next increment of load shall be applied only when the difference in settlement of readings between the last two readings does not exceed 0.02 mm. On application of test load, readings shall be taken at every hour.

Unloading will be done in following decrements of load :

i) Test load to design load

ii) Design load to 50% of design load

iii) 50% of design load to 25% of design load

iv) 25% of design load to complete unloading

Each decreased load shall be kept for a minimum of half an hour and readings of rebound taken every ten minutes. The next decrement shall be applied only when the difference in readings between the last two readings is less than 0.02 mm.

The observation and recording of settlement and rebound shall be done simultaneously by the Contractor and the Engineer's representative. Three copies of all the readings for the test shall be supplied by the Contractor to the Engineer-in-charge. Actual proforma for recording the results shall be proposed by the Contractor and approved by the Engineer-in-charge before the start of the load test.

The pile shall be deemed to be acceptable if the gross settlement at the test load of one and a half times the designed load does not exceed 0.01" per tonne of test load or 1/2" (12 mm) whichever is less.

In case a pile fails under or during the load test, the Engineer shall select two additional piles in lieu of each of such piles failed and the Contractor shall carry out load tests on these piles in the same way as the load tests on the original piles at his own cost. This procedure will be repeated in the case of each failure of pile under/during load test.

The Contractor shall arrange at his own expense sufficient amount of knowledge for loading well in advance of the commencement of the load test.

Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Contractor to the Engineer-in-charge for checking and approval.

The pile head shall be chipped off to natural horizontal plane till sound concrete is met. The projecting reinforcement shall be cut-off or bent suitably and the top finished smooth and level. A bearing plate with a hole at the centre shall be placed on the head of the pile for the jacks to rest.

Jacks used in any particular load test should be of the same capacity and their number shall be limited to two only. They should preferably be connected and operated by one pump. The Contractor shall submit certificates certifying the correctness of the calibrations of the pressure gauges and jacks before use. All jacks should be fitted with locking devices. Settlement and rebound shall be recorded by minimum two (2) deflectometers of 0.01 mm sensitivity and also by other independent means of direct measurement. Deflectometers shall be supported independently and in such a way as to be not affected by the settlement of the piles.

4.04.03 **Lateral Load Test**

The test shall be carried out by introducing hydraulic jack with gauge between two piles under test or the reaction shall be suitably obtained otherwise. When the test is conducted by jack located between two piles, the full load imposed by the jack shall be taken as the lateral resistance of each pile.

Load shall be applied in increments of about one-fifth of the design load. The next increment shall be applied after the rate of displacement is nearer to 0.1 mm per 30 minutes. Displacement shall be read by using at least two (2) deflectometer of 0.01 mm sensitivity spaced by 30 cm and kept horizontally one above the other or by any means as per IS-2911 (Part-4) or as approved by the Engineer. The safe lateral load on pile shall be taken as the least of the followings :

a) Fifty percent (50%) of the final load at which displacement increases to 12 mm.

b) Final load at which the total displacement corresponds to 5 mm.

4.04.04 **Pull-out Test**

The test shall be carried out to an overload of fifty percent (50%) of the estimated safe load or a displacement of 12 mm total whichever is earlier.

Uplift force may preferably be applied by means of hydraulic jack(s) with gauge using a suitable pull-out set up as per IS-2911 (Part-4) or as approved by the Engineer.

The pull-out load increments and consequent displacement readings shall be same as in the case of Vertical Load Test.

The safe load shall be taken as the least of the followings :

a) Two-thirds of the total load at which the load-displacement is 12 mm.

b) Half the load at which the load-displacement curve shows a clear break (downward trend).

4.05.00 **Non-destructive Dynamic Test on Working Piles**

4.05.01 **"Low Strain" Method for Integrity Investigation of Concrete Piles**

The method of testing shall conform to ASTM D 4945.

All equipments e.g., small impact device 16 lbs. nylon tipped hand held hammer, accelerometer, pile integrity tester & pile driving analyser shall be arranged by the Contractor. Analysis shall be carried out by exponential amplification of the signal with time and the average velocity curve obtained by numerically integrating the acceleration record to be submitted. From analysis of the results any defect like necking, honey-combing, segregation or weakness in concrete, when detected shall be reported in detail.

4.05.02 **"High Strain" Method for Determining of Pile Capacity**

The method of testing shall conform to ASTM D 4945. All equipment including piezoelectric transducers, strain gauges, pile driving analyser, two track oscilloscope for displaying data and analog tape recorders for recording data shall be arranged by the contractor. For every hammer below, the analyser shall determie the following data :

i) Pile bearing capacity

ii) Transferred energy

iii) Maximum compression force

iv) Maximum tension force

v) Maximum impact velocity

vi) Maximum acceleration

vii) Maximum displacement

which are to be properly recorded and analysed and submitted in a detailed report form.

4.06.00 **Acceptance Criteria**

The piles shall be accepted as satisfactory only when the work has been executed in accordance with this specification to the satisfaction of the Engineer and the standards stated hereinafter.

a) The head of the pile shall be within 75 mm of the specified position on the drawings.

b) The pile shall not be out of plumb by more than two percent.

c) The toe of the pile shall be at the approved bearing level in each case.

d) The total volume of concrete shall not be less than 20% and not more than 50% greater than the calculated volume. The calculated volume for this purpose shall be the cross-sectional area inside the casing multiplied by the length of the shaft. The concrete shall show the specified strength as indicated by the cube test results.

e) The results of the load tests incl. non- destructive dynamic test carried out in accordance with the contract and with the specifications shall be satisfactory.

f) In case of single pile the positional tolerance shall not be more than 50 mm.

4.07.00 **Lateral Dynamic Load Test on Piles**

Two types of tests, namely, free and forced vibration lateral tests shall be carried out to observe response of soil-pile system under horizontal dynamic loads and for the evaluation of soil-pile stiffness, soil modulus, natural frequency, time period and damping characteristics of soil-pile system.

A minimum of three representative piles of same type in almost similar soil conditions shall be tested. Two adjacent piles shall be subjected first to free vibrations and then to forced vibrations, the third pile shall only be tested under forced vibrations.

The equipment and accessories for the test, setting up and test procedure and recording of observations shall be as described in relevant sections of IS : 9716 (Guide for Lateral Dynamic Load Test on Piles). The tests shall normally be carried out without sustained vertical load other than that of the oscillator assembly. However, sustained weight can be used to increase dynamic force to obtain resonance or nearly resonance condition.

From analysis of test data, the following parameters shall be determined :

i) Frequency of vibrations

ii) Amplitude of vibrations

iii) Imparted dynamic force

iv) Natural frequency

v) Damping coefficient

vi) Soil-pile stiffness

vii) Coefficient of horizontal soil modulus variation

5.00.00 INFORMATION TO BE SUBMITTED

5.00.01 With Tender

The tenderer should submit the following information alog with his tender.

5.01.01 Design Data

The contractor will submit full details of the method of construction, design data and drawings for the type of piles he wishes to adopt.

5.01.02 Programme of Construction

The contractor will also submit the details of the construction equipment that he will employ. A proposed construction programme, matching with the capacity of the equipment and taking into consideration the various idle and non production periods on account of shifting of equipment, testing and possible delays due to modifications of design should be drawn up and submitted along with the tender, keeping in view the completion dates stipulated in the tender.

5.02.00 After Award

After award of the contract, the successful tenderer is to submit the following details :

5.02.01 **Execution Plan**

Within 15 days of receiving the letter of intent the contractor will submit six (6) copies of drawings showing the sequence of piling. The drawings will be prepared on the basis of a master plan giving identification number of the piles, which will be furnished by the engineer.

5.02.02 **Detailed Construction Programme**

Within thirty (30) days of award of the contract, a detailed construction programme for completion of the work is to be submitted. This master programme will be reviewed and updated every month or at more frequent intervals as directed by the engineer, incorporating the various factors that have caused or are likely to cause changes in the programme.

5.02.03 **Requirement of Materials, Tools and Plants and Equipment**

In accordance with the master programme, a detailed material, tools and plants and equipment requirement schedule, particularly for those items which the owner is to supply or is to help in procurement as per the terms and conditions of contract is to be submitted within thirty (30) days of award of the contract.

5.02.04 **Test Results**

The test data and results for the various items like welding of pipes, ingredients of RCC, concrete cubes and cylinders, driving of the shell, static load tests on single piles and pile groups and dynamic tests on working pile will be submitted regularly and as and when directed by the engineer.

6.00.00 **RATES**

The rates for the items of installation of cast-in-situ bored piles shall include the cost of mateials consumed in this work or incidental to it as well as testing of materials, the cost of plants and equipment, labour, supervision, transport, taxes, insurance, royalties and revenue expenses, security and safety measures, approaches, power, fuel, lubricants, services, preliminary and enabling works, camps, stores, etc. and overheads & profits complete. The rate shall include the entire cost of boring, supplying and installing concrete including the cost of extra concrete above cut-off level and subsequently dismantling and removing the same and providing steel casing wherever required. In case no specific item is provided in the schedule to cover any particular item of work, it is implied that the contractor will include the cost of executing such work in the rates quoted for connected items in the schedule.

7.00.00 METHOD OF MEASUREMENT

7.01.00 Piles

Unless specified otherwise in the schedule of items piles shall be measured in number and payment shall be done for the number of piles of a specific size and with a specified length measured from the toe of piles upto the pile cut-off level.

For any addition or reduction over the above specified lengths, the extra/rebate in rates for specific sizes shall be measured in length units.

7.02.00 Permanent Steel Casing

The weight of M.S.plate for use as casing shall be measured for payment.

7.03.00 Reinforcement

Length of reinforcing steel measured or calculated from drawings, whichever is less, including laps will be multiplied by standard unit weights to arrive at the quantity to be paid for.

7.04.00 Filling in boreholes

The theoretical volume of the selected material required to fill the borehole between the concrete pile and surface level or the actual quantity of such material provided, whichever is less, shall be measured for payment.

7.05.00 Load Tests

For load tests, measurement shall be taken for vertical, lateral load or pull-out tests on single piles or pile group and dynamic test on working piles as per specification and schedule of items on each occasion of test.

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SECTION-IX

TECHNICAL SPECIFICATION
FOR
FABRICATION OF STRUCTURAL STEELWORK

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SECTION-IX

TECHNICAL SPECIFICATION FOR FABRICATION OF STRUCTURAL STEELWORK

1.0.0 SCOPE

This specification covers supply, fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork in general covered under the scope of the contract. However, for any special structures such as rail & road bridges, steel chimney, tanks, transmission towers, furnace structures, etc., the relevant Indian Standard or IRC specification and Codes of Practices shall be given due consideration over & above this specification.

2.0.0 GENERAL

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following :

a) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on approved design drawings marked 'Released for construction'.

b) To submit revised design with calculations and detailed fabrication drawings in case any substitution of the designed sections are to be made.

c) To submit design calculations for joints and connections developed by the contractor along with detailed fabrication drawings.

d) Prepare and submit monthly materials reconciliation statement showing effective utilization of raw steel materials supplied from EPC contractor's store for time to time assessment of scrape generation.

e) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.

f) Suitably mark, bundle and pack for transport all fabricated materials.

g) Prepare and furnish detailed Bill of Materials, Drawing Office Despatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

h) Insure, load and transport all fabricated steelwork field connection materials to site.

2.2.0 **Work by others**

No work under this specification will be provided for by any agency other than the contractor, unless specifically mentioned otherwise elsewhere in the contract.

2.3.0 **Codes and standards**

All work under this specification shall, unless otherwise specified in the contract, conform to the requirements of the latest revision and/or replacements of the following or any other relevant Indian Standard specifications and codes of practice. In case any particular aspect of the work is not specifically covered by any Indian Standard Specification, any other standard practice, as may be specified by the Engineer shall be followed :

IS : 800 - Code of practice for general construction in steel.

IS : 801 - Code of practice for use of cold formed light gauge steel structural members in general building construction.

IS : 806 - Code of practice for use of steel tubes in general building construction.

IS : 808 - Dimensions for rolled steel beams, channels and angle sections.

IS : 812 - Glossary of terms relating to welding & cutting of metals.

IS : 813 - Scheme of symbols for welding.

IS : 814 - Covered electrodes for metal arc welding of carbon and carbon manganese steel.

IS : 815	-	Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile 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 & testing metal arc welders.
IS : 818	-	Code of practice for safety and health requirements in electric and gas welding and cutting operations.
IS : 819	-	Code of practice for resistance spot welding for light assemblies in mild steel.
IS : 822	-	Code of practice for inspection of welds.
IS : 919 (Part - 1&2)	-	Recommendations for limits and fits for engineering.
IS : 1161	-	Steel Tubes for structural purposes.
IS : 1182	-	Recommended practice for Radiographic Examination of fushion welded butt joints in steel plates.
IS : 1200 (Part - 8)	-	Method of measurement of steel work and iron work
IS : 1239 (Part - 1&2)	-	Mild steel tubes, tubulars & other wrought steel fittings
IS : 1363 (Part - 1 to 3)	-	Hexagon head bolts, screws & nuts of product grade C
IS : 1364 (Part - 1 to 5)	-	Hexagon head bolts, screws and nuts of product grade A & B
IS : 1365	-	Slotted counter sunk head screws (dia. 1.6 to 20 mm)
IS : 1367 (Part - 1 to 18)	-	Technical supply conditions for threaded steel fasteners.
IS : 1608	-	Method for tensile testing of steel products.
IS : 1730	-	Dimensions for steel plate, sheet and strip for structural and general engineering purposes.

IS : 1852	-	Rolling and cutting tolerances for hot-rolled steel product.
IS : 1977	-	Structural steel (Ordinary quality)
IS : 2016	-	Plain washer
IS : 2062	-	Steel for general structural purposes.
IS : 2629	-	Recommended practice for hot-dip galvanising of iron and steel.
IS : 2633	-	Method for testing uniformity of coating on zinc coated articles.
IS : 3644	-	Code of practice for ultrasonic pulse echo testing by contact and immersion method.
IS : 3757	-	High Strength Structural Bolt
IS : 4000	-	High strength bolts in steel structure
IS : 4759	-	Specifications for hot-dip zinc coatings on structural steel and other allied products.
IS : 4923	-	Hollow steel sections for structural use.
IS : 5334	-	Code of practice for magnetic particle flaw detection of weld.
IS : 5369	-	General requirements for plain washers and lock washer.
IS : 6005	-	Code of practice for phosphating of iron and steel.
IS : 6649	-	Specification for hardened and tempered washers for high strength structural bolts and nuts.
IS : 6623	-	Specification for high strength structural nuts.
IS:7215	-	Tolerances for fabrication of steel structures.
IS : 7280	-	Bare wire electrode for submerged arc welding
IS : 8500	-	Structural steel micro alloyed (medium & high strength quality).

IS : 8629 (Part - I to III)	-	Code of practice for protection of iron steel & structures from atmospheric corrosion.
IS : 9595	-	Recommendation for metal arc welding of carbon manganese steels.

PAINTING

IS : 117	-	Specification for ready mixed paint, brushing, finishing, exterior, semi-gloss, for general purposes.
IS : 128	-	Specification for ready mixed paint, brushing, finishing, semi-gloss for general purposes, black.
IS : 1477 (Part - I & II)	-	Code of practice for painting of ferrous metal in building
IS : 2074	-	Ready mixed paint, air-drying red-oxide zinc chrome priming.
IS : 2339	-	Specification for aluminium paints for general purposes in dual container.
IS : 2932	-	Specification for enamel, synthetic exterior type - I.
IS : 2933	-	Specification for enamel, synthetic exterior type - II.

2.4.0 **Conformity with Designs**

Except where the standard connection details are furnished, the contractor shall design all connections, supply and fabricate all steelwork and furnish all connection materials in accordance with the approved drawings and/or as instructed by the Engineer Keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, marking, packing and delivery of all fabricated materials shall be in accordance with the provisions of the contract and/or as approved by the Engineer. Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

2.5.0 **Materials to be used**

2.5.1 **General**

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Engineer and/or Consultant.

If desired by the Engineer, Test Certificates of materials supplied by the contractor in respect of each consignment shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Engineer, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

The arc welding electrodes shall conform to the relevant Indian Standard Codes of Practice and Specifications and shall be of heavily coated type and the thickness of the coating shall be uniform and concentric. With each container of electrodes, the manufacturer shall furnish instructions giving recommended voltage and amperage (Polarity in case of D.C. supply) for which the electrodes are suitable.

2.5.2 **Steel**

All steel materials to be used in construction within the purview of this specification shall comply with any of the following Indian Standard Specifications as may be applicable :

IS : 801	-	Cold formed light gauge steel structural member.
IS : 806	-	Steel tubes in general building construction.
IS : 1161	-	Steel tubes for structural purpose.
IS : 1977	-	Structural steel (Ordinary quality) St-42-0
IS : 2062	-	Steel for general structural purpose
IS : 8500	-	Structural steel-microalloyed (Ordinary & high strength quality)

In case of imported steel materials being used, these shall conform to specifications equivalent to any of the above as may be applicable.

2.5.3 **Electrodes**

All electrodes to be used under the Contract shall comply with any of the following Indian Standard Specifications as may be applicable :

IS : 814 - Covered electrodes for metal arc welding structural steel

IS : 815 - Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.

IS : 7280 - Base wire electrode for submerged arc welding.

2.5.4 **Bolts and Nuts**

All bolts and nuts shall conform to the requirements of Indian Standard Specification IS:1367 - Technical Supply Conditions for Threaded Fasteners.

Materials for Bolts and nuts under the purview of this contract shall comply with any of the following Indian Standard Specifications as may be applicable.

a) Mild Steel : All mild steel for bolts and nuts when tested in accordance with the following Indian Standard Specification shall have a tensile strength of not less than 44 Kg/mm2 and a minimum elongation of 23 per cent on a gauge length of 5.6 ÖA, where 'A' is the cross sectional area of the test specimen :

IS : 1367 - Technical supply conditions for threaded fasteners.

IS : 1608 - Method for tensile testing of steel other than sheet, strip, wire and tube.

b) High Tensile Steel : The material used for the manufacture of high tensile steel bolts and nuts shall have the mechanical properties appropriate to the particular class of steel as set out in IS:1367 or as approved by the Engineer.

2.5.5 **Washers**

Washers shall be made of steel conforming to any of the following Indian Standard Specifications as may be applicable under the provisions of the Contract :

IS : 1977 - Structural steel (Ordinary Quality) St-42-0

IS : 2062 - Steel for general structural purpose

IS : 8500 - Structural steel - microalloyed (medium & high strength quality)

IS : 6623 - High Strength Structural Nuts

IS : 6649 - Hardened and tampered washers for high strength structural bolts & nuts.

2.5.6 **Paints**

Paints to be used for shop coat of fabricated steel under the purview of this contract shall conform to the Indian Standard Specification IS:2074 - Ready mixed Paint, Air Drying, Red Oxide - Zinc Chromate Priming.

In highly corrosive environment other type of primer such as epoxy rasin based zinc rich primer (such as blast steel EZ1 of Shalimer Paints Ltd., or equivalent) may be necessary.

2.6.0 **Storage of Material**

2.6.1 **General**

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed from the contractor's yard immediately, failing which, the Engineer shall be at liberty to get the material removed and the cost incurred thereof shall be realised from the Contractor. The Contractor shall maintain upto date accounts in respect of receipt, use and balance of all sizes and sections of steel and other materials. In case the fabrication is carried out in contractor's fabrication shop outside the plant site where other fabrication works are also carried out, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

2.6.2 **Steel**

The steel to be used in fabrication and the resulting cut- pieces shall be stored in separate stacks off the ground section-wise and length-wise so that they can be easily inspected, measured and accounted for at any time. If required by the Engineer, the materials may have to be stored under cover and suitably painted for protection against weather.

2.6.3 **Electrodes**

The electrodes for electric are welding shall be stored in properly designed racks, separating different types of electrodes in distinctly marked compartments. The electrodes shall be kept in a dry and warm condition if necessary by resorting to heating.

2.6.4 **Bolts, Nuts and Washers**

Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments according to diameter, length and quality.

2.6.5 **Paints**

Paints shall be stored under cover in air tight containers. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

2.7.0 **Quality Control**

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer or Engineer's representative. As far as possible, all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at Site or elsewhere. The Contractor shall co-operate with the Engineer or Engineer's representative in permitting access for inspection to all places where work is being done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Contractor.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work :

a)	Steel	:	Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
b)	Bolts, Nuts & Washers	:	Manufacturer's certificate, dimension checks, material testing.
c)	Electrodes	:	Manufacturer's certificate, thickness and quality of flux coating.
d)	Welders	:	Qualifying Tests

e) Welding sets : Performance Tests

f) Welds : Inspection, X-ray, Ultrasonic tests

g) Paints : Manufacturer's certificate, physical Inspection reports

h) Galvanizing : Tests in accordance with IS : 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS : 4759 - Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products.

2.8.0 **Standard Dimensions, Forms and Weights**

The dimensions, forms, weights and tolerances of all rolled shapes bolts, nuts, studs, washers etc. and other members used in the fabrication of any structure shall, wherever applicable, conform to the requirements of the latest relevant Indian Standards, wherever they exist, or, in the absence of Indian Standards, to other equivalent standards.

2.9.0 **Shop Drawings**

The contractor shall within thirty (30) days after the award of the Contract submit to the Engineer the Schedule of Fabrication and delivery of structural steelwork for approval. He shall, within forty-five (45) days after the award of the contract start to submit progressively for approval, the shop drawings based on the approved Design Drawings and, before proceeding with the fabrication work, shall get the said shop drawings approved in accordance with the contract.

The sequence of submission of shop drawings for approval shall match with the approved fabrication and delivery schedule. The approval for the shop drawings will be accorded only towards the general conformity with the design requirements as well as specification and will ensure the correctness of general arrangement for centre line dimensions and levels, Section sizes, and adequacy of connections including splice joints as to the no. of bolts, weld length, size of gusset/end plates. The correctness of all other details like cutting lengths, matching of holes, notch dimensions, match markings, bill of materials, bolt list etc. will be entirely the contractor's responsibility. The approval of the drawing however shall not relieve the contractor of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The shop drawings shall include but not be limited to the following :

a) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.

b) Dimensional drawings of base plates, foundation bolt location etc.

c) Details of all connections with supporting calculations.

d) Comparison sheets to show that the proposed alternative section, if any, are as strong as the original sections shown on the Design Drawings.

e) Complete Bill of Materials and detailed drawings of all sections as also their billing weights.

f) Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof.

The shop drawings shall give all the necessary information for the fabrication, erection and painting of the steelwork in accordance with the provisions of this Specification. Shop drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection. Shop drawings shall give complete information necessary for fabrication of various components of the steelwork, including the location, type, size and extent of welds. These shall also clearly distinguish between shop and field bolts and welds and specify the class of bolts and nuts. The drawings shall be drawn to a scale large enough to convey all the necessary information adequately. Notes on the shop drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding shall be carefully controlled to minimize the locked -up stresses and distortion. Welding symbols used shall be in accordance with the requirements of the Indian Standard Specification --IS:813 - Scheme of symbols for Welding, and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.

The Contractor shall be responsible for and shall pay for any alterations of the work due to any discrepancies, errors or omissions on the drawings or other particulars supplied by him, whether such drawings or other particulars have been duly approved or not in accordance with the Contract.

3.0.0 WORKMANSHIP

3.1.0 Fabrication

3.1.1 General

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of the Indian Standard IS:800 - Code of Practice for use of Structural Steel in General Building Construction and other relevant Indian Standards or equivalent.

3.1.2 Straightening Material

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed by the Indian Standard Specification IS:1852 - Specification for rolling and cutting tolerance for hot-rolled steel products. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600 Deg. C.

3.1.3 Cutting

Cutting shall be effected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Engineer.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which will be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep will be permitted. Gouges greater than 4 mm, that remain from cutting, shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

3.1.4 Planning of Edges

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Engineer.

3.1.5 Clearances

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end, but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

3.2.0 **Bolted Construction**

3.2.1 **Holes**

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for rivets or black bolts shall be not more than 1.5 mm or 2.0 mm (depending on whether the diameter of the bolt is less or more than or equal to 25 mm) larger in diameter than the nominal diameter of the black bolt passing through them.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS:919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

3.2.2 **Assembly**

Drifting to enlarge unmatching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted not otherwise damaged, and shall be so prepared that the specified cambers, if any, are maintained.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified. In special cases, however, shop bolt connections may be allowed if directed by the Engineer.

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or lock-nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings.

3.3.0 Welded Construction

3.3.1 General

Welding shall be in accordance with relevant Indian Standards and as supplemented in the Specification Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS:817.

3.3.2 Preparation of Material

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

3.3.3 Assembling

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned. Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2 Deg.).

The work shall be positioned for flat welding whenever practicable.

3.3.4 Welding Sequence

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as will avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph.

When required by the Engineer, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Engineer.

3.3.5 **Welding Technique**

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross- section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

3.3.6 **Temperature**

No welding shall normally be done on parent material at a temperature below (-) 5 Deg.C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5 Deg. C and 0 Deg. C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is handwarm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 20 Deg. C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

3.3.7 **Peening**

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

3.3.8 **Equipment**

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be approved by the engineer.

3.4.0 **Finish**

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2.0 mm.

3.5.0 **Slab bases and caps**

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

To facilitate grouting, holes shall be provided, where necessary, in stanchion bases for the escape of air.

3.6.0 **Lacing bars**

The ends of lacing bars shall be neat and free from burrs.

3.7.0 **Separators**

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

3.8.0 **Bearing Plates**

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

3.9.0 **Architectural Clearances**

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

3.10.0 **Shop Connections**

a) All shop connections shall be welded as specified on the Drawings.

b) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Engineer for convenience of erection and the Contractor will have to make the desired changes at no extra cost to the Owner.

3.11.0 **Castings**

Steel castings shall be annealed

3.12.0 **Shop Erection**

The steelwork shall be temporarily shop-erected complete or as directed by the Engineer so that accuracy of fit may be checked before despatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected in such a way as will facilitate the check of interchangeability.

3.13.0 Shop Painting

3.13.1 General

Unless otherwise specified, steelwork which will be concealed by interior building finish need not be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given one coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned, in accordance with the following paragraph, by brush, spray, roller coating, flow- coating or dipping as may be approved by the Engineer.

After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand- wire brushing or by other mechanical cleaning methods to remove loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent. Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil or grease by solvent cleaners and be cleaned of dirt and other foreign material by through sweeping with a fibre brush.

After completion of the pre-cleaning, the metal surface shall be immediately painted with red oxide zinc chromate primer conforming to IS : 2074.

In highly corrosive environment, all steelwork shall be given a coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned by sand blasting to SA 2/1/2 grade minimum. The shop paint shall be epoxy rasin based zinc rich primer such as Blast Steel EZ1 of Shalimer Paint Limited or equivalent.

3.13.2 Inaccessible Parts

Surfaces not in contact, but inaccessible after assembly, shall receive two coats of shop paint, positively of different colours to prove application of two coats before assembly. This does not apply to the interior of sealed hollow sections.

3.13.3 Contact Surfaces

Contact surface shall be cleaned in accordance with Sub-clause 3.13.1 before assembly.

3.13.4 Finished Surfaces

Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

3.13.5 **Surfaces adjacent to field welds**

Unless otherwise provided for, surfaces within 50 mm of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

3.14.0 **Galvanizing**

3.14.1 **General**

Structural steelwork for switchyard or other structures as may be specified in the Contract shall be hot dip galvanized in accordance with the American Society for Testing and Materials Specification ASTM-A 123 or IS : 2629 - Recommended practice for Hot-Dip Galvanising of Iron and steel. Where the steel structures are required to be galvanized the field connection materials like bolts, nuts and washers shall also be galvanized.

3.14.2 **Surface Preparation**

All members to be galvanized shall be cleaned, by the process of pickling of rust, loose scale, dirt, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing. Pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

3.14.3 **Procedure**

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with IS:2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS:4759 - Specification for Hot-dip zinc coatings on Structural Steel & other allied products.

After finishing the threads of bolts, galvanizing shall be applied over the entire surface uniformly. The threads of bolts shall not be machined after galvanizing and shall not be clogged with zinc. The threads of nuts may be tapped after galvanizing but care shall be taken to use oil in the threads of nuts during erection.

The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized. Where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.
Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes

damaged after having been dipped twice, it shall be rejected. Special care shall be taken not to injure the skin on galvanized surfaces during transport and handling. Damages, if occur, shall be made good in accordance with the provisions of this Specification or as directed by the Engineer.

4.0.0. INSPECTION, TESTING, ACCEPTANCE CRITERIA AND DELIVERY

4.1.0 Inspection

Unless specified otherwise, inspection to all work shall be made by the Engineer or Engineer's representative at the place of manufacture prior to delivery. The Engineer or his representative shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification.

The Contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Engineer to carry out inspection and/or tests in accordance with the Contract.

The Contractor shall guarantee compliance with the provisions of this Specification.

4.2.0 Testing and Acceptance Criteria

4.2.1 General

The Contractor shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost, unless otherwise specified in the Contract. The Contractor shall get the specimens tested in a laboratory approved by the Engineer and submit to the Engineer the test results in triplicate within 3 (three) days after completion of the test.

4.2.2 Steel

All steel supplied by the Contractor shall conform to the relevant Indian Standards. Except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used. In case unidentified steel materials are permitted to be used by the Engineer, random samples of materials will be taken from each unidentified lot of 50 M.T. or less of any particular section for tests to conform to relevant Indian Standards. Cost of all tests shall be borne by the Contractor.
All material shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

4.2.3 **Testing Criteria for checking Lamination in raw steel plates**

All raw steel plate of thickness more than 20 mm supplied by the contractor shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Engineer :

a) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.

b) If the results of the tests in (a) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (a) or as directed by the Engineer.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop, if the Engineer requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Contractor. If the plates in the fabricated item is found to be laminated, the component will be rejected.

4.2.4 **Welding**

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Engineer may ask for at least 1 (one) test-destructive or non-destructive including X-ray, ultrasonic test or similar, the cost of which shall be borne by the Contractor. In the event of further tests as may be desired by the Engineer, the cost of such test shall be borne by the Contractor if the results are found to be unsatisfactory; and if the test shows no defect, the cost shall be borne by the Owner. In cases of the test results showing deficiency, the Engineer shall have option to reject or instruct any remedial measures to be taken free of charge to the Owner.

4.2.5 **Bolts, nuts and washers**

All bolts, nuts and washers shall be procured from reputed manufacturer approved by the Engineer and shall conform to the relevant Indian Standards. If desired by the Engineer, representative samples of these materials may have to be tested in an approved laboratory and in accordance with the procedures described in relevant Indian Standards. Cost of all such testing shall have to be borne by the Contractor.

4.2.6 **Shop painting**

All paints and primers shall be of standard quality and procured from approved manufacturers and shall conform to the provisions of the relevant Indian Standards.

4.2.7 **Galvanizing**

All galvanizing shall be uniform and of standard quality when tested in accordance with IS:2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS:4759 - specification for Hot-Dip Zinc Coatings on Structural Steel & other allied products.

4.3.0 **Tolerance**

The tolerances on the dimensions of individual rolled steel components shall be as specified in IS:1852 - specification for rolling and Cutting Tolerances for Hot-rolled Steel Products. The tolerances on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures other than steel railway & road bridges, structures subjected to dynamic loading (like wind, seismic etc.) and thin walled construction (like box girders) shall be as specified in IS:7215 - Tolerances for Fabrication of Steel Structures.

4.4.0 **Acceptance**

Should any structure or part of a structure be found not to comply with any of the provisions of this Specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Engineer considers the defects rectifiable. The Engineer may, at his discretion, check the test results obtained at the Contractor's works by independent tests at an approved laboratory and should the items, so tested, be found to be unsatisfactory, the costs shall be borne by the contractor, and if satisfactory, the costs shall be borne by the Owner.

When all tests to be performed in the Contractor's shop under the terms of this contract have been successfully carried out, the steelwork will be accepted forthwith and the Engineer will issue an acceptance certificate, upon receipt of which, the items will be shop painted, packed and despatched. No item to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

4.5.0 **Delivery of Materials**

4.5.1 **General**

The Contractor will deliver the fabricated structural steel materials to site with all necessary field connection materials in such sequence as will permit the most efficient and economical performance of the erection work. the Owner may prescribe or control the sequence of delivery of materials, at his own discretion.

4.5.2 **Marking**

Each separate piece of fabricated steelwork shall be distinctly marked on all surfaces before delivery in accordance with the markings shown on approved erection drawings and shall bear such other marks as will further facilitate identification and erection.

4.5.3 **Packing and Shipping**

All projecting plates or edges and all ends of members of joints shall be stiffened, all straight members and plates, shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all bolts, nuts, washers, and small loose parts shall be packed separately in order to prevent damage or distortion during shipping.

Shipping shall be strictly in accordance with the sequence stipulated in the agreed programme. Payment may be held up for items sent in advance of the sequence till they could be erected. The Contractor shall include and provide for in his rates, the freight and other charges for despatching the materials to the worksite and also for securely protecting and packing the materials to avoid loss or damage during transport by rail, road or water. All packings shall allow for easy removal and checking at site. Special precautions shall be taken against rusting, corrosion, breakage or damage otherwise of the materials. All parts shall be adequately braced to prevent damage in transit.

Each bundle, bale or package delivered under this contract shall be marked on as many sides as possible and such distinct marking (all previous irrelevant markings being carefully obliterated) shall show the following : -

a) Name and address of the consignee

b) Name and address of the consignor

c) Gross weight of the package in tonnes and its dimensions

d) Identification marks and/or number of the package

e) Custom registration number, if required

All markings shall be carried out with such materials as would ensure quick drying and indelibility.

Each component or part or piece of material when shipped, shall be indelibly marked and/or tagged with reference to assembly drawings and corresponding piece numbers.

Each packing case shall contain in duplicate in English a packing list pasted on to the inside of the cover in a water- proof envelope, quoting especially -

a) Name of the Contractor

b) Number and date of the Contract

c) Name of the office placing the contract

d) Nomenclature of stores

e) A schedule of parts or pieces, giving the parts or piece number with reference to assembly drawings and the quantity of each.

The shipping dimensions of each package shall not exceed the maximum dimensions permissible for transport over the Indian Railways/Roads.

After delivery of the materials at site, all packing materials shall automatically become the property of the Owner without any extra payment.

Notwithstanding anything stated here in before, any loss or damage resulting from inadequate packing shall be made good by the Contractor at no additional cost to the Owner. When facilities exist, all shipments shall be covered by approved Insurance Policy for transit at the cost of the Contractor.

The contractor shall ship the complete materials or part on board a vessel belonging to an agency approved by the Owner or on rail and/or road transport as directed. The Contractor shall take all reasonable steps to ensure correct appraisal of freight rates, weights and volumes and in no case will the Owner be liable to pay any warehouse, wharfage, demurrage and other charges.

If, however, the Owner has to make payment of any of the above mentioned charges, the amount paid will be deducted from the progressive bills of the Contractor.

Necessary advise regarding the shipment with relevant details shall reach the Engineer at least a week in advance.

5.0.0. INFORMATION TO BE SUBMITTED

5.1.0 With Tender

The following information are required to be submitted with the Tender :

a) **Progress Schedule**

The Contractor shall quote in his Tender a detailed schedule of progress of work and total time of completion, itemizing the time required for each of the following aspects of work.

i) Preparation and approval of shop drawings

ii) Procurement of materials

iii) Fabrication and shipping of all anchor bolts

iv) Fabrication and shipping of main steelwork

v) Fabrication and shipping of steelwork for bunkers. Tanks and/ or silos as applicable.

vi) Fabrication and shipping of all other remaining steel work including miscellaneous steelwork

vii) Final date of completion of all shipments

Time required for completion being one of the main criteria for selecting the successful bidder, it is desired that the bidder quotes the minimum time required by him for completing the work.

b) **Shop**

Location of the Tenderer's fabrication workshop giving details of equipment, manpower, the total capacity and the capacity that will be available exclusively for this contract shall be submitted.

c) **Matching Steel**

A rough indication of the quantities and details of matching steel sections required to start the work shall be furnished.

5.2.0 After Award

After award of the Contract the successful Tenderer is to submit the following :

a) Complete fabrication drawings, material lists, cutting lists, bolt lists, field welding schedules based on the design drawings furnished to him in accordance with the approved schedule.

b) Monthly Progress Report with necessary photographs in six (6) copies to reach the Engineer on or before the 7th day of each month, giving the up-to-date status of preparation of detailed shop drawings, bill of materials, procurement of materials, actual fabrication done, shipping and all other relevant information.

c) Detailed monthly material reconciliation statements relevant to the work done and reported in the Progress Report, giving the stock at hand of raw steel, work in progress, finished materials and scrap.

d) Results of any test as and when conducted and as required by the Engineer.

e) Manufacturer's mill test report in respect of steel materials, bolts, nuts and electrodes as may be applicable.

6.0.0 RATES

6.1.0 General

In general, even though it may not be specifically mentioned in the Schedule of Items, the rates for items mentioned in the Schedule of Items shall include cost of all materials consumed in the work or incidental to it, hire charges of tools and plants, cost of labour, insurance, all transport charges including taking delivery of raw steel from Contractor's Site Stores and transporting the same to the Contractor's fabricating workshop and delivery of finished fabricated materials ~~back~~ to sites, all taxes, royalties,, making approaches, security and safety arrangements, power, fuel, lubricant, preparation of all fabrication drawings, material lists, cutting lists, bolt lists, field welding schedule, services, supervision, overheads, profits etc. complete in all respects unless certain items specifically excluded by the terms and conditions of the Contract and as mentioned in the following sub-clauses.

6.2.0 Fabrication

The rates quoted for fabrication of various categories of steelwork shall specifically include taking delivery and transport of raw steel from the stockyard as mentioned in the Contract upto the Contractor's fabricating shop and one shop coat of approved metal protection paint but exclude any transport of the fabricated materials. The rates for fabrication shall also include supply of all electrodes required for shop and field work including 10% extra for field work.

6.3.0 Transport

The rate quoted for transport shall include all C.I.F. from the Contractor's fabricating shop upto the Site and loading of the fabricated materials on railway wagons or trucks at the fabricating shop but shall generally exclude unloading at site(which is generally included in the rate for erection). But, in case the terms & conditions of the contract so desire, the cost of unloading of the fabricated material at site shall also be included in the quoted rates for transport.

6.4.0 **Bolts, nuts and washers**

The rates quoted for the supply of bolts, nuts and washers shall include the total cost of delivery of the materials at site or to the Owner's Site stores as directed by the Engineer.

7.0.0 **METHOD OF MEASUREMENT**

7.1.0 **Fabrication**

Measurement shall be in tonnes and based on the unit weights as per relevant Indian Standards and on the following considerations : -

a) All members, except plate works paid under rates for bunkers, tanks, etc., will be measured square.

b) All plate works paid under rates for bunkers, tanks, etc. as applicable will be measured as actual.

c) No deduction will be made for bolt and/or holes and/or holes upto 25 Sq.Cm.

d) Unless otherwise specified no allowance shall be made for weld metals in case of welded steel structure.

7.2.0 **Supply of bolts, nuts and Washers**

The supply of bolts, nuts and washers will be measured on standard unit weight basis or actuals whichever is less.

7.3.0 **Transport**

The measurement for transport of fabricated steelwork will be for the net weight of the fabricated materials as measured under Sub-clause 7.1.0 excluding the weight of all packing and supporting materials necessary for transport.

8.0.0 **PAYMENT**

Unless mentioned otherwise in the tender / contract document, for fabricated materials delivered to Site, the Contractor shall be entitled to 90% of the value of the materials supplied and the balance 10% shall be paid only after the final erection, and aligning of the fabricated materials. In addition, the Security Money as stipulated in the Contract, shall be deducted from each payment.

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SECTION-X

TECHNICAL SPECIFICATION
FOR
ERECTION OF STRUCTURAL STEEL WORK

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SECTION-X

TECHNICAL SPECIFICATION FOR ERECTION OF STRUCTURAL STEEL WORK

1.0.0 SCOPE

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at Site, and/or from Contractor's Site Stores or store Yard, installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract.

2.0.0 GENERAL

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless otherwise specified in the Contract, shall include but not be limited to the following :

a) The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.

b) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Contractor shall pay all demurrage and/or wharfage charges etc. on account of default on his part.

c) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures.

d) Checking center lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. any defect observed in the foundation shall be brought to the notice of the Engineer. The Contractor shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.

e) Aligning, plumbing, leveling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Engineer.

f) Painting of the erected steel structures if required by the Contract.

g) All minor modifications of the fabricated steel structures as directed by the Engineer including but not limited to the following:-

i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.

ii) Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.

iii) Reaming of holes for use of higher size bolt if required.

iv) Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting will be permitted only at the discretion of the Engineer.

v) Refabrication of parts damaged beyond repair during transport and handling or Refabrication of parts which are incorrectly fabricated.

vi) Fabrication of parts omitted during fabrication by error, or subsequently found necessary.

vii) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.

viii) Carry out tests in accordance with this Specification if directed.

2.2.0 **Work by others**

No work under this Specification will be provided for by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

2.3.0 **Codes and Standards**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions and/or replacements of the following or any other Indian Standard Specification and codes of Practice of equivalent :

IS-800	:	Code of Practice for general construction in steel
IS-456	:	Code of Practice for plain or reinforced concrete
IS-7205	:	Safety Code for erection of Structural Steel work
IS-12843	:	Tolerance for erection of Steel Structures

2.4.0 **Conformity with designs**

The Contractor will erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and/or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and/or the instructions of

the engineer. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and /or the instructions of the Engineer.

2.5.0 **Material**

2.5.1 **General**

All fabricated steel structures and connection materials shall be supplied by the Contractor for fabrication work. The Contractor for erection work will take delivery of all the materials from the Contractor's Stores or storage yard at Site. The Contractor may also have to take delivery directly from railway wagons or trucks at Site as per terms & condition of the contract, in which case he shall have to unload the materials and perform all formalities like checking of materials and attend to insurance matters in accordance with Sub-Clause 2.1.0 and as specified herein before.

While taking delivery, the Contractor will check the quantity, quality and the sizes of the materials and verify the adequacy of the same in accordance with the Drawings and Specifications. In case the Contractor finds any material inadequate, he shall inform the Engineer immediately prior to taking delivery of the same. No claim whatsoever, in respect of bad quality, shortages or difference in size will be entertained once the delivery is taken and the Contractor shall make good any such deficiency, if detected later, either by repair or with fresh material as may be directed by the Engineer at the Contractor's Own cost.

Excepting all field connection materials like bolts, nuts, washers and electrodes, which will be supplied by the fabrication Contractor to the extent of 10% in excess of the estimated requirements as per Drawings, all other consumables like oxygen and acetylene gas, paints, fuels, lubricants, oil, grease, cement, sand, aggregates and any other material that may be required for the execution of the works in accordance with the contract will be supplied by the contractor for erection work and will be deemed to have been included in this rates.

2.5.2 **Materials to conform to Indian Standards**

All materials required to be supplied by the Contractor under this Contract shall conform to the relevant Indian Standard Specifications.

2.6.0 **Storage of materials**

2.6.1 **General**

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site, failing which, the Engineer shall be at liberty to get the materials removed by agency and the cost incurred thereof shall be realised from the Contractor's dues.

2.6.2 **Yard**

The Contractor will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access for large cranes, trailers and other heavy equipments. The yard shall be fenced all around with security arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

The Tenderer should visit the site prior to submission of his Tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor at his own cost as directed by the Engineer.

2.6.3 **Covered Store**

All field connection materials, paints, cement etc. shall be stored on well designed racks and platforms off the ground in a properly covered store building to be built at the cost of the Contractor.

2.7.0 **Quality control**

The contractor shall establish and maintain quality control procedures for different items of work and materials as may be directed by the Engineer to assure compliance with the provisions of the Contract and shall submit the records of the same to the Engineer. The quality control operation shall include but not be limited to the following items of work :

a) Erection : Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.

b) Grouting : Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency and strength of grout.

c) Painting : Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

2.8.0 **Taking Delivery**

The erection Contractor shall take delivery of fabricated structural steel and necessary connection materials supplied by the fabrication Contractor from railhead, trucks and/or the Owner's stores at site as may be necessary and as per terms & conditions of the contract or as directed by the Engineer. He shall check, unload, transport the materials to his stores for proper storing at his own cost. The erection Contractor shall submit claims to insurance or other authorities and pursue the same in case of loss or damage during transit and handling and all loss thereof shall be borne by him.

The erection contractor shall also take all precautions against damage of the materials in his custody after taking delivery and till the same are erected in place and accepted. The Contractor shall salvage, collect and deliver all the packing materials to the Owner free of charge.

3.0.0 **WORKMANSHIP**

3.1.0 **Erection**

3.1.1 **Plant and equipment**

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Engineer.

3.1.2 **Method and sequence of erection**

The method and sequence of erection shall have the prior approval of the Engineer. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

3.1.3 **Temporary bracing**

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, free of cost to the Owner, temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

If additional temporary guys are required to resist wind or seismic forces acting upon components of the finished structure installed by others during the course of the erection of the steel framing, arrangement for their installation by the erector shall be made free of cost to the Owner.

The responsibility of the Contractor in respect of temporary bracings and guys shall cease when the structural steel is once located, plumbed, levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Engineer.

The temporary guys, braces, false work and cribbing shall be removed immediately upon completion of the steel erection and shall return to the Owner's store in good condition if the materials are supplied by the Owner otherwise permission shall be given to Contractor to take out the materials from the project site. The Owner may remove and return the materials in good condition to the Contractor without any charge if they have been left in place under other agreed arrangement.

3.1.4 **Temporary floors for buildings**

It shall be the responsibility of the Contractor to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and/or by-laws of state, Municipal or other local authorities.

3.1.5 **Setting out**

Positioning and leveling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the approved Drawings and to the satisfaction of the Engineer. Concrete foundations, where required, shall be made by other agencies. Anchor bolts and other anchor steel shall be embedded by other agencies. The Contractor

shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations. He shall remain responsible for correct positioning. For heavy columns, etc. the Contractor shall set proper screed bars if desired by the Engineer, to maintain proper level. No extra payment shall be made for this.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

3.1.6 **Field bolting**

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following :

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum bolt tension by any of the following methods.

a) **Turn-of-nut method**

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into good contact with each other. "snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table-1 with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

TABLE - I

Bolts length not exceeding 8 x dia. or 200 mm	Bolt length exceeding 8xdia. or 200 mm	Remarks
1/2 turn	2/3 turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation - 30 over or under.

Bolts may be installed without hardened washers when tightening is done by the turn-of-nut method. However, normal washers shall be used.

Bolts tightened by the turn-of-nut method may have the outer face of the nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

b) **Torque Wrench tightening**

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE - II. Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

TABLE - II

Nominal Bolt Diameter (mm)	Torque to be applied (Kg.M) for bolt class 8.8 of IS : 1367
20	59.94
22	81.63
24	103.73

NOTE :

The above torque values are approximate for providing tensions of 14.7 MT for 20 mm dia., 18.2 MT for 22 mm dia; and 21.2 MT for 24 mm dia. bolts under moderately lubricated condition. The torque wrench shall be calibrated at least once daily to find out the actual torque required to produce the above required tension in the bolt by placing it in a tension indicating device. These torques shall be applied for tightening the bolts on that day with the particular torque wrench.

In either of the above two methods, if required, for bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches if used shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this sub clause.

3.1.7 **Field Welding**

All field assembly and welding shall be carried out in accordance with the requirements of the specification for fabrication work applicable to the project, excepting such provisions therein which manifestly apply to shop conditions only. Where the fabricated structural steel members have been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joints.

3.1.8 **Holes, cutting and fitting**

No cutting of sections, flanges, webs, cleats, bolts, welds etc. shall be done unless specifically approved and / or instructed by the Engineer.

The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract or directed by the Engineer. Wherever such work is specified the Contractor shall obtain complete information as to size, location and number of alterations prior to carrying out any work. The Contractor shall not be entitled for any payment on account of any such work.

3.2.0 **Drifting**

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

3.3.0 **Grouting of stanchion bases and bearings of beams and girders on stone, brick or concrete (Plain or reinforced)**

Grouting shall be carried out with Ordinary Cement grout as described below :

The mix shall be one (1) part cement and one (1) part sand and just enough water to make it workable. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water and any accumulated water shall be removed. These shall be placed under expert supervision, taking care to avoid air-locks. Edges shall be finished properly. If the thickness of grout is 25 mm or more, two (2) parts of 6 mm down graded stone chips may be added to the above noted cement-sand grout mix, if required, by the Engineer or shown on the drawings.

Admixtures like aluminium powder, "ironite" or equivalent may be required to be added to the grout to enhance certain desirable properties of the grout.

Alternatively, the grouting may be done with non-shrink high strength free flow cementious grout (ready mixed) like Conbextra-GP-1 or "Sika grout - 214", or "Anchor NSG" or approved equivalent.

No grouting shall be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, leveled and plumbed and sufficient floor beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally leveled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

3.4.0 **Painting after erection**

Field painting, if required to be done by the erection Contractor, shall only be done after the structure is erected, leveled, plumbed, aligned and grouted in its final position, tested and accepted by the Engineer. However, touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the erection Contractor free of cost to the Owner. The materials and specification for such painting in the field shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable for the project.

Painting shall not be done in rainy or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted. Before painting of steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

All field bolts, welds and abrasions to the shop coat shall be spot painted with the same paint used for the shop coat. Where specified, surfaces which will be in contact after site assembling shall receive a coat of paint (in addition to the shop coat, if any) and shall be brought together while the paint is still wet.

Surface which will be inaccessible after field assembly shall receive the full specified protective treatment before assembly. Bolts and fabricated steel members which are galvanized or otherwise treated and steel members to be encased in concrete shall not be painted.

The specification for paint and workmanship shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable to the project. The number of coats and the shades to be used shall be as specified or as directed by the Engineer.

3.5.0 **Stainless Steel Plate Lining in Bunker Hopper**

The hopper portion of the coal bunkers shall be lined with stainless steel plates of 3 mm thickness. The stainless steel shall be of AISI-316 quality. The work includes supply, fabrication, welding and fixing of stainless steel lining plate to bunker M.S. plate as per drawing & specification.

The stainless steel liner shall be fixed to the tanker hopper MS shall be plug welding using special electrodes (such as, Inox-CW coding AWS-310-16, ISMBOS-311 or Inox-D2 coding AWSE-309-16, ISMB 04-311 manufactured by Advani Oerlikon Ltd. or equivalent). Such plug welding shall be done by drilling 21.5 mm dia. holes at 300 mm centre to centre both ways as per drawings. The plug welding shall be ground flush with the lining plate.

3.6.0 **Final cleaning up**

Upon completion of erection and before final acceptance of the work by the Engineer, the Contractor shall remove free of cost all false work, rubbish and all Temporary Works resulting in connection with the performance of his work.

3.7.0 **Safety Measures during Erection**

The safety measures to workmen and supervisors during all types of erection work (e.g., use of lifting appliances, slingning, welding, gas cutting, etc.) should be taken as per IS : 7205. When any statutory provisions exist, the same shall be complied with in addition to the provisions contained in the above code.

4.0.0 **TESTING AND ACCEPTANCE CRITERIA**

4.1.0 **General**

Loading tests shall be carried out on erected structures, if required by the Engineer, to check adequacy of fabrication and/or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member as per the Contract of either fabrication or erection of steelwork whoever is responsible for it and no payment towards the cost of the dismantled portion and any connected work shall be made to the Contractor, unless it is proved that the deficiency is due to reasons beyond the Contractor's scope. On the basis of the tests, the Engineer will decide whether the fabricator or the erector is responsible for the unacceptable member or structure and his decision will be final. In case it is established that the unacceptability of the member or structure is due to design deficiency, the cost of replacement and/or modifications will be borne by the Owner. In course of dismantling, if any damage is done to any other parts of the structure or to any fixtures, the same shall be made good free of cost by the Contractor responsible,

to the satisfaction of the Engineer. The cost of the tests specified hereinafter shall be borne by the Owner. Any extra claim due to loss of time, idle labour, etc. arising out of these testing operations shall not be entertained, however, only reasonable and appropriate time extensions will be allowed.

The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated in the following Sub-clauses 4.1.1, 4.1.2 and 4.1.3. The method of testing and application of loading shall be as approved by the Engineer.

4.1.1 **Stiffness Test**

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to 1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 per cent of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 per cent of the maximum increase in strain or deflection recorded during the second test.

4.1.2 **Strength Test**

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours.

In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole. Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

4.1.3 **Structure of same design**

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous Sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure.

When a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Engineer. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20% of the maximum strain or deflection recorded at similar load in the test on the prototype.

4.1.4 **Repair for subsequent test and use after strength tests**

An actual structure which has passed the "Strength Test" as specified in Sub-clause 4.1.2 herein before and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' as specified in Sub-clause 4.1.1. herein before.

4.2.0 **Tolerances**

Some variation is to be expected in the finished dimensions of structural steel frames. Unless otherwise specified, such variations are deemed to be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabricating tolerances for the finished parts and the rolling tolerances for the profile dimensions permitted under the Specifications for fabrication of structural steelwork applicable to this Project and as specified below:

I. **For Buildings Containing Cranes**

Component	**Description**		**Variation Allowed**
Main columns	a)	Shifting of column axis at foundation level with respect to building line	
		i) In longitudinal direction	i) $\pm$ 3.0 mm
		ii) In lateral direction	ii) $\pm$ 3.0 mm
	b)	Deviation of both major column axis from vertical between foundation and other member connection levels :	
		i) For a column upto and including 10M height	i) $\pm$ 3.5 mm from true vertical

Component	Description		Variation Allowed
	ii)	For a column greater than 10M but less than 40M height any 10M	ii) ± 3.5 mm from true vertical for length measured between connection levels, but not more than ± 7.0 mm per 30 m length
	c)	For adjacent pairs of columns across the width of the building prior to placing of truss.	± 9 mm on true span.
	d)	For any individual column deviation of any bearing or resting level from levels shown on drawings.	± 3.0 mm
	e)	For adjacent pairs of columns either across the width of building or longitudinally level difference allowed between bearing or seating level supposed to be at the same level.	3 mm
Trusses	a)	Deviation at centre of span of upper chord member from vertical plane running through centre of bottom chord	1/1500 of the span or not greater than 10 mm which ever is the least
	b)	Lateral displacement of top chord at centre of span from vertical plane running through centre	1/250 of depth of truss or 20 mm whichever is the of supports least

Component	Description		Variation Allowed
Crane Girders & Tracks	a)	Difference in levels of crane rail measured between adjacent columns.	2.0 mm
	b)	Deviation to crane rail gauge	± 3.0 mm
	c)	Relative shifting of ends of adjacent crane rail in plan and elevation after thermit welding.	1.0 mm
	d)	Deviation of crane rail axis from centre line of web.	± 3.5 mm
Setting of Expansion gaps		At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30^{o}C. The coefficient of expansion or contraction shall be taken as 0.000012 per Deg.C per unit length.	

II. **For Building without Cranes**

The maximum tolerances for line and level of the steel work shall be ± 3.0 mm on any part of the structure. The structure shall not be out of plumb more than 3.5 mm on each 10M section of height and not more than 7.0 mm per 30 M section.

These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.

4.3.0 **Acceptance**

Structures and members which have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.1.0, 4.1.1, 4.1.2, 4.1.3 and 4.1.4 and other applicable provisions of this Specification and are within the limits of tolerances specified in Sub-clause 4.2.0 and/or otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfilment of the provisions of this Contract.

5.0.0 INFORMATION TO BE SUBMITTED

5.1.0 Before Tender

Along with the Tenders the Tenderers will be required to submit the following information :

5.1.1 Tentative Programme

The Tenderer shall submit a tentative programme based on the information available in the Tender Document and visit to Site indicating the structure-wise erection schedule proposed to be maintained by the Contractor to complete the job in time in accordance with the Contract.

5.1.2 Constructional Plant and Equipment, Tools, Temporary Works & Manpower

A detailed list of all Constructional Plant & Equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the Tenderer which he will be able to employ on the job to maintain the progress of work in accordance with the Contract shall be submitted along with the Tender. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.

5.1.3 Erection yard

A site plan showing the layout and location of the erection yard proposed to be established by the Tenderer shall be attached with the Tender indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the Contractor shall comply with the same without any claim whatsoever.

5.2.0 After award of the Contract

After award of the contract, the Contractor shall submit the following :

5.2.1 Detailed Programme

The Contractor shall submit a detailed erection programme within a month of the award of the Contract for completion of the work in time in accordance with the Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required and an assessment of required strength of various categories of workers in a proforma approved by the Engineer.

5.2.2 **Fortnightly Progress Report**

The Contractor shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and all details of actual achievements against the target programme specified in Sub- clause 5.2.1 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the Contractor shall also furnish details of fabricated materials in hand at site and the strength of his workers.

6.0.0 **RATES**

Even though it may not be specifically mentioned in the Schedule of Items, the rates shall include all work to be provided by the Contractor in accordance with Sub-clause 2.1.0 of this Contract and cost of all materials and labour required to complete the work or incidental to it, hire charges of Constructional Plant and Equipment and erection tools, insurance, all necessary transport, taxes and royalties, making necessary arrangements for approaches, yard, security, safety and other facilities, power, fuel, lubricant, services, supervisions, overheads, profits etc. complete in all respects. It shall also include cost of all other work and supplies not specifically mentioned but reasonably implied as being necessary to complete the works in all respects in accordance with the Contract.

7.0.0 **METHOD OF MEASUREMENT**

7.1.0 **Erection**

All measurement shall be in tonnes and based on the theoretical unit weights as per Indian Standard and on the following considerations :

a) All members, except plate work paid under rates for bunkers, tanks, etc. shall be measured square.

b) All plate work paid at rates for bunkers, tanks, etc. shall be measured as actual.

c) No deduction shall be made for bolt and/or holes for other purposes upto 25 Sq.cm. in area.

d) Unless otherwise specified in the case of welded steel structure, no allowance shall be made for the weld metal.

e) No separate payment shall be made for field connection materials such as permanent bolts, nuts, washers, erection bolts and nuts. No extra payment shall be made for site welding.

7.2.0 **Grouting**

The measurement of grouting the stanchion and other base plates shall be on the basis of theoretical volume of the voids to be filled in Cu.M. without any deduction for the volume of embedments. Edges of the grouting shall be measured square neglecting chamfers, if any.

7.3.0 **Painting**

The finish painting, other than touch up and other painting, if required to be done within the quoted rates as per this Specification, shall be measured on the basis of the tonnage of the structure erected and painted calculated on the basis of Sub-clause 7.1.0.

8.0.0 **PAYMENT**

Unless mentioned otherwise in the Tender/Contract document for fabricated materials erected, aligned, plumbed, levelled and grouted, the Contractor shall be paid 95% (ninety-five percent) of the value of erection. the balance 5% (five percent) shall be paid after acceptance of the structure withstanding necessary tests in accordance with the Contract. Necessary deductions towards Security Money shall be made from all bills of the Contractor in accordance with the Contract.

VOLUME : IIG/3

SECTION-XI

TECHNICAL SPECIFICATION
FOR
ROADS AND DRAINAGE

CONTENT

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SECTION-XI

TECHNICAL SPECIFICATION FOR ROADS AND DRAINAGE

1.00.00 **SCOPE**

This specification covers all work required for the construction of road including box-cutting, edging, preparation of sub-base, water bound macadam, bituminous macadam, wearing course etc. excluding toppings and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work. Notwithstanding the provisions of the technical specification, all road works shall be carried out as per IRC / MORT&H specification.

This specification also includes all work required for drainage including road side RCC drain, RCC culverts, pipe-culverts, drainage pipes, manholes etc. and all other incidental items.

2.00.00 **GENERAL**

2.01.00 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless specified otherwise, shall include but not be limited to the following :

a) Furnish all labour, supervision, services, materials, equipment, tools and plants, transportation etc. required for the work.

b) Submit for approval detailed schemes of all operations required for executing the work e.g. material handling, placement, services, approaches etc.

c) To carry out and submit to the Engineer results of tests whenever required by the Engineer to assess the quality of work.

2.02.00 **Work to be provided for by others**

No work under this specification will be provided for by any agency other than the Contractor unless specifically mentioned elsewhere in the Contract.

2.03.00 **Codes and Standards**

All work under this specification, unless specified otherwise, shall conform to the latest revision and/or replacements of the following or any other relevant I.S. Specifications and Codes of Practice.

1. Specification for road and bridge works of Ministry of Road Transport & Highways (Fourth Revision). Published by the IRC, New Delhi-2001.

2. IRC-19 Standard specifications and Code of Practice for Water Bound Macadam.

3. IRC : SP-11 Hand Book of Quality Control for Construction of Roads and Runways.

4. IS : 456 Indian Standard Code of Practice for Plain and Reinforced Concrete.

5. IS : 783 Code of Practice for Laying of Concrete Pipes.

6. IRC : 36 Recommended Practice for Construction of Earthen embankments for Road Works.

7. IRC : 37 Guidelines for the design of Flexible pavements

8. Other specifications mentioned elsewhere in this specification.

In case any particular aspect of work is not covered specifically by Indian Standard Specification, any other standard practice as may be specified by the Engineer shall be followed.

2.04.00 **Conformity with Designs**

The contractor shall carryout the work as per the drawings issued to him and/or contractor's drawings which are approved by the Engineer and/or the Engineer's instructions.

2.05.00 **Materials to be Used**

2.05.01 **General**

All materials required for the work shall be of best commercial variety and as approved by the Engineer. Material to be used in the work shall conform to the specifications mentioned on the drawings, the requirements laid down in MORT&H Specification and specification for relevant items of work carried under these specifications.

2.06.00 **Control of Alignment, Level and Surface Regularity**

The Contractor shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer. Permitted tolerances for roadworks are described hereinafter.

i) **Horizontal Alignments**

Horizontal alignments shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of± 10 mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be± 25 mm.

ii) **Surface Levels**

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in Table1.

TABLE-1.

TOLERANCES IN SURFACE LEVELS
(Table 900-1 of MORT&H)

1.	Subgrade		+ 20 mm - 25 mm
2.	Sub-base + 10 mm :		
	a)	Flexible pavement	- 20 mm
	b)	Concrete pavement (Dry lean concrete or Rolled concrete)	+ 6 mm - 10 mm
3.	Base-course for flexible pavement		
	a)	Bituminous course	+ 6 mm - 6 mm
	b)	Other than bituminous	+ 10 mm
		i) Machine laid	- 10 mm + 15 mm
		ii) Manually laid	- 15 mm

4.	Wearing course for flexible pavement :		
	a)	Machine laid	+ 6 mm - 6 mm
	b)	Manually laid	+10 mm -10 mm
5.	Cement concrete pavement		+ 5 mm - 6 mm *

* This may not exceed - 8 mm at 0- 30 cm from the edges.

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course, if the thickness of the former is thereby reduced by more than 6 mm for flexible pavements and 5 mm for concrete pavements.

For checking compliance with the above requirement for subgrade, sub-base and base courses, measurements of the surface levels shall be taken on a grid of points placed at 6.25 m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the permitted tolerance.

TABLE-2

MAXIMUM PERMITTED NUMBER OF SURFACE IRREGULARITIES
(Table 900-2 of MORT & H)

	Surfaces of Carriageways and paved shoulders				Surfaces of laybys, service areas and all bituminous base courses			
Irregularity	4mm		7mm		4mm		7mm	
Length (m)	300	75	300	75	300	75	300	75
National Highways/ Expressways*	20	9	2	1	40	18	4	2
Roads of lower category*	40	18	4	2	60	27	6	3

*Category of each section of road as described in the Contract.

The maximum allowable difference between the road surface and underside of a 3 m straight-edge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer shall be:

for pavement surface (bituminous and cement concrete)	3 mm
for bituminous base courses	6 mm
for granular sub-base/base courses	8 mm
for sub-bases under concrete pavements	10 mm

2.07.00 **Rectification**

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

i) Subgrade : Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to be used shall conform to the requirements of Clause 305 of MORT&H.

ii) Granular sub-base: Same as at (i) above, except that the degree of compaction and the type of material to be used shall conform to the requirements of Clause 401 of MORT&H.

iii) Water Bound Macadam/Wet Mix Macadam Sub-base/Base: Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted to Clause 404. This shall also apply to wet mix macadam to Clause 406 of MORT&H.

iv) Bituminous Constructions: For bituminous construction other than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material over a suitable tack coat if needed and recompacting to specifications. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 m in length and not less that 3.5 m in width.

2.08.00 **Quality Control Tests During Construction**

As per Clause 903 of MORT&H specification.

3.00.00 **EXECUTION**

3.01.00 **Shoulder**

3.01.01 **Description**

This work shall consist of constructing shoulders on either side of the pavement in accordance with the requirements of MORT&H specification and in conformity with the lines, grades and cross- sections shown on the drawings or as directed by the Engineer.

3.01.02 **Materials**

Shoulder may be of selected earth/ granular material/paved conforming to the requirements of MORT&H specification.

3.01.03 **Construction Operations**

Shoulder

The sequence of operations shall be such that the construction of paved shoulder is done in layers each matching the thickness of adjoining pavement layer. Only after a layer of pavement and corresponding layers in paved and earth shoulder portion have been laid and compacted, the construction of next layer of pavement and shoulder shall be taken up.

Where the materials in adjacent layers are different, these shall be laid together and the pavement layer shall be compacted first. The corresponding layer in paved shoulder portion shall be compacted thereafter, which shall be followed by compaction of earth shoulder layer. The adjacent layers having same material shall be laid and compacted together.

Compaction requirement of earthen shoulder shall be as per latest MORT&H specification. In the case of bituminous course, work on shoulder (earthen/hard/paved), shall start only after the pavement course has been laid and compacted.

During all stages of shoulder (earthen/hard/paved) construction, the required crossfall shall be maintained to drain off surface water.

Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed, without damage to the pavement, and the area so affected thoroughly cleaned.

3.02.00 **Sub-base (Granular Sub-base)**

3.02.01 **Description**

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of MORT&H specifications. The material shall be laid in one or more layers as shown on the drawings and according to lines, grades and cross sections shown on the drawings or as directed by the Engineer.

3.02.02 **Materials**

The materials to be used for the work shall be natural sand, moorum, gravel, crushed stone, crushed slag, crushed concrete, brick metal, laterite, kanker etc. or combinations thereof depending upon the grading required. The material shall be free from organic or other deleterious constituents and conform to one of the three gradings given in Table 3.

While the gradings in Table 3 are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding gradings for the coarse-graded materials for each of the three maximum particle sizes are given at Table 4. The grading to be adopted for a project shall be as specified in the Contract.

TABLE-3

GRADING FOR CLOSE-GRADED GRANULAR SUB-BASE MATERIALS (TABLE 400-1 of MORT&H)

IS Sieve Designation	Per cent by weight passing the IS sieve		
	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	80-100	100	-
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (Minimum)	30	25	20

TABLE-4

GRADING FOR COARSE GRADED GRANULAR SUB-BASE MATERIALS
(Table 400-2 of MORT&H)

IS Sieve Designation	Per cent by weight passing the IS Sieve		
	Grading I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm		100	
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	<10	<10	<10
CBR Value (Minimum)	30	25	20

Note : The material passing 425 micron (0.425 mm) sieve for all the three gradings when tested according to IS : 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 percent respectively.

3.03.03 **Physical Requirements**

The material shall have a 10 per cent fines value of 50 kN or more (for sample in soaked condition) when tested in compliance with BS: 812 (Part III). The water absorption value of the coarse aggregate shall be determined as per IS: 2386 (Part 3); if this value is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which be taken as being the density relating to a uniform air voids content of 5 percent.

3.03.04 **Spreading and Compacting**

The sub-base material of grading specified in the Contract shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of the loose material shall be checked in accordance with IS: 2720 (Part II) and suitably adjusted by sprinkling additional water from a hose line, truck mounted water tank or other approved means so that at the time of compaction it is from 1 percent above to 2 percent below the optimum moisture content corresponding to IS:2720 (Part VIII). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means if so directed by the Engineer until the layer is uniformly wet.

Immediately thereafter, rolling shall be started with 8 to 10 tonne smooth wheeled rollers or other approved plant. Rolling shall commence at the edges and progress towards the centre longitudinally except that on super elevated portions it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and camber shall be checked and any high spots or depressions which become apparent corrected by removing or adding fresh material.

Rolling shall be continued till the density achieved is at least 95% of the maximum dry density for the material determined as per IS: 2720 (Part VII). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

3.04.00 Water Bound Macadam Sub-base/Base Course

3.04.01 Description

Water bound macadam shall consist of clean, crushed aggregates mechanically interlocked by rolling,, and bonded together with screenings, binding material, where necessary and water, laid on a prepared subgrade or sub-base, as the case may be, and finished in accordance with the requirements of MORT&H Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or otherwise directed by the Engineer.

3.04.02 **Materials**

3.04.02.1 **Coarse Aggregates**

Coarse aggregates shall be either crushed or broken stone, crushed slag, overburnt (Jhama) brick aggregates or any other naturally occurring aggregates such as kankar and laterite of suitable quantity. The aggregates shall conform to the physical requirements set forth in Table 5.

TABLE 5 (Table 400-6 of MORT&H)

PHYSICAL REQUIREMENTS OF COARSE AGGREGATES FOR WATER BOUND MACADAM FOR SUB-BASE/BASE COURSES

	Test	Test Method	Requirements
1.	* Los Angeles Abrasion value Or * Aggregate Impact value	IS : 2386 (Part-4) IS : 2386 (Part-4) or IS : 5640 **	40 per cent (Max) 30 per cent (Max)
2.	Combined Flakiness and Elongation Indices (Total) ***	IS : 2386 (Part-1)	30 per cent (Max)

* Aggregate may satisfy requirements of either of the two tests.

** Aggregates like brick metal, kankar, laterite etc. which get softened in presence of water shall be tested for Impact value under wet conditions in accordance with IS : 5640.

*** The requirement of flakiness index and elongation index shall be enforced only in the case of crushed broken stone and crushed slag.

3.04.02.2 **Crushed or Broken Stone**

Crushed or broken stone shall be hard, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter.

3.04.02.3 **Grading Requirements of Coarse Aggregates**

The coarse aggregates shall conform to one of the gradings given in Table 6, provided, however, the use of Grading No. 1 shall be restricted to sub-base courses only.

TABLE 6 (Table 400-8 of MORT&H)

GRADING REQUIREMENTS OF COARSE AGGREGATES

Grading No.	Size Range	IS Sieve Designation	Per cent by Weight passing
1.	90 mm to 45 mm	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5
2.	63 mm to 45 mm	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3.	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Note : The compacted thickness for a layer with Grading 1 shall be 100 mm while for layer with other Gradings e.g. 2 & 3, it shall be 75 mm.

3.04.02.4 **Screenings**

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

Screenings shall conform to the gradings set forth in Table7.

TABLE 7

GRADINGS FOR SCREENINGS (Table 400-8 of MORT&H)

Grading Classification	Size of Screenings	IS Sieve Designation	Per cent by weight passing the IS Sieve
A	13.2 mm	13.2 mm	100
		11.2 mm	95-100
		5.6 mm	15-35
		180 micron	0-10
B	11.2 mm	11.2 mm	100
		5.6 mm	90-100
		180 micron	15-35

3.04.02.5 **Binding Material**

Binding material to be used for water bound macadam as a filter material meant for preventing ravelling, shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS : 2720 (Part-5).

The quantity of binding material where it is to be used, will depend on the type of screenings. Generally, the quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 m3/10m2 and 0.08-0.10m3/10m2 for 100 mm compacted thickness.

The above mentioned quantities should be taken as a guide only, for estimation of quantities for construction etc.

Application of binding materials may not be necessary when the screenings used are of crushable type such as moorum or gravel.

3.04.03 **Construction Operations**

3.04.03.1 **Preparation of Base**

The sub-grade/sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm surface is obtained if necessary by sprinkling water.

3.04.03.2 **Inverted Choke**

If the water bound macadam is to be laid directly over the subgrade, without any other intervening pavement course, a 25 mm course of screenings (Grading B) shall be spread on the prepared subgrade before application of the coarse aggregates is taken up.

3.04.03.3 **Spreading Coarse Aggregate**

The coarse aggregates shall be spread uniformly upon the prepared surface in such quantities that the thickness of the compacted layer is 100 mm for grading 1 and 75-100 mm for gradings 2 and 3 for each layer.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The coarse aggregate shall not normally be spread more than 3 days in advance of the subsequent construction operations.

3.04.03.4 **Rolling**

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or tandem or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall continue until the aggregates are thoroughly keyed and the creeping of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done, if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and re-rolling until the entire surface conforms to desired camber and grade. In no case shall the use of screenings be permitted to make up depressions.

3.04.03.5 **Applications of Screenings**

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders, or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

3.04.03.6 **Sprinkling and Grouting**

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly.

The sprinkling, sweeping and rolling operations shall be continued, with additional screenings applied as necessary, until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

3.04.03.7 **Application of Binding Material**

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

3.04.03.8 **Setting and Drying**

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course if in his opinion it would cause excessive damage to the surface.

3.05.00 **Tack Coat**

3.05.01 **Description**

The work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing bituminous road surface preparatory to the superimposition of bituminous mix, when specified in the Contract or instructed by the Engineer.

3.05.02 **Materials**

Binder: The binder used for tack coat shall be bitumen emulsion complying with IS: 8887 of a type and grade as specified in the Contract or as directed by the Engineer.

3.05.03 **Construction Operations**

3.05.03.1 **Preparation of Base**

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt and any extraneous material. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom and high pressure air jet, or by other means as directed by the Engineer.

3.05.03.2 **Application of tack coat**

The application of tack coat shall be at the rate specified in the Contract, and shall be applied uniformly. The normal range of spraying temperature for a bituminous emulsion shall be 20 degree Celsius - 70 degree Celsius and for a cutback 50 degree Celsius – 80 degree Celsius if RC-70/MC-70 grade is used. The method of application of the tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed of forward movement. The contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

3.06.00 **Bituminous Macadam Binder Course**

3.06.01 **Description**

This work shall consist of construction, in a single course, of 50 mm to 100 mm thickness or in multiple courses of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of MORT&H Specifications.

3.06.02 **Materials**

3.06.02.1 **Bitumen**

The bitumen shall be paving bitumen of penetration grade complying with Indian Standard Specifications for “Paving Bitumin”IS: 73, and of the penetration indicated in table 500-4 of MORT&H

3.06.02.2 **Coarse Aggregates**

The aggregates shall consist of crushed stone, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. Where crushed gravel is used, not less than 90 per cent by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces.

The aggregates shall satisfy the physical requirements set forth in Table 8.

TABLE 8 (Table 500-3 of MORT&H)

PHYSICAL REQUIREMENTS FOR COARSE AGGREGATES FOR BITUMINOUS MACADAM

Property	Test	Specification
Cleanliness	Grain size analysis	Max 5 % passing 0.075 mm sieve
Particle shape	Flakiness and Elongation Index (combined)2	Max 30%
Strength	Los Angeles Abrasion Value Aggregate Impact Value	Max 40% Max 30%
Durability	Soundness : Sodium Sulphate Magnesium Sulphate	 Max 12% Max 18%
Water Absorption	Water Absorption	Max 2%
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures	Minimum retained coating 95%
Water Sensitivity	Retained Tensile Strength	Min 80%

3.06.02.3 **Fine aggregates**

Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter

3.06.02.4 **Proportioning of Materials**

The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirements of table 500-4 of MORT&H.The binder content shall be within a tolerance of

3.06.03 **Construction Operations**

3.06.03.1 **Weather and Seasonal Limitations**

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

3.06.03.2 **Preparation of Base**

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as directed by the Engineer. The surface shall be thoroughly swept and scraped clean and free from dust and foreign matter.

3.06.03.3 **Tack Coat**

A tack coat shall be applied over the base.

3.06.03.4 **Preparation and Transport of Mix**

It would be carried out as per Clause 501.3 and 501.4 of MORT&H

3.06.03.5 **Spreading**

It would be carried out as per Clause 501.5.3 of MORT&H.

3.06.03.6 **Rolling**

It would be carried out in accordance with the provisions of Clauses 501.6 and 501.7 of MORT&H.

3.07.00 **Bituminous Concrete**

3.07.01 **Scope**

This clause specifies the construction of bituminous concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single or multiple layers of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25 mm to 100 mm in thickness.

3.07.02 **Materials**

3.07.02.1 **Bitumen**

The bitumen shall be paving bitumen of penetration grade complying with Indian Standard Specification for Paving Bitumen. IS:73 and of the penetration indicated in Table 500-18 of MORT&H, for bituminous concrete or this bitumen as modified by one of the methods specified in clause 521 of MORT&H, or as otherwise specified in the contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

3.07.02.2 **Coarse Aggregates**

The coarse aggregates shall be generally as specified in clause 507.2.2 of MORT&H, except that the aggregates shall satisfy the physical requirements of Table 500-17 of MORT&H.

3.07.02.3 **Fine Aggregates**

The fine aggregates shall be all as specified in clause 507.2.3 of MORT&H.

3.07.02.4 **Filler**

Filler shall be generally as specified in clause 507.2.4 of MORT&H. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-17 of MORT&H then 2 percent by total weight of aggregate, of hydrated lime shall be added without additional cost.

3.07.02.5 **Aggregate grading and binder content**

When tested in accordance with IS:2386 Part 1 (Wet grading method), the combined grading of the coarse and fine aggregates and added filler shall fall

Within the limits shown in Table 500-18 of MORT&H for gradings 1 or 2 as specified in the Contract.

3.07.03 **Mixture Design**

3.07.03.1 **Requirements for the mixture**

Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-19 of MORT&H.

The requirements for minimum percent voids in mineral aggregate (VMA) are set out in Table 500-12 of MORT&H.

3.07.03.2 **Binder content**

The binder content shall be optimised to achieve the requirements of the mixture

Set out in Table 500-19 of MORT&H and the traffic volume as specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve and retained on the 22.4 mm sieve, where approved by the Engineer.

3.07.03.3 **Job mix formula**

The procedure for formulating the job mix formula shall be generally as specified in clause 507.3.3 of MORT&H and the results of tests enumerated in Table 500-19 of MORT&H as obtained by the Contractors.

3.07.03.4 **Plant trials-permissible variation in job mix formula**

The requirements for plant trials shall be all as specified in clause 507.3.3 of MORT&H and the results of tests enumerated in Table 500-19 as obtained by the contractors.

3.07.03.5 **Laying trials**

The requirements for plant trials shall be all as specified in clause 507.3.5 of MORT&H.

3.07.04 **Construction Operations**

3.07.04.01 Weather and seasonal limitations

The provisions of clause 501.5.1 of MORT&H shall apply.

3.07.04.02 **Preparation of base**

The surface on which the bituminous concrete is to be laid shall be prepared in accordance with clauses 501 and 902 of MORT&H as appropriate, or as directed by the engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot access, other approved methods shall be used as directed by the engineer.

3.07.04.03 **Tack coat**

Where specified in the Contract, or otherwise required by the Engineer, a tack coat shall be applied in accordance with the requirements of clause 503 of MORT&H.

3.07.04.04 Mixing and transportation of the mixture

The provisions as specified in clauses 501.3 and 501.5.4 of MORT&H shall apply.

3.07.04.05 **Spreading**

The general provisions of clauses 501.5.3 and 501.5.4 of MORT&H shall apply.

3.07.04.06 **Rolling**

The general provisions of clauses 501.6 and 501.7 of MORT&H shall apply, as modified by the approved laying trials.

3.07.05 **Opening to traffic**

The newly laid surface shall not be open to traffic for at least 24 hours after laying and the completion of compaction, without the express approval of the engineer in writing.

3.07.06 **Surface finish and Quality control**

The surface finish of the completed construction shall conform to the requirements of clause 902 of MORT&H. All materials and workmanship shall comply with the provisions set out in section 900 of this specification.

3.07.07 **Arrangements for traffic**

During the period of construction, arrangements for traffic shall bemade in accordance with the provisions of clause 112 of MORT&H.

3.08.00 **Road Side Drains**

3.08.01 **Formation of Drains**

The road side drains shall be made in sizes and slopes as shown on drawings and/or as instructed by the Engineer. The minimum side slope shall be as instructed by the Engineer. The sides and bottom shall be neatly dressed after excavation. Proper connections shall be made to the culverts, outside plant area, as per instructions of the Engineer.

The excavated spoils shall be transported and filled in low areas within the plant area or in embankments as instructed by the Engineer. The lining for the drains shall be as per Dwg.

3.09.00 **Culverts**

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per the instructions of Engineer after clearing the site, etc. as per specifications of earthwork. Backfilling with ramming and watering shall be done after construction of the foundations.

The construction of culverts shall be done true to lines and levels and as shown on the drawing. The specification for Masonry and/or Plain and Reinforced Cement concrete shall be followed, as applicable.

3.10.00 **Pipe Culverts and Drainage Pipes**

3.10.01 **Materials**

The drainage pipes unless otherwise shown on drawings or instructed by the Engineer shall be made of R.C.C. and shall be either Class NP2 or NP3.

Pipe culverts shall be made of reinforced concrete pipe and shall be of class NP3 or of RDSO class for railway as decided by the Engineer or shown in the drawing. All pipes shall meet the requirements of IS:458-Latest edition and shall be procured from approved manufacturers with collars as per manufacturer's standard specifications. The tenderer shall specifically mention the particular manufacturer's product he proposes to use.

Cement shall be ordinary Portland cement as per IS: 8112 - Latest edition.

Aggregates shall be as per IS: 383 - Latest edition - Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller.

Fine aggregates for concrete shall be as per IS: 383 - Latest edition.

3.10.02 **Laying of Pipes**

Laying of concrete pipes shall correspond to IS:783 - Latest edition - and to specification given below :

a) The foundation bed for pipe shall be excavated true to lines and grades shown on the drawings or as directed by the Engineer. When trenching is involved its width on either side of the pipe shall not be less than 150 mm nor more than one-third the diameter of pipe unless otherwise instructed/ permitted by the Engineer. The sides of the trench shall be as nearly vertical as possible. Side slope, shoring, bailing out water, etc. as required shall be done by the Contractor without any extra cost to the Owner. Side slips, if there be any, shall be removed by the Contractor without any extra cost to the Owner. After laying of the pipes are completed, backfilling of the trenches shall be done in 250 mm layers, measured loose clods and lumps

broken, watered and compacted with iron rammers to the satisfaction of the Engineer. The surplus spoils shall be transported and filled in low areas within the plant area, as instructed by the Engineer.

When bed-rock or boulder strata are encountered, excavation shall be taken down to at least 200 mm below the bottom level of the pipe with prior permission of the Engineer and all rock/boulders in the area shall be removed and space filled with approved earth free from stone or fragmented material, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

When two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm.

Laying of pipes shall start from the outlet and proceed towards inlet.

All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care not to damage them. Under no circumstances the pipes shall be dropped into the trench or on supports from a height.

b) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS:783 - Latest edition - having a projection ratio of not greater than 0.70, in which the pipe is carefully bedded on fine granular materials in an earth foundation carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height, and in which earth filling material is thoroughly rammed and tamped in layers not exceeding 15 cm in depth around the pipe for the remainder of the lower 30 percent of its height.

If the pipe is laid in trench, pipe bedding shall be first class bedding as per IS: 783.

When indicated on the drawings or directed by the Engineer, the pipe shall be bedded on a craddle constructed of concrete having a mix not leaner than M25. The shape and dimension of the cradle shall be as indicated on the drawing or directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete has set.

c) The drop walls shall be made with first class brickwork in 1:4 cement mortar.

d) The pipe culverts shall be made with proper care regarding the invert of the pipe, gradient, if any, etc. as specified on drawings and/or as instructed by the Engineer.

e) Where R.C.C. pipes are encased in concrete at road crossings or at other places the pipes need be suitably supported avoiding reinforcements of concrete blocks, joints properly done before concreting is taken up. Concreting of total height of block may be done in a single operation or may be done upto some height for pipes to be properly laid in position and remaining height of block to be concreted subsequently.

f) The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part cement and 2 parts of clean sand with only enough water for workability. Procedure of jointing shall be as per IS:783 - latest edition.

3.10.03 **Relation with Water Supply Pipeline**

Unless specifically cleared by the Engineer, under no circumstances shall drainage pipes be allowed to come close to water supply pipelines.

3.11.00 **Manholes and Inspection Chambers**

The maximum distance between manholes shall be 30 meter unless specifically permitted otherwise. In addition at every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 meters unless permitted otherwise. Manhole shall be constructed so as to be watertight under test. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow.

Connection to existing pipelines shall be through a manhole.

Manholes shall be provided with standard covers, usually C.I. or as directed by the Engineer. The covers shall be close fitting so as to prevent gases from coming out.

3.12.00 **Plaster to Concrete**

Before application of plaster the surface shall be cleaned of all dirt, grease or loose particles by hard brush and water. The surface shall be thoroughly moist to prevent absorption of water from the base course. Any excess water shall be mopped up.

Unless otherwise mentioned in the schedule of items plastering shall be done with cement sand mortar - 1 part by volume of cement to 4 parts by volume of clean, sharp, well graded sand. For sand cement plaster, sand and cement in the specified proportion shall be mixed dry on a watertight platform and minimum water added to achieve working consistency. For lime gauge plaster, lime putty or hydrated lime and sand in the required proportion shall

be mixed on a watertight platform with necessary addition of water and thoroughly ground in mortar mill. This mix shall then be transferred to a mechanical mixer to which the required quantity of cement is added and mixed for at least 3 minutes.

No mortar which has stood for more than half an hour shall be used.

Plaster, when more than 12 mm thick, shall be applied in two coats. All plaster work shall correspond to IS: 1661- latest edition.

3.12.01 **Finish**

Generally, all plastered surfaces shall have a standard finish unless otherwise shown on the drawing or directed by the Engineer. The interior plaster shall be finished to a smooth surface by steel trowelling. The exterior surfaces shall be finished with a wooden float.

However, if shown on the drawing or directed by the Engineer the plastered surface shall have a neat cement finish. Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg per Sq.M. and rubbed smooth with a trowel.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 Roads

All testing, as mentioned in the body of the specification and as mentioned in section 900 of MORT&H shall be carried out by the Contractor as per direction of the Engineer. No extra payment shall be made for such tests.

4.02.00 Cement Concrete

The strength requirements and acceptance criteria shall conform to the relevant clauses of IS: 456.

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SECTION-XII

TECHNICAL SPECIFICATION
FOR
CONSTRUCTION OF REINFORCED CONCRETE CHIMNEY

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SECTION-XII

TECHNICAL SPECIFICATION FOR CONSTRUCTION OF REINFORCED CONCRETE CHIMNEY

1.00.00 **SCOPE**

This specification covers plain and reinforced cement concrete work, lining and insulation work, miscellaneous steel and metal work, painting and protective treatment work, lightning protection system and aviation obstruction lighting system, connected with construction of RCC Chimney.

2.00.00 **GENERAL**

2.01.00 Work to be provided for by the Contractor

Work to be provided by the Contractor, unless specified otherwise, shall include but shall not be limited to the following :

a) Furnish all labour, supervision, services, insurance, material, power, fuel, forms, templates, supports, scaffolding, tools, plants, construction equipment, approaches, transportation etc. required for the entire work.

b) Design and prepare working drawings for formworks, scaffoldings, supports, staging etc. and submit them for approval.

c) Prepare and submit for approval, as per approved schedule, detailed drawings for R.C. work in shell, hopper, platforms and ground floor and bending schedules for reinforcement bars, showing the positions and details of spacers, chairs, supports, hangers, openings etc.

d) Prepare detailed fabrication and erection marking drawings for steel and metal works and submit them for approval.

e) Prepare detailed shop drawings for various inserts, anchors, sleeves, frames, templates, anchor bolts etc. showing relative locations of their installations and submit them for approval.

f) Prepare and submit for approval the detailed schemes for operations like material handling, placement of concrete etc. and for items like approaches, services etc.

g) Design and submit for approval the mix proportions for concrete to be adopted on job.

h) Furnish samples and submit for approval the results of tests for various properties of the following materials :-

i) Ingredients of concrete, (ii) Concrete, (iii) Metal work components, (iv) Acid proof bricks, (v) Fire bricks, (vi) Castable refractories, (vii) Insulation material, (viii) Paints, (ix) Electrical Items.

i) Provide all incidental items not specified or shown on drawings in particular but reasonably implied or necessary for successful completion of the work in accordance with drawings and specifications.

j) Produce, if directed by the Engineer, a guarantee, in approved proforma, for satisfactory performance, for a specified period, of material manufactured by specialist firms.

2.02.00 **Work by others**

No work under this specification will be provided for by agency other than the Contractor for this Contract unless specifically mentioned otherwise in the Contract.

2.03.00 **Codes and Standards**

All works under this Specification, unless specified otherwise, shall conform to the latest revisions/replacements of the following Indian Standard Codes, Criteria, Specifications, alongwith those mentioned therein. In case any particular aspect of work is not covered by Indian Standards, other standard specification, as may be specified by the Engineer, shall be followed. 'IS Specification' shall mean Codes, Criteria etc. of IS -

IS:6	:	Moderate heat duty fireclay refractory, Group-A.
IS:104	:	Ready mixed paint, brushing, zinc chrome, priming.
IS:158	:	Ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and heat resisting for general purposes.
IS:226	:	Structural Steel (Standard Quality).
IS:269	:	Ordinary, and low heat Portland cement.

IS:383	:	Coarse and fine aggregates from natural sources for concrete.
IS:432	:	Mild steel and medium tensile steel bars.
IS:456	:	Code of practice for plain and reinforced concrete.
IS:516	:	Methods of test for strength of concrete.
IS:732	:	Code of practice for electrical wiring installations (System voltage not exceeding 650 Volts).
IS:800	:	Code of practice for general construction in steel.
IS:808	:	Rolled steel beam, channel & angle sections.
IS:813	:	Scheme of symbols for welding.
IS:814	:	Covered electrodes for metal arc welding of structural 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:818	:	Code of practice for safety and health requirements in electric and gas welding and cutting operations.
IS:822	:	Code of procedure for inspection of welds.
IS:1139	:	Hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcements.
IS:1161	:	Steel tubes for structural purposes.
IS:1199	:	Methods of sampling and analysis of concrete.
IS:1200	:	Methods of measurement of building works.
IS:1239 (Part-I)	:	Mild steel tubes.
IS:1367	:	Technical supply conditions for threaded fasteners.
IS:1526	:	Sizes and shapes for firebricks (230 mm. series).

IS:1554	:	Cables.
IS:1566	:	Hard-drawn steel wire fabric for concrete reinforcement.
IS:1608	:	Methods for tensile testing of steel products.
IS:1730	:	Dimensions for steel plate, sheet and strip for structural and general engineering purposes.
IS:1731	:	Dimensions for steel flats for structural and general engineering purposes.
IS:1786	:	Cold-twisted steel bars for concrete reinforcement.
IS:1791	:	Batch type concrete mixers.
IS:1893	:	Criteria for Earthquake Resistant Design of Structures.
IS:1977	:	Structural steel (ordinary quality).
IS:2062	:	Weldable structural steel.
IS:2074	:	Ready mixed paint, red oxide - zinc chrome priming.
IS:2309	:	Code of practice for the protection of buildings and allied structures against lightning.
IS:2386 (Part-I)	:	Methods of test for aggregates for concrete. Particle size and shape.
IS:2386 (Part-II)	:	Estimation of deleterious materials and organic impurities
IS:2386 (Part-III)	:	Specific gravity, density, voids, absorption and bulking.
IS:2386 (Part-IV)	:	Mechanical properties
IS:2386 (Part-V)	:	Soundness
IS:2386 (Part-VI)	:	Measuring mortar making properties of fine aggregate.
IS:2386 (Part-VII)	:	Alkali aggregate reactivity.
IS:2386	:	Petrographic examination.

(Part-VIII)

IS:2502	:	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:2505	:	Concrete vibrators, immersion type.
IS:2506	:	Screed board concrete vibrators.
IS:2633	:	Methods of testing uniformity of coating on zinc coated articles.
IS:2722	:	Portable swing weigh batchers for concrete (single and double bucket type).
IS:2750	:	Steel scaffoldings.
IS:2751	:	Code of practice for welding of mild steel bars used for reinforced concrete construction.
IS:3025	:	Methods of sampling and test (Physical and Chemical) for water used in industry.
IS:3043	:	Code of Earthing
IS:3144	:	Methods of Test for Mineral Wool Thermal Insulation Material.
IS:3346	:	Method for the determination of thermal conductivity of thermal insulation materials (two slab, guarded hot-plate method).
IS:3495 (Part-I to IV)	:	Method of test for clay building bricks.
IS:3550	:	Methods of test for routine control for water used in industry.
IS:3558	:	Code of practice for use of immersion vibrators for consolidating concrete.
IS:3677	:	Unbonded rock and slag wool for thermal insulation.
IS:4014 (Part-I&II)	:	Code of practice for steel tubular scaffolding.
IS:4031	:	Method of physical tests for hydraulic cement.
IS:4634	:	Method for testing performance of batch-type concrete mixers.

IS:4687	:	Gland packing asbestos.
IS:4860	:	Acid-resistant bricks.
IS:4990	:	Plywood for concrete shuttering work.
IS:4998 (Part-I)	:	Criteria for design of reinforced concrete chimneys.
IS:5410	:	Cement paint, colour as required.
IS:5445	:	Long fluted machine reamers with Morse taper shanks.
IS:5495	:	Sizes and shapes for firebrick (300 mm. and higher series).
IS:8112	:	High strength ordinary portland cement.
IS:8183	:	Bonded Mineral Wool.
IS:9595	:	Recommendation for Metal Arc Welding of Carbon and Carbon Manganese steels.
CP326	:	British Standard - Protection of structures against lightning.
NEPA NO. 78	:	Code of protection against lightning.

Draft Code of Practice for the protection of buildings against lightning - 1954 of Institution of Engineers (India).

The Indian Electricity Rules.

The requirements of Department of Civil Aviation, Govt. of India.

2.04.00 **Conformity with drawings and specifications**

The Contractor shall carry out all the work in strict accordance with the drawings stamped Released for Construction' and specification issued to him and as per Contractor's detailed drawings approved by the Consulting Engineer. Prior to concreting, the Contractor shall prepare a check list on a set format of all items of work involved, and inform the Engineer well in advance so that the Engineer shall have the opportunity of satisfying himself if the works mentioned in the format are done according to drawings and specification, and he can allow the Contractor in writing to start pouring of concrete. The entire operation of concreting shall be carried on as per specification, to the complete satisfaction of the Engineer. No deviation from the drawings will be allowed unless otherwise directed by the Engineer in writing.

For steelwork and metal work, the Contractor shall design all connections, inserts for scaffolding, supply and fabricate all steelwork and metal work and furnish all connection materials in accordance with approved shop drawings prepared by him and/or as instructed by the Engineer, keeping in view the maximum utilisation of the available sizes and shapes for metal components.

2.05.00 **Materials to be used**

2.05.01 **General Requirement**

All materials, whether to be incorporated in the work or to be used temporarily for the construction, shall conform to the relevant IS specifications unless stated otherwise and shall be of the quality approved by the Engineer.

2.05.02 **Cement**

Portland Cement shall be as per the requirements laid down in IS:269.

2.05.03 **Coarse Aggregate**

Coarse aggregate shall be graded crushed or broken stone from approved sources, free from impurities and shall be screened free of dust and other deleterious matter. It shall conform to IS:383 or IS:515 and shall be washed clean, if necessary. The maximum size of coarse aggregate for chimneys shall be 20 mm. down graded, unless otherwise stated (vide serial 5(b) of clause 3.03.00). Grading for a particular size shall conform to relevant IS Codes and shall be such as to produce a dense concrete of specified proportion and strength and shall be of consistency that will work readily into position without segregation.

2.05.04 **Fine Aggregate**

Fine aggregate shall be river or pit sand, free from any clay, earth, vegetable matters, salt or other impurities and shall be clean and fit for use, to the satisfaction of the Engineer. Sand acceptable for the work shall normally have a grading falling within the limits of one of the three grades, mentioned in the relevant IS Specifications.

2.05.05 **Water**

The water for both mixing and curing of concrete shall be clean, free from oil, acid, alkali, organic or other deleterious substances. Contractor shall test the water as and when required by the Engineer, at no extra cost to the Owner.

2.05.06 **Reinforcement**

Mild steel or Medium or High Tensile steel deformed bars specified for reinforcement shall conform to the latest relevant IS Specifications and shall

be of tested quality under ISI Certification Scheme. The reinforcement shall be free from any oil, foreign material or mill or rust scales.

2.05.07 **Structural Steel**

All steel materials to be used in construction of Chimney ladder, hand rails, flue opening frame, access door frame, door shutters etc. shall comply with IS:226, IS:1239, IS:1367, IS:1608 and with other relevant IS Specifications.

2.05.08 **Paints**

Paints to be used for shop coat of fabricated steel shall conform to the IS:2074. Paint for treatment of outside face of Chimney with Cement water proof paint shall conform to IS:5410.

2.05.09 **Fire Bricks, Acid Resistant Bricks and Castable Refractories**

Fire Bricks for the internal lining of the chimney shall conform to IS:6-1983 Group-A and IS:5445. Acid resistant bricks for internal lining of shell and hopper shall conform to IS:4860. Castable refractories shall be of hydraulic setting, rapid hardening type. It shall have refractory properties similar to Fire bricks conforming to IS:6, Group-A and working temperature shall be upto 1350 Deg.C.

2.06.00 **Storage of Materials**

2.06.01 **General**

All materials shall be so stored as to prevent deterioration and intrusion of foreign matter and to ensure the preservation of their quality and characteristics for the work. Any material, which is deteriorated or is damaged or is otherwise considered defective by the Engineer, shall not be used for construction and shall be removed from site immediately, failing which the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The Contractor shall maintain an up to date accounts of receipt, issue and balance of all materials issued by the Owner.

2.06.02 **Cement**

Contractor shall store cement in water-tight and properly designed stores so that the Cement can be kept dry and the stock can be handled in rotation. The doors of stores shall be at least 30 cm. above G.L. Deteriorated cement shall be removed immediately from the site. Not more than ten bags of cement shall be stacked one above the other.

2.06.03 **Aggregate**

Different materials shall be transported, handled and stored separately in such a manner as to prevent damage, deterioration or contamination.

Stockpiles of fine and coarse aggregates shall be allowed to drain, so that aggregates do not contain too much water.

2.06.04 **Reinforcement**

Reinforcement shall be stored preferably under cover and stacked off ground in size and grade-wise separate stacks for easy identification.

2.06.05 **Steel, Metal and Fittings**

All steel, metal and fittings to be used for fabrication and erection shall be stored sectionwise and lengthwise in separate stacks, off ground, so that they can be handled, inspected, measured and accounted for easily at any time. If required by the Engineer, the materials may have to be stored in a covered shed.

2.06.06 **Paints**

Paints shall be stored under cover, in air-tight containers. Paints supplied in sealed containers shall be used as soon as possible once the container is opened. Left over paints shall be kept in air-tight containers.

2.06.07 **Bricks**

Bricks shall be stored in systematic stacks for ease of handling and counting. While unloading the bricks from trucks, they shall be stacked right away and shall not be dumped in a heap.

2.06.08 **Insulation Material**

All insulation materials like glass or mineral wool, asbestos ropes etc. shall be stored in packing boxes, under covered shed, avoiding their coming in contact with objectionable matter.

2.06.09 **Electrical Items**

All electrical items shall be stored properly under covered water- tight shed so that they do not come in contact with moisture or cement dust.

2.07.00 **Quality Control**

Contractor shall establish and maintain quality control for different items or work and materials as may be directed by the Engineer to assure compliance with contract requirement and submit to the Engineer records of the same. The Contractor shall submit all records and test results in original to the Engineer for his approval, if so desired by him.

The quality control operation shall include but shall not be limited to the following items of work :-

a)	Cement	:	Test to satisfy relevant IS Specifications if supplied by the Contractor.
b)	Aggregate	:	Physical, Chemical and Mineralogical qualities, grading, moisture contents and impurities.
c)	Water	:	Impurities Test.
d)	Reinforcement:		Material tests or certificates to satisfy relevant IS Specification if supplied by the Contractor
e)	Structural Steel:		Material tests or certificate to satisfy relevant IS Specification if supplied by the Contractor.
f)	Bricks	:	Compressive strength, water absorption, efflorescence, warpage.
g)	Fire Bricks	:	Cold crushing strength, alumina content & water absorption test, density test, thermal conductivity test
h)	Acid Resistant	:	Compressive and tensile strength, acid bricks/tiles resistance and water absorption test.
i)	Mortar	:	Compressive and tensile strength, adhesion and acid resistance test.
j)	Insulation	:	Thermal conductivity, density, heat and acid resistance.

3.00.00 **EXECUTION**

3.01.00 **Concrete**

3.01.01 **Trial Mix, Grades of Concrete**

At least three weeks before commencing any concreting in the work the Contractor shall make trial mixes using samples of coarse aggregates, sand, water and cement, typical of those to be used in the work. A clean dry mixer shall be used for mixing and the first batch shall be discarded.

For guidance in designing the mix, standard tables for maximum allowable water-cement ratio, minimum cement content, maximum proportion of aggregates and limits of consistency may be used by the Contractor. The Contractor's design mix shall fall within limits of the following tables :-

i) Strength requirements of concrete : Table-2 of IS:456-2000.

ii) Concrete Mix Proportion : Table-3 of IS:456-2000.

iii) Minimum cement content/Cu.m. of finished concrete shall be as per table-V of IS-456-2000.

iv) Limit of consistency : Refer Table in Item 3.1.4 of this specification.

v) Cement/Total Aggregate Ratio : As per the following table.

MIX PROPORTIONS (BY WEIGHT) EXPECTED TO GIVE DIFFERENT DEGREES OF WORKABILITY WITH DIFFERENT VALUES OF WATER - CEMENT RATIO (FOR GUIDANCE) CEMENT/TOTAL AGGREGATES RATIOS

Workability	Water/ Cement Ratio	Ratio by weight of cement to gravel aggregate		Ratio by weight of cement to crushed stone aggregate	
		20 mm. size	38 mm. size	20 mm. size	38 mm. size
Very Low slump 0-25 mm.	0.4	1:4.8	1:5.3	1:4.5	1:5
	0.5	1:7.2	1:7.7	1:6.5	1:7.4
	0.6	1:9.4	1:10	1:7.8	1:9.6
	0.7	1:10	1:12	1:8.7	1:10.6
Low slump 25-50 mm	0.4	1:3.9	1:4.5	1:3.5	1:4
	0.5	1:5.5	1:6.7	1:5	1:5.5
	0.6	1:6.8	1:7.4	1:6.3	1:7
	0.7	1:8	1:8.5	1:7.4	1:8
Medium slump 50-100mm.	0.4	1:3.5	1:3.8	1:3.1	1:3.6
	0.5	1:4.8	1:5.7	1:4.2	1:5
	0.6	1:6	1:7.3	1:5.2	1:6.2
High slump 100 - 175 mm.	0.4	1:3.2	1:3.5	1:2.9	1:3.3
	0.5	1:4.4	1:5.2	1:3.9	1:4.6
	0.6	1:5.4	1:6.7	1:4.7	1:5.7
	0.7	1:6.2	1:7.4	1:5.5	1:6.5

NOTE -1 :

Notwithstanding anything mentioned above, the cement /Total aggregate ratio is not to be increased beyond 1:9 without specific permission of the Engineer.

It should be noted that such high aggregate cement ratios will be required for concretes of very low slump and high water-cement ratios, which may be required to be used in mass concrete work only.

NOTE - 2 :

The above figures are for guidance only, the actual cement/ aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used and from trial mixes.

For each grade of concrete, a set of eighteen cubes shall be made. Of these not more than six may be made on any day and further, of the six cubes made in one day not more than two cubes may be made from any single batch. Nine of these cubes each representing a different batch of concrete shall be tested at the age of seven days and remaining at twenty-eight days. The making of the cubes, their curing, storing, transporting and testing shall be in accordance with the relevant IS Specifications. The test shall be carried out in laboratory approved by the Engineer. If the average strength of the concrete cubes falls below the requirement, the method described above shall be repeated till acceptable results are obtained. The method may have to be repeated whenever there is a significant change in the quality of any of the ingredients for concrete, at the discretion of the Engineer. All cost for trial mixes and tests shall be borne by the Contractor and shall be included in the contract rates.

3.01.02 **Batching of concrete**

For controlled concrete, only weigh batching shall be allowed. All concrete ingredients, except water, shall be batched by weight, using an approved make of weigh batcher. Batching shall be accurate to 1/2 Kg. The batcher shall be tested for accuracy of calibration, first before commencement of work and at least once a fortnight or as directed by the Engineer thereafter. Water shall be batched by weight or by volume measures, as approved by the Engineer.

3.01.03 **Mixing of Concrete**

Materials for concrete shall be emptied in rotation into the mixer. When all the ingredients are in the drum, the drum will rotate for one minute for dry mixing. After that water shall be added in measured quantities in the manner specified. The mixer shall then rotate for at least two minutes, or at least forty revolutions or until there is apparent uniform distribution of the materials and till the mass is uniform in colour. The entire content of the drum shall be discharged before the ingredients for the succeeding batch are fed into the drum. The mixer shall be thoroughly cleaned to the satisfaction of the Engineer, before a different quality of concrete is put through the mixer and also at the end of day's work.

3.01.04 **Workability of Concrete**

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments, and to give the required surface finish shall depend on the type and nature of structure and shall be based on experience and tests. 15 mm. to 40 mm. slump in chimney works shall be adopted subject to Engineer's approval unless stated otherwise (vide serial 1(d) of clause no. 3.03.00). The usual limits of consistency for various types of structure are given below :

LIMITS OF CONSISTENCY

Degree of workability	Slump in mm. with standard concrete		Use for which concrete is suitable
.	Min.	Max	
Very Low	0	15	Large mass concrete work with heavy compaction equipment.
Low	15	35	Uncongested wide and shallow RCC structures.
Medium	35	65	Deep and wide RCC structures with congestion of reinforcement and inserts.
High	65	100	Very narrow and deep RCC with congestion due to reinforcement and inserts.

NOTE : The above table is for guidance only. Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer.

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately, to keep the ratio of water to cement same, as adopted in trial mix design, for each grade of concrete. No extra payment will be made for this additional cement.

The workability of concrete shall be checked at frequent intervals by slump tests. Alternatively, where facilities exist or if required by the Engineer, the compacting factor test, in accordance with IS:1199, shall be carried out.

3.01.05 **Placing and Compaction of Concrete**

Concreting shall proceed in a manner directed by the Engineer, concrete shall be placed in forms as soon as possible but in no case later than twenty minutes, after mixing.

The height of any single lift of concrete, for different structural members, shall be decided by the Engineer. The concrete shall be placed in the forms gently and not dropped from a height, which may cause segregation of aggregates. Each layer of concrete shall be compacted fully before the succeeding layer is placed and separate batches shall follow each other so closely that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken an initial set.

The concrete, after placing, shall be consolidated only by power driven vibrators. The vibrators shall be of a make and size, approved by the Engineer. In using the vibrator, the standard practice and the Engineer's directions, shall be followed.

Vibration shall begin as soon as one batch of concrete has been placed and shall continue till the entire section being poured has been thoroughly consolidated.

To secure even and dense surfaces, free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic, without damaging or endangering the stability of the formwork.

A sufficient number of spare vibrators including petrol vibrators shall be kept readily accessible to the place of deposition of the concrete to assure adequate vibration in case of breakdown of those in use.

3.01.06 **Curing of Concrete**

Curing of exposed surface of concrete shall commence immediately after the concrete has set. Exposed sides shall be covered with canvas etc. immediately after stripping of forms, and curing shall be continued for a period of not less than 14 days, reckoned from the date and hour of completion of concreting. All surfaces of the pour shall be kept wet with water at all times after concreting and till the curing period is over. The Contractor shall plan and employ proper equipment and sufficient labour considered adequate by the Engineer under able supervisor for curing and all cost for this purpose shall be borne by him.

3.01.07 **Construction Joints**

In concreting the chimney shell one full ring lift shall be completed in a day's pour. Before the formwork for the following pour starts the horizontal surface of the Chimney shell shall be chipped, cleaned and washed with water, and when the formwork is complete, the surface shall be cleaned and washed again and covered with 1:2 sand cement slurry before fresh concrete is placed. The horizontal construction joints shall be so arranged and made that they are regular and neat. No vertical joint shall be allowed. No separate payment shall be allowed to the Contractor for forming joints or chipping and cleaning them or cover with slurry prior to concreting. The number of construction joint shall be kept minimum and the spacing should not exceed three (3) meters. The Contractor shall submit to the Engineer, any proposal of providing construction joints to facilitate his work, for the study and approval of the Engineer well in advance.

3.01.08 **Ordinary Concrete**

Ordinary concrete like lean concrete shall be of nominal mix as per relevant clauses of IS:456.

3.02.00 **Reinforcement**

3.02.01 **Bending of Reinforcement**

All bars shall be carefully and accurately bent by the Contractor in accordance with approved Drawings and bar bending schedules. Special care shall be taken to ensure correct lengths of laps. The bars shall not be bent or straightened in any manner that will injure the bars or impair the bond between reinforcement & concrete. Bends and hooks are to be provided as laid down in the IS:2502.

3.02.02 **Placing**

All reinforcement shall be placed and maintained in the position shown in the drawings. Contractor shall provide approved type of cover blocks to suit the requirement of the Drawings. Where reinforcement is to be provided on two faces of the shell, the Contractor shall provide adequate number of separators, with the approval of the Engineer. Any additional support to the reinforcing cage, if required at the time of concreting, shall also be provided, to the satisfaction of the Engineer. Lapping of reinforcement as specified in the drawings or as directed by the Engineer, shall be provided. Laps shall be staggered and too many laps shall be avoided. Welded laps shall be provided only when directed or approved by the Engineer.

3.02.03 **Fixing of Reinforcement**

18 SWG annealed steel wire shall be used as binding wire. Bar crossing one another and contact laps shall be bound with this wire twisted tight to make the skeleton or network rigid so that the reinforcement is not displaced during placing of concrete.

3.03.00 **Forms**

Construction by slip-form Method

Slip-form construction will be encouraged if proposed by the Tenderer. Type of Slip-form proposed should be indicated in the offer with sketches, drawings and construction statement as explained hereinafter. Number, type and capacities of jacks, the control system and achievable rate of progress in mm/hour should also be indicated. The chosen scheme shall be of a past proven design. A certified performance record of the scheme should be submitted with the offer to guarantee workability of the scheme both from execution time and safety point of view.

The Tenderer should furnish a brief but comprehensive statement indicating the planning & programme and method of work to be followed, for the approval of Owner at the time of submitting Tender. This statement shall include the following items :

i) Type and description of Slip-form equipment and its accessories.

ii) Design of scaffolding and staging.

iii) Description of materials including admixtures to be used for construction.

iv) Manpower planning, construction spaces required, standby arrangement.

v) Rate of Slip-forming.

vii) Proposed workability requirement of concrete and type of cement & admixture to be used.

viii) Quality assurance programme.

ix) Method of Transportation of material

x) Method of curing and rectification of defects.

xi) Planned interruption, if proposed, and activities during planned interruption. Treatment of construction joint.

xii) Contingency solution for unplanned interruptions.

xiii) Time of completion.

While selecting the Contractor, due consideration will be given to the merit of the above mentioned statement proposed by the Tenderer and minimum time of completion, apart from his past experience in such types of work as also technical and financial resources of the Tenderer.

Not withstanding what have been specified in earlier clauses, following guide lines are being presented which should be kept in view by intending Tenderers, while quoting for Slip-form method of construction :

1. Care to be taken to prevent dragging of concrete along with upward movement of the shuttering. For this purpose following steps are advisable :

   a) Shutter plates have to be smooth and should be thoroughly clean. Before fixing them in position all the surfaces which will be coming in contact with concrete to have a coat of epoxy paint.

   b) In areas where concrete thickness is 750 mm or more rate of pouring should be such that minimum slipping of shuttering is 100 mm per hour.

   c) Mix design should be so done that it will be self- lubricant at the contact face of shutter and concrete and thus reduce friction. Suitable cement of approved manufacturer (conforming to relevant I.S. Specification) may be used for the purpose. An optimum ratio of coarse/fine aggregate should be established to suit the purpose depending on availability of aggregates.

   d) Mix design also should be so done that it has a slump of 50 mm at the point where concrete is placed under an ambient temperature of around 40°C. This will also keep vibration by needle vibrators to required minimum. Slump should not drop down to zero in less than 45 minutes. Suitable retarding agent and plasticizer of approved manufacture may be added in mix to achieve this purpose. These admixtures to be properly identified by preliminary tests both for performance and for compatibility with particular type of cement proposed to be used. The admixtures shall be used strictly as per manufacturer's Specification.

Additional steps like spraying of water over the shutters and keeping down the temperature of coarse aggregates by continuous spraying of water over those may be resorted to if ambient temperature is more than 40°C.

e) The slip form platform shall have a parallel platform 2M below the main platform on inside and outside to provide finishing to the surface of the chimney wherever required.

2. Care must be taken to prevent twist, which predominantly occur in the initial stages because of low slipping rate, in the horizontal plane of Slip-form assembly. A thorough check on this aspect must be kept at every 15 minutes interval. One person should exclusively be assigned this work together with rectifying any defect.

3. Every endeavour has to be made so as not to occur any tilt in the shutter assembly. To achieve this following steps need be taken :

a) Performance of jacks has to be closely observed and any defective one needs immediate replacement. Difference in levels of opposite jacks at any instant of time should not exceed 5 mm.

b) Loading on Slip-form truss/yokes has to be fairly equal.

c) Sleeve through which jacking rod passes has to be of sufficient length so that later gets an uniform clearance and does not get any chance to tilt. Sleeve should have a minimum wall thickness of 3.25 mm and should be such that jacking rod gets a maximum clearance of 1 mm to 1.5 mm all-round.

4. For taper walled chimneys overlapping of shutters which are kept to effect the tapering, needs careful attention otherwise these may be filled with concrete slurry.

5. In designing the mix following aspects should be borne in mind :

a) Cement used should have an initial setting time of not less than 50 minutes and preferably should have a specific surface around 3600 Sq.Cm. per gram.

b) Coarse and fine aggregates should be well graded and rounded aggregates offer better performance in Slip-form technique. These help to keep down water/cement ratio and also offers better lubrication between concrete and shutter surface. 40 mm down size of coarse aggregates should preferably be used unless reinforcement detailing calls for lesser size aggregates.

c) From the point of view of creep, shrinkage as well as initial setting property of concrete, cement content should not preferably be more than 400 Kg. per Cu.M of concrete.

d) Minimum compressive strength (after 4 to 6 hours of mixing) of concrete immediately below the shutter as slipform proceeds should be between 0.1 to 0.2 Newton/ Sq.mm.

e) It is advisable to use cement from a single source during the entire operation of slip form technique since once the system starts, there might not be any time left for conducting trial mixes if the source of procurement of cement changes.

6. Large diameter vibrator needles should not be used for vibrating concrete. Sizes of these needles should preferably be restricted to 25 mm diameter and to 40 mm diameter - only in exceptional cases. At least two nos. standby vibrator units should always be maintained on top of working deck at all time during the entire period of slipform operation.

7. It is preferable to have membrane curing compounds sprayed on fresh surfaces emerging out of shutter panels for ensuring proper curing at great heights.

   In case such spraying is not envisaged then elaborate arrangement has to be made for adequate supply of water both on inside and outside vertical surfaces with spraying arrangement, necessary length of pipelines and pump of adequate head to serve the purpose. It is always advisable to have a stand-by pump for effective utilisation of the system.

8. If Slipforming is carried out in summer, rate of slipping should be around 400 mm per hour. If lesser value is contemplated appropriate retarders should be specified.

9. Exact number and capacity of jacks as well as spacing of yoke frames are to be determined taking into account various loadings including self weight of the system, dead and live loads on working and other platforms, horizontal load on formwork, wind load etc.

   It is desirable that jacking system, based on which the entire slipform system works, should consist of jacks 3 Tonne/6 Tonne capacity and a hydraulic pump with necessary pipe connections.

   Spacing of yoke legs should preferably be kept within 2 metres to prevent overloading on jacks and consequent failure resulting in twist of the formwork.

Jacking rods should be of 25 mm diameter for 3 Tonne Jacks and 32 mm diameter for 6 Tonne Jacks.

10. At least 30% spare jacks and jacking rods should be kept ready during the entire operation. It is obligatory to maintain spare hydraulic pump along with a set of loose pipes in perfect working condition on top of working deck.

11. In sections where thickness is 500 mm or more it is prudent to go in for two nos. of jacks for each slipform yoke.

12. For effective utility of this technique following areas need careful attentions at the very conceptual stage :

    a) Detailed quality assurance programme.

    b) Advance Planning and preparations.

    c) Arrangement for on site supervision and adequate access facilities.

13. Construction methods including description and types of different equipment proposed to be used, structural arrangement and analysis of the system, description and type of different materials, planned interruptions, description and frequency of various checks and tests for Slipform technique as well as for material, method of preparing, transporting and pouring of concrete, solution for probable defects during slipping, sequence of operations during planned interruptions etc. should be prepared beforehand by executing agency and to be approved by Engineer before starting the actual work.

14. Placing and binding of reinforcement is also a very critical item and needs special attention. From practical considerations not more than two or three layers of horizontal steel can be tied at a time and this causes a definite limitation in placement of reinforcement.

    Vertical reinforcements should be kept vertical by providing suitable holders within the slipform system.

15. It is desirable to have a break of at least one day for every two weeks of continuous operation. Such break should be utilised for various maintenance activities, removal of jack rods etc.

16. Numbers and locations of hoists for lifting concrete, reinforcement and other materials have to be planned well in advance. Capacity of hoists should be such as to match with hourly requirement of concrete and reinforcement. If felt necessary one hoist may be exclusively earmarked for transporting concrete.

For movement of personnel supervising the work a separate hoist must be arranged for.

17. The system being operative round the clock it is obligatory to have adequate lighting arrangement both on various platform levels as well as on ground below. Arrangement has to be made for facilitating continuous upward movement of the entire system along with slipform.

18. Winches for lifting men and material and mixers, if located within unsafe area around chimney, should be protected by adequate shelter from possible damage.

19. Proper telecommunication system has to be established between the personnel working on top of Chimney and control room below.

20. A small laboratory should be maintained at site for testing different materials like cement, coarse and fine aggregates. A cube testing machine may also be installed at site for getting quick feed back results.

    Apart from using plumb bobs, level and the odolite instruments for survey purpose arrangement should also be kept for lasers.

21. In case of interruption in the course of slipping of formwork following measures should be taken:

    a) Provision of a key and additional reinforcement at the junction of new and old concrete.

    b) Slipform system should be brought up freely to have a minimum overlap of 100 mm or so over previously cast concrete.

    c) Washing of old concrete surface with compressed air and water jet and thereafter pouring a layer of neat cement grout.

    d) Clearing of shuttering panels of loose materials, concrete etc. by compressed air and applying a coat of epoxy paint, if felt necessary by Engineer.

    e) Neatly finishing the interface of old or new concrete as soon as it comes out of shutter panel.

22. It is preferable to suspend the construction work under high wind condition.

23. It is of utmost importance that for effective implementation of this system an Engineer fully conversant with Slipform technique with enough experience in planning and control of formwork should be in overall command of the site and he should be ably supported by well trained mid level supervisory staff, skilled workers and operators.

24. Operation of slipform method of construction is a continuous one and it demands continuous/intermediate inspection of accuracies in line, level, dimensions and position and immediate rectification of any noticed deviation. All these ask for personnel of high quality having constant vigilance over the construction activity.

25. While all the activities in effective implementation of the work needs utmost care keeping safety of men and material in mind it is obligatory that all activities should be carried out under the guidance of a qualified and trained safety Engineer.

    Safety measures as listed below must be adhered to but should not be limited to only these :

    a) Safety helmets and belts to be provided to all supervising staff and workers.

    b) Safety nets to be provided below both inside and outside platforms as instructed by Engineer.

    c) Hand railing and toe guard to be provided around all openings and platforms.

    d) Regular maintenance of equipment, checking of hoists, scaffoldings etc.

    e) Passenger hoist must have multiple ropes.

    f) Emergency lights, coloured lamps to be provided in accordance with relevant Indian Standards and as supplemented in the Specification and to be operative in case of sudden power failure Emergency standby generator must be kept ready during the entire period of slipform method of construction.

    g) Emergency vehicles, first aid facilities must be kept ready during the entire period of work.

26. Permissible construction tolerances should be limited to the following :

Variation in wall thickness	:	(-) 5 mm, (+) 25 mm
Variation from Design Diameter	:	(±) 25 mm or (±) 12.5 mm per 3 m dia. whichever is larger, but in no case more than (±) 75 mm.
Out of Plumb in General	:	1 in 1000 of height subject to a maximum of 200 mm.

Although deviations in general will not be encouraged, the Contractor, however may mention in his offer the additions to or deviations from drawings/Technical Conditions issued with the tender papers and any other special requirement implied with the adoption of the Slipform method, which may include but need not be limited to the following items as applicable :-

a) Particular requirement of type and brand of cement, if any.

b) Special admixture to be added to concrete.

c) Any change required in the geometry of the Chimney including the shell thickness or side slope from that shown in the N.I.T. drawing.

d) Any change/special requirement in the arrangement of reinforcement.

e) Implications if any of necessary in situ bending of rebars for corbels/brackets etc. and straightening/cleaning of the same prior to casting of brackets.

f) Any additional constructional opening in the shell required at ground level for concreting.

All deviations from tenders must be justified and tender price shall include all such variation/deviation. Such deviation without assigning any reason will be rejected.

3.04.00 Chimney Steel and Metal Work

3.04.01 General

All workmanship shall be of best practice in modern structural shops, and shall conform to the provisions of the IS:800 and other relevant IS Specifications, unless otherwise specified.

3.04.02 **Fabrication**

Rolled materials, before being used for fabrication, shall be straight and shall be within the tolerance laid down in the IS:852. Straightening, if necessary, may be done by mechanical means and if required, by applying localised heat, the temperature of the material not exceeding 600 Deg.C locally. Cutting of mild steel members shall be effected by power saw or gas cutting. If gas cutting is used, allowance shall be made in working out the effective length, based on the shop drawing and templates. Care shall be taken in gas cutting so that the member does not bend or warp. Edge preparation for welding may be done by gas cutting with necessary precautions and cleaning. Holes shall be drilled with power drill. Arrangement shall be made for clamping the member to be drilled so that the member is not displaced while drilling is in progress. When two or more members are to be drilled together, all the parts shall be clamped together. After drilling they shall be separated and burs shall be removed with power driven hand grinder. Boltholes shall not be formed by a gas-cutting torch.

3.04.03 **Assembly**

Riveting, bolting and welding shall be carried out as per requirements laid down in IS:800. Shop assembly of elements of platforms or the entire platforms, brackets and similar items if required and/or asked for by the Engineer, shall be arranged so as to check the accuracy of fit. Necessary temporary supports like props, cross bracings etc. shall be provided to keep the parts in place both for mock up and at the time of erection. Each steel piece shall bear erection marking, written in paint.

3.04.04 **Painting**

If steel and iron members are to be painted as per contract, it shall be done as per requirement laid down in IS:800. A coat of shop painting shall be applied to all steel and metal work, unless stated otherwise. All steel ladder, platforms, balconies, hand railing, frames, doors etc. which are specified for painting shall be painted first with two coats of red oxide zinc chromate paint conforming to IS:2074 and then with two coats of Synthetic enamel paint (as per IS:2932 & 2933) or aluminium paint (as per IS:2339) of approved quality or acid resisting paints as specified in drawing or elsewhere.

Total dry-film thickness of paints provided on structures located outside windshield shall be 190 microns and that on inside be 125 microns minimum.

All paints shall be of make and shade as instructed and approved by the Engineer. Necessary test certificates, manufacturer's literature and samples shall be submitted to the Engineer for his approval, before bulk purchase is made.

The metal surfaces which are to be painted shall be prepared properly by rubbing, washing, treating prior to application of paint as per paint manufacturer's specifications and as per relevant IS Specifications.

3.04.05 **Galvanizing**

All steel including threaded bolts, nuts and washers, unless specified otherwise in contract, shall be hot dip galvanized in accordance with American Society for Testing and Material Specification ASTM 123 or IS:2629 - Recommended practice for Hot- Dip Galvanising of Iron and Steel.

All members to be galvanized shall be cleaned thoroughly, to the satisfaction of the Engineer, by the process of pickling. Pickling shall be carried out in an acid bath containing sulphuric or hydrochloric acid of suitable and adjusted concentration and temperature. Pickling process shall be completed by rinsing the members thoroughly in warm water.

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath and it shall meet all the requirements when tested in accordance with IS:2633 and IS:4759. The zinc coating shall be of uniform thickness. If the galvanizing of any member is damaged, the Engineer shall be shown of the extent of damage and if so directed, the galvanizing may have to be redone in the similar manner stated above.

3.04.06 **Erection**

Erection of structural members and C.I. Chimney caps shall be done as per requirement of IS:800. The Contractor shall submit to the Engineer a programme of erection for his approval. All plant, equipment, tools, tackle and any other accessories required for the erection shall be provided by the Contractor. Storing and handling of fabricated materials for erection, setting out of members, providing temporary supports, bracing, fasteners, bolts, nuts etc. shall be the responsibility of the Contractor and shall be taken into account in quoting the rate.

3.04.07 **Cast Iron Chimney Cap**

The cast iron cap, fitted at the top of the chimney, shall be of thickness not less than 10 mm. This shall preferably be a single cap covering both the concrete shell and the lining, with the segments bolted together securely and properly anchored inside the concrete in such a manner as to form a complete annular unit, allowing for unequal circumferential and vertical expansion and contraction of concrete shell and lining and for deflection of shaft due to wind.

All bolts, nuts, washers, rag bolts and other fasteners as required for fixing cast iron cap shall be of bronze material. Gaps between segments are to be filled with asbestos mill-board or fibreglass packing. Casting is to be assembled to match with the dimensions specified in approve drawings, before despatch to site. C.I. caps to be painted with two coats of acid resisting paints over primer coats as recommended by paint manufacturer.

3.05.00 **Insulation and Protective Treatment**

3.05.01 **Acid and Heat Resistant Paint**

The inside surface of concrete shell and corbels and outside surface for height as specified in the drawing shall receive a protective treatment of three coats of acid and heat resistant black paint. The quality and type of the paint shall have the prior approval of the Engineer. For this, a small area shall be painted and a sample of paint shall be shown to the Engineer.

The surface to be painted shall be prepared and primary coat, if required as per the paint manufacturer's specification and direction of the Engineer, shall be applied. The paint shall conform, unless otherwise stated, to the requirement of IS:158. Necessary samples, test certificates and manufacturer's literature shall be submitted to the Engineer for his approval. The surface to be painted shall be completely dry before the paint is applied and the drying time between consecutive coats shall not be less than 5 hours.

3.05.02 **Cement Paint**

The outside face of the Chimney shell, unless specified otherwise, shall be painted with Cement water proof paint. The quality shall be approved by the Engineer. Necessary samples shall be submitted to the Engineer for his approval. The surface of the shell shall be prepared as per paint manufacturer's specification. In addition, care shall be taken that the surface is free from stain, honey comb and any rough and uneven surface. The joints between two shuttering and two lifts of shuttering shall be so prepared that any unevenness, if by chance exists, shall be removed. If one coat of paint is not sufficient to give the required finish, the Contractor, at his own cost, shall repaint the surface, until the Engineer is satisfied with the workmanship. The paint shall conform, unless otherwise stated, to IS:5410. Necessary samples, test certificates and manufacturer's literature shall be submitted to the Engineer for approval.

3.05.03 **Acid Resistant Brick Lining**

The Contractor shall use acid resistant bricks for the job. They shall be fine grained in texture, dense and homogeneous. The brick shall be sound, true to shape, flat and free form flaws and other manufacturing defects affecting their utility. The bricks shall conform to IS:4860-1968 Class-I for acid resistant bricks. The bricks shall be of necessary curvature and of taper so that the lining conforms to the inner radius of the flue lining and hopper surface. No attempt shall be made to use straight bricks and than to try to match with the

inner radius of the lining of chimney by providing extra mortar. No broken bricks shall generally be used. The compressive strength of the bricks shall not be less than 700 Kg/Sq.cm as per IS:4860 Class-I. The Contractor shall provide sample for visual inspection and approval . For testing purposes, the Contractor shall select, at random, bricks from the stack, in presence of the Engineer. The sample bricks thus collected, shall be sent to laboratory for testing of compressive strength, acid resistance and water absorption. The cost of sending to the laboratory, testing and any other incidental expenditure shall be borne by the Contractor and the rate should include such test.

The Contractor shall submit to the Engineer the original test results for his scrutiny and approval.

Bricks shall be thoroughly wetted before using. The mortar to be used shall have similar characteristics, i.e., it shall also be acid resistant. The mortar shall be acid-proof mortar-potassium silicate type (resistant to sulphuric acid) as per IS-4832 Part-I & IS-4441. The mortar shall also be tested at Contractor's cost, in a laboratory approved by the Engineer. The mortar shall be used immediately after mixing. The water cement ratio and the workability shall be strictly maintained. The brickwork shall be flush pointed, after necessary raking of joints and cleaning of surfaces. The lining shall be kept wet for a period of at least 3 days, after which exposed face shall be thoroughly cleaned. The air space and all ventilation holes in the shell and corbels shall be kept clean of any mortar for thorough ventilation. The mortar between bricks shall not be more than 3 mm. thick and the mortar used shall be freshly prepared, used within the setting time. No re-tampering shall be permitted.

3.05.04 **Fire Brick Lining**

The Contractor shall use fire bricks for lining of the Chimney and hopper. The bricks shall be of necessary curvature and of taper so that the lining conforms to the inner radius of the flue lining. No attempt shall be made to use straight bricks and then to try to match with the inner radius of flue lining of chimney by providing extra mortar. Fire bricks shall be well burnt, compact and of homogeneous texture generally white to yellowish white in colour and free from cracks and other flaws; no broken bricks shall be allowed to be used except for closing the course. The crushing strength of the bricks shall be not less than 200 Kg./Sq.cm and shall be of Group-A conforming to IS:6-1983, Specification for Moderate Heat Duty Fireclay Refractories, Group-A. The water absorption of the bricks shall not exceed 13% and the density of bricks shall be approximately 1800 to 2000 kg/Cu.m. Thermal conductivity of firebrick shall not exceed 1 kcal/hr.m.deg.C. Sample of bricks shall be submitted by the contractor for approval of the Engineer. For testing of bricks sample shall be taken according to the scheme given in IS:1528-1962, IS for Sampling and Physical Testing of Refractory Material; and cost for testing and incidental expenditure shall be borne by the Contractor and rates quoted shall include the cost.

The brick shall be laid with air setting fireclay mortar free from potassium/Sodium silicate. The mortar may be "Tataset-FK-40" manufactured by Tata Refractories Ltd. The material shall be kept in a cool place under covered shed before use. The mortar shall be applied strictly as per manufacturer's instructions.

Thickness of mortar joint shall not be more than 3 mm. The bricks are to be laid one course of header followed by two courses of stretchers and so on or as directed by the Engineer. The exposed face shall be true to the line, parallel to the Chimney shell unless shown otherwise. Steel straps made of flats shall be provided on the exterior surface of brick lining both circumferentially and vertically for both acid resistant brick lining and firebrick lining. The steel straps shall be double hot dip galvanised.

3.05.05 **Insulation and Packing**

All packing and insulation material shall be of thickness, diameter and type required for the heat load and as per relevant codes requirement. The packing and insulating material shall be made of asbestos rope, vermiculite concrete, slag or mineral wool and asbestos millboards.

a) **Asbestos Rope**

The diameter of the rope shall be as per approved drawing. The material shall be of best quality available in the market and shall be purchased after a sample is approved by the Engineer. The rope shall be plain, Grade-I, conforming to IS:4687-1968. The strand shall be long, well twisted and no torn thread shall stick out. The rope shall be firmly packed so as to prevent gas leakage.

b) **Slag or mineral wool**

The thickness of packed slag wool shall be as required for the heat load and as per relevant codes requirement. The packed density of the wool shall be within the range of 175 to 200 Kg./cu.m. and the co-efficient of thermal conductivity shall conform to the requirement of IS:3677 at a mean temperature of 150 Deg.C. The material shall be well packed in position where possible. IS:3677 for Rock and Slag wool mats for thermal insulation may be referred for guidance. The co-efficient of thermal conductivity and packed density shall be tested according to IS:3677 and IS:3346.

c) **Vermiculite Concrete**

Vermiculite concrete shall be made by mixing exfoliated vermiculite, portland cement and water. It shall be of Grade-B, having a density of 210 Kg./Cu.M. The vermiculite aggregate size shall be maximum 6 mm. The mix shall be 1 cement and 8 vermiculite by volume.

d) **Asbestos Mill Board**

It shall be of best quality of standard make available in the market and samples shall be submitted to the Engineer for approval. It shall be plain, dense and homogeneous texture, without cracks, flaw and any other manufacturing defect. It shall be laid directly onto the concrete bed after removing any loose material or any aggregate. The concrete shall be prepared without mortar so that the board can have a good seating.

3.06.00 **Lightning Protection System**

3.06.01 **General**

The lightning protection system to be installed on the chimney by the Contractor shall be strictly as per drawings and specifications and shall satisfy the following requirements.

3.06.02 **Air Terminals**

The Chimney shall be provided with pointed air terminals uniformly distributed along the top rim of the chimney. The projected length of the air terminals above the top of the chimney shall not be less than 1000 mm. The air terminals shall be made of lead coated solid copper rods having a minimum diameter of 20 mm. The air terminals shall be secured to the top of chimney by at least two fasteners of substantial construction to withstand high wind pressure acting in the area commensurate with the height involved. All the air terminals shall be electrically connected together by means of a band of 75 x 6 mm galvanized steel flat which shall form a close loop 600 mm. below the top of the chimney. Each segment for the cast iron cap of the chimney shall be connected to this galvanized steel flat band by means of tightly bolted connections.

3.06.03 **Down Conductors**

There will be two separate system of vertical down conductors of 50x6 mm flats spaced as shown in the drawings. One system, envisaged for lightning protection, will have two numbers of down conductors starting from the top encircling band leading to the ground. The other system, envisaged for earthing of platforms/ ladders etc. on the stack, will also have ground conductors originating below the platform and leading to ground. Galvanised steel 50x6 mm flat bands shall be provided below each platform. These bands shall be connected to each ground conductor. No part of the down conductor system for lightning protection shall have electrical contact with hand rails of platform, cage ladder and encircling band ring forming the earthing system.

The connections of the galvanized steel down conductors to the copper air terminals shall be brazed and connection to the nearest grounding grid at the bottom shall be arc welded. Connection between any two galvanized steel flats/bands shall be made by arc welding.

The galvanized steel flat encircling bands shall be supported at an interval of maximum 600 mm. and the vertical down conductors shall be supported at an interval of approx. 2500 mm. The fasteners shall be of same grade of material as the conductors and have to be galvanized. The conductor shall be laid straight and sharp bends shall be avoided as far as practicable. A suitable bolted test piece shall be provided at each down conductor at a convenient height near the bottom of the chimney.

At All supports, the portion embedded inside the chimney shell concrete shall not touch the reinforcement bars and shall be duly insulated from them.

3.06.04 **Bonding**

All exposed metallic parts of the chimney shall be bonded to the ground conductors. Such parts shall include ladders, balconies, conduits, etc. If the metal has considerable length, it shall be bonded at each end. If the metallic components are composed of electrically discontinuous parts, each part shall be bonded to the ground conductors. The bond shall have a minimum cross sectional area equal to that of the ground conductor.

3.06.05 **Joints**

The joints in the lightning/ground conductors shall be kept to a minimum and there shall be no joint in the underground portions of conductors. All joints, except those for the air terminals, shall be done by arc welding process. Overlapping of the conductors at straight joints shall not be less than 150 mm. The bolted joint of the test piece shall be covered with thick coating of bituminous paint after successful testing. The connections between the down conductors/short piece (of 50 x 6 mm. galvanized steel flat) and the copper air terminals shall be brass brazed as shown in the drawing (with the help of brass rods, manufactured by Indian Oxygen Limited (Silos or Ruptum 14) or equivalent.

3.07.00 **Aviation Obstruction Lighting System**

3.07.01 **Lighting System**

The Contractor shall supply and install the aviation obstruction Lighting system on the chimney strictly as per drawings and specification and shall consist of the following items :-

a) 4 sets of single obstruction lights with fixtures at balcony levels.

b) Complete C.I. conduits, PVC insulated wires, G.I. grounding conductor, weatherproof outdoor junction box and all accessories viz. supports, clamps, junction boxes, etc. to make the installation complete in all respects. Conduit wiring shall be from the lighting fixtures to the junction box located at the bottom of the chimney.

3.07.02 **Lighting Fixtures**

The lighting fixtures shall be suitable for 240 V ± 10%, 50 Hz ± 5%, single phase, A.C. supply. All fixtures and accessories shall be weatherproof, outdoor type, capable of withstanding highly humid and flue-laden atmosphere. The obstruction lighting fixtures shall be equivalent to G.E.C. Cat. No. ZH750 and complete with all necessary accessories. The intensity of each light shall not be less than 10 (ten) candles of red light. A set of four nos. single lights shall be installed on each balcony at 90 Deg.C apart with suitable supporting arrangement to withstand high wind pressure.

3.07.03 **Conduit Wiring**

All the obstruction lights shall be uniformly distributed over three single-phase circuits. Conduit wiring for lighting installation shall be done with PVC cables drawn through the G.I. conduit of proper size. The GI conduits shall be terminated to a fuse box mounted on the chimney shell, at an accessible height from the ground. The cables shall be 1100/650V Grade, 1/c, 10Sq.mm, PVC insulated and sheathed Stranded Aluminium conductor. The conduits shall be clamped at interval not greater than 600 mm. by means of approved type of saddles, clamps, etc. securely fixed on the shell/ladder. PVC bush shall be used at either end of the conduit. The minimum size of conduit to be used for the installations shall be 65 mm. Pull boxes, at intervals of not more than 10 meters, inspection bends, etc. are to be provided at suitable locations to facilitate laying of wires. 8 SWG G.I. wire shall be run along the conduit for grounding purpose. All conduit accessories and junction boxes shall be hot-dip galvanized and of approved type. Wiring shall be done as per the relevant IS. Specification.

3.07.04 **Junction Box**

The junction box at the chimney bottom shall be weatherproof and suitable for flue laden atmosphere and provided with suitable terminal blocks and conduit knockouts for incoming and outgoing conduits. 4-core PVC insulated cable with Aluminium Conductor will be used to feed power supply to the bottom most junction box. Purchaser will arrange for laying the cables but the Contractor shall terminate this cable to the bottom most junction box, which shall have suitable double compression type cable gland.

3.07.05 **Painting and Lead Coating**

All welded joints with galvanized steel shall be provided with cold galvanizing paint. Other accessories necessary for lightning protection as well as brackets, supports and other items of obstruction lighting installations, shall be painted with two coats of Red Oxide priming paint and one coat of Aluminium finishing paint. The Red Oxide paint shall be applied on the down conductors and bands before installation and the Aluminium paint coating shall be applied after the installation is over. The copper air terminals, conductors, fasteners and other accessories up to the top encircling band shall have a continuous lead covering of about 2 mm. thickness, for protection against corrosion due to gases and weather.

3.07.06 **Temporary Obstruction Lights**

The Contractor shall provide at least two (2) lights located at diametrically opposite points at the top of the chimney during the period of construction till the permanent obstruction lights are installed and energised, to serve as temporary obstruction lighting.

3.08.00 **Sampling Port**

Sampling ports of minimum 0.1 m dia shall be provided in the Chimney as shown in the drawing to maintain records of emission. Minimum length of port shall be 0.5 m measured from inside face of the lining to the outside end of the port. The port shall be provided with industrial flange capped when not in use. Location of port shall be at least two times the top diameter below the stack exit and at least eight times the stack diameter above the last obstruction. One meter below sampling port a working platform has to be provided at least 1 m wide with safeguard rail and access ladder. Ladder well shall be located at least 1 m away from ports. There shall be no obstructions within 1 m horizontal radius on platform beneath ports. A power source of 220 V, 15A single phase 50 Hz AC shall be located on the platform. There shall be two ports 90 Deg. apart when stack dia is less than 3 m plus port length and 4 ports when stack dia is more than 3 m plus port length.

3.09.00 MS insert plates for mounting of instruments for the measurement of amplitude of vibration and wind speed :

For mounting of accelerometer and wind speed censors 600 x 600 x 20 thick, MS inserts with 25 nos. threaded (1/2" whit worth) holes shall be fixed on the outer circumference of the chimney shell with MS lugs as shown on the drawing. During casting, the holes shall be temporarily plugged to prevent concrete from filling in the holes. Two nos. of such inserts shall be fixed at the top of the chimney for mounting accelerometers and a set of four nos. of such inserts shall be fixed at one-third and two-third heights of the chimney for mounting wind speed censors. A working platform of 1 meter width with safeguard rail shall be provided 1 metre below each level of these inserts as shown on the drawing.

For laying of cables, the same cable tray used for illumination/ aviation light shall be utilised.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 General

The Contractor shall carry out all sampling and testing in accordance with the relevant IS Specifications and as supplemented herein, for the following items or any other item as may be required by the Engineer, at his own cost, unless otherwise specified in this specification. The Contractor shall get the specimens tested in laboratory, approved by the Engineer and shall submit to him, the original test results in triplicate, within seven days after the completion of the test.

4.02.00 Cement

Representative samples shall be taken as per the relevant IS Specification from each consignment of Cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time, compressive strength and soundness tests, and the Contractor shall carry out the above tests as per relevant Indian Standard.

4.03.00 Aggregate

The Contractor shall carry out any or all the tests on aggregates as may be required by the Engineer, in accordance with IS:2386 Parts-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant IS specifications.

4.04.00 Water

Sampling and testing of water being used for concrete works shall be carried out as per IS:3550, by the Contractor, at regular intervals and whenever directed by the Engineer. The final acceptance criterion in case of doubt shall be as per IS:3025.

4.05.00 Concrete

The Contractor shall take cubes for works test as per requirement laid down in IS:516 regularly from the day's pour. The number of test cubes to be taken shall be as per IS:456. The Engineer may also use his discretion in deciding the rate of cubes to be taken. The acceptance criteria is to meet the requirement of IS:456. If the cube test results indicate that some portions of the work is below the required strength, the Engineer may order demolition of that portion of work which is below strength and ask the Contractor to rebuild, provided a satisfactory method of load testing is not possible. Such testing or

demolishing and rebuilding shall be carried out by the Contractor at his own cost.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 With Tender

The following technical information are required with the tender:-

a) Source and arrangement of processing of aggregates proposed to be adopted.

b) Type of plant and equipment proposed to be used.

c) Names of firms with which association is sought for to execute the special items of work in the contract.

d) Types of formwork proposed to be used. All details as per clause no. 3.03.00 to be submitted, if slip form method is proposed to be used.

e) Proposal for lifting of men and material in constructing the chimney.

5.02.00 After Award

The following information and data including samples where necessary, shall be submitted by the Contractor, progressively during the execution of the Contract.

5.02.01 Programme of execution and requirement of materials

Within 30 days of the award of the Contract, the Contractor will submit a Master Programme for completion of the work giving month-wise requirement of materials, and for the procurement of which the help of the Owner is required as per the terms & conditions of the Contract. In case the Contractor proposes to take on hire any machinery or tools and plants from the Owner, the detailed phased out programme of such hire is also to be submitted.

The master programme may have to be reviewed and updated by the Contractor quarterly or at more frequent intervals as may be directed by the Engineer depending on the exigencies of the work.

Detailed day to day programme of every month is to be submitted by the Contractor before the commencement of the month.

5.02.02 Samples

Samples of all materials proposed to be used shall be submitted as directed by the Engineer, in sufficient quantities, free of cost, for approval. All samples shall be submitted well in advance of starting work at site. Approved samples will be preserved by the Engineer for future reference. The approval of the Engineer shall not, in any way, relieve the Contractor of his responsibility of supplying material of specified quality.

5.02.03 **Design Mix**

Design mix as per details of this specification giving proportions of ingredients, sources of aggregates and cement along with accompanying test results of trial mixes as per relevant IS Specifications shall be submitted to the Engineer, for his approval, before it can be used on the work.

5.02.04 **Detail Drawings**

Following items shall be provided by the Contractor which are to be approved by the Owner.

a) Detail drawings and designs of form work including scaffolding to be used. If slipform method of construction is adopted, then detail drawings showing all the arrangements for slipform technique including methods for reducing internal diameter and providing required slopes on outer diameter.

b) Detail drawings and bar bending schedules for concrete components.

c) Shop drawings for steel and metal work, including inserts etc.

d) Detail drawings for templates and temporary supports for embedments.

5.02.05 **Reports**

Following Test Reports shall be furnished by the Contractor :-

a) Mill Test Report for cement and reinforcing steel.

b) Inspection Report of formwork and reinforcement.

c) Reports of tests of various material and concrete.

d) Any other data or report or test result required by the relevant IS Specifications and if required by the Engineer for satisfactory quality control of the workmanship.

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SECTION-XIII

TECHNICAL SPECIFICATION FOR PROPERTIES, STORAGE AND HANDLING OF COMMON BUILDING MATERIALS

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SECTION-XIII

TECHNICAL SPECIFICATION FOR PROPERTIES, STORAGE AND HANDLING OF COMMON BUILDING MATERIALS

1.00.00 **SCOPE**

The scope of this Section is to specify the properties, storage and handling of common building materials unless otherwise mentioned in drawings or schedule of items.

2.00.00 **MATERIALS**

a) **Bricks**

i) Common Burnt Clay Bricks : Bricks for general masonry work shall conform to IS: 1077-1970 and for face brick work shall conform to the specifications in IS: 2691-1972.

Bricks for general masonry work shall be of first class (Class-A) quality, well burnt, of uniform size, shape and colour free from cracks, flaws warpage or nodules or free lime, having a frog 100mm in length 40 mm in width and 10mm to 20mm deep on one of its flat sides and omit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, lumps boles etc.

Compressive strength shall be as per table-1 below. The bricks, when tested, shall have a minimum average compressive strength for various classes as given in Table-1 below. The compressive strength of any individual brick tested shall not fall below the min. average compressive strength specified for the corresponding class of brick by more than 20%. In case compressive strength of any brick tested exceeds the upper limit for the corresponding class of bricks, the same shall be limited to upper limit of the class as specified in Table-1 for the purpose of calculating the average compressive strength.

The average value of water absorption of bricks when tested shall not be more than 20% by weight.

All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chippage for face bricks shall be 6 mm at the edges and 10 mm for corners. The rating of efflorescence shall not be more than 'moderate'.

Each brick shall have the manufacturer's identification marks clearly marked on the frog. Representative samples shall be submitted and approved sample shall be retained by the Engineer for future comparison and reference. The colour and texture of face bricks shall be up to the specification and defective bricks shall be removed immediately from site at the Contractor's own cost.

TABLE-1

Class Designation	Average compressive strength			
	Not less than		Less than	
	N/mm^2	(kg/cm^2)	N/mm^2	(kg/cm^2)
12.5(125)	12.5	(125)	15.0	150
10 (100)	10	(100)	12.5	125
7.5 (75)	7.5	(75)	10	100
5 (50)	5	(50)	7.5	75
3.5 (35)	3.5	(35)	5.0	50

ii) Fly Ash Lime Bricks (FLAG Bricks): The Fly Ash Lime Bricks (flag Bricks) shall conform to IS 12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side. Fly ash shall confirm to IS 3812.

Note : This item will be operated only for load bearing structure up to 2 storied and for non-load bearing walls 23cms thick for multi-storeyed buildings.

Bottom ash used as replacement of sand shall not have more than 12 % loss on ignition when tested.

Sand : Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

Lime : Lime shall confirm to class 'C' hydrated lime of IS 712

Additives : Any suitable additive considered not detrimental to the durability of bricks may be used.

iii) **Clay Fly Ash Bricks :** The clay fly ash bricks shall conform to IS 13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter, the bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly ash shall conform to grade I or Grade II of IS 3812.

iv) **Mechanised Autoclave Fly Ash Lime Brick:** These bricks shall be machine moulded and prepared in plat by appropriate proportion of fly ash and lime. The autoclave fly ash bricks shall conform to IS 12894. Visually, the bricks shall be sound, compact and uniform shape, free from visible cracks, warpage and organic matters. The brick shall be solid with or without frog, and of 100/80 mm in length, 40 mm width and 10 to 20 mm deep one of its flat side as per IS 12894. The brick shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour. Fly ash shall conform to IS 3812 and lime shall conform to class 'C' hydrated lime of IS 712.

b) **Stone**

All stones shall be from approved quarries, hard, tough, durable compact grained, uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky or earthy appearance. Stone showing mottled colours shall not be used for face work. A stone shall not absorb more than 5 per cent of its weight of water after 24 hours immersion and for laterite this percentage is 12%. The type of stone shall be as specified on drawings and/or instructed by the Engineer. Samples shall be submitted by the Contractor and approved samples shall be retained by the Engineer for comparison of bulk supply. The compressive strength of common types of stones shall be as per Table below.

TABLE-2

Type of stone	Maximum Water Absorption Percentage by weight	Minimum Compressive Strength kg/sq.cm
Granite	0.5	1000
Basalt	0.5	400
Lime stone(Slab & Tiles)	0.15	200
Sand stone (Slab & Tiles)	2.5	300
Marble	0.40	500
Quartzite	0.40	800
Laterite(Block)	12	35

c) **Lime**

Lime shall be stone lime and conform to the specification Building Limes - IS: 712. Lime putty may be prepared from hydrant lime or quick lime. Hydrated lime shall be mixed with water to form putty and stored with reasonable care to prevent evaporation for at least 24 hours before use. Quick lime shall be shaked with enough water to make a cream, passed through a No. 0 Sieve and then stored with reasonable care to prevent evaporation for at least 7 days before use.

d) **Cement**

Cement used shall be ordinarily Portland cement conforming to Code for ordinary cement in IS: 269 and shall be fresh when delivered. The Contractor shall submit the manufacturer's certificate for each consignment of cement procured to the Engineer. If the cement is procured by the Owner and issued to the Contractor, the Contractor shall satisfy himself at the time of taking delivery that the quality, quantity and freshness of cement are up to the specified standards. No complain later on regarding the cement supplied by the Owner shall be entertained and all rectification work on this account shall be done by the Contractor at his own expense. If at any time, the Engineer feels that the cement being used by the Contractor is not up to specification, he may stop the work and send the samples of the cement to a testing laboratory for standard tests and all expenses incurred thus shall be borne by the Contractor. The Contractor shall also have no claim for this type of suspension of work.

e) **Coarse Aggregates**

Coarse aggregates shall be as per IS:383 latest edition, consisting of hard, strong and durable pieces of crushed stone and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles etc. and any other material liable to affect the strength, durability or appearance of concrete.

Aggregates other than crushed stone conforming to the provisions of specification may be used if permitted by the Engineer.

Washing of aggregates by approved means shall be carried out, if desired by the Engineer.

Grading of coarse aggregates shall generally conform to IS:383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

f) **Sand**

Sand shall be hard, durables, clean and free from adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrities, alkalis, salts, coal, mica or other laminated materials in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of mortar, plaster or concrete or to cause corrosions to any metal in contact with such mortar, plaster or concrete. All sand shall be properly graded. Unless otherwise directed by the Engineer all sand shall pass through IS Sieve No. 240 and 15 to 35% of and for masonry mortar and 5 to 50% of sand for plaster shall pass through IS Sieve No. 30. Sand for concrete shall conform to IS: 383.

g) **Water**

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discolouration, efflorescence etc.

h) **Reinforcement**

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Structural steel shall conform to IS: 226. Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement shall conform to IS: 432 Cold twisted steel bars shall conform to IS: 1786. Hexagonal wire netting shall conform to IS: 3150. All steel bars including and above 10 mm diameter shall be of tested quality. All wire netting shall be galvanised.

3.00.00 STORAGE AND HANDLING OF MATERIALS

a) Bricks

Bricks shall not be dumped at site. They shall be stacked in regular tiers, even as they are unloaded, to minimise breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately.

b) Stones

Stones shall be stored at site in manner approved by the Engineer. Dressed stone for wall facing, paving etc. shall be stored with special care to avoid defacement of faces and edges or damp and rust stains.

c) Lime

Lime shall be stored in weatherproof sheds.

d) Cement

The cement shall be stored above the ground level in perfectly dry and watertight sheds. The bags shall be stacked in a manner so as to facilitate removal or first in first out basis. Any material considered defective by the Engineer shall not be used by the Contractor and shall be removed from the site immediately.

e) Coarse and Fine Aggregates

Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substances at any stage. Aggregate of different size shall be kept in separate stacks. If so desired by the Engineer aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

f) Reinforcement

Reinforcement bars shall be stored off the ground and under cover if so desired by the Engineer. If necessary, a coat of cement wash shall be given to the bars to guard against rusting.

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TECHNICAL SPECIFICATION FOR ANTI-TERMITE TREATMENT

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SECTION-XIV

TECHNICAL SPECIFICATION FOR ANTI-TERMITE TREATMENT

1.00.00 SCOPE

The scope of work is to prevent the subterranean termites from reaching the super-structure of the building and its contents can be achieved by creating a chemical barrier between the ground, from where the termites come and other contents of the building which may form food for the termites while the building is under construction. This is achieved by treating the soil beneath the building and around the foundation with a suitable insecticide.

2.00.00 EXECUTION

2.01.00 General

All work shall in general be executed as specified in IS: 6313 Part II-1981 and as per approved specification of the agency having special know-how for the job.

All necessary work to ensure uniform distribution and proper penetration of treatment of treating solution shall be done according to the instruction of the Engineer.

Soil treatment shall not be done when it is raining or when the soil is wet with rain or subsoil water. Once formed, the treated soil barrier shall not be disturbed.

Anti-termite treatment chemical is available in concentrated form in the market and concentration is indicated on the sealed containers. To achieve the specified percentage of concentration, chemical should be diluted with water in required quantity before it is used. Graduated containers shall be used for dilution of chemical with water in the required proportion to achieve the desired percentage of concentration. 19 parts of water shall be added to one part of chemical for achieving 1% concentration.

2.02.00 **Safety Precautions**

Chemical used for anti-termite treatment are insecticides with a persistent action and are highly poisonous. This chemical can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed.

The containers having emulsifiable concentrates shall be clearly labeled and kept securely closed in stores so that children or pet cannot get at them. Storage and mixing of concentrates shall not be done near any fire source or flame. Persons using these chemical shall be warned that absorption though skin is the most likely source of accidental poisoning. Particular care shall be taken to prevent skin contract with concentrates and prolonged exposure to dilute emulsion shall also be avoided. After handling the concentrates or dilute emulsion, workers shall wash themselves with soap and water and wear clean clothing, especially before eating. In the event of severe contamination, clothing shall be removed at once and skin washed with soap and water. If chemical has splashed into the eyes, they shall be flushed with plenty of soap and water and immediate medical attention shall be sought.

Care should be taken in the application of chemicals to see they are not allowed to contaminate wells or springs which serve as source of drinking water.

2.03.00 **Chemicals and Rate of Application**

Any of the following chemicals (conforming to relevant Indian Standards) in water emulsion shall be applied by pressure pumps, uniformly over the area treated.

Chemicals		**Concentration by Weight, Percentage**
Chlorpyrifos Emulsifiable (20EC) (IS 8944 - 1978)	:	1.0
Heptachlor Emulsifiable (20EC) Concentrate (IS: 6439 - 1978)	:	0.5
Chlordane Emulsifiable (20EC) Concentrate (IS: 2682 - 1984)	:	1.0
Lindane (20 EC) (IS: 632)	:	1.0

2.03.01 **Treatment**

To facilitate proper penetrations of chemical in to the surface to be treated, hand operated pressure pump shall be used. To have proper check for uniform penetration of chemical, graduated containers shall be used. Proper check should be kept so that the specified quantity of chemical is used for the required area during the operation. Chemical treatment for the eradication and control of sub-terranean termites shall be done as per IS 6313 (Part III).

2.03.02 **Treatment of Column Pits, Wall Trenches and Basement Excavations**

Foundations, basements etc. may either be fully enveloped by the chemical barrier or the treatment may start 500 mm below ground level. The bottom surface and sides of excavation (up to a height of about 300 mm) for column pits, walls trenches and basements shall be treated with chemicals at the rate of 5 litres / M^2 of surface area. Backfills around columns, walls etc. shall be treated at the rate of 7.5 litres / M^2 of the vertical surface. Chemical treatment shall be done in stages following the compaction of earth in layers. The treatment shall be carried out after the ramming operation is done by rodding the earth at 150 mm centres close to the wall surface and spraying the chemicals in the specified dose.

If there is a concrete or masonry apron around the building, approximately 12mm diameter holes shall be drilled as close as possible to the plinth wall about 300mm apart, deep enough to reach the soil below and the chemical emulsion pumped into these holes to sock the soil below at the rate of 2.25 litres per linear metre.

2.03.03 **Treatment of Top Surface of Plinth Filling**

Holes 50 mm to 75 mm deep at 150 mm centres both ways shall be made with crowbars on the surface of compacted plinth fill. Chemical emulsion at the rate of 5 litres / M^2 of surface shall be applied prior to laying soling or sub-grade. Special care shall be taken to maintain continuity of the chemical barrier at the junction of vertical and horizontal surfaces.

2.03.04 **Treatment of Soil Surrounding Pipes, Wastes and Conduits**

Special care shall be taken at the points where pipes and conduits enter the building and the soil shall be treated for a distance of 150 mm and a depth of 75 mm at the point where they enter the building.

2.03.05 **Treatment of Expansion Joints**

These shall receive special attention and shall be treated in a manner approved by the Engineer.

2.03.06 **Treatment at Junction of the Wall and the Floor**

Special care shall be taken to establish continuity of the vertical chemical barrier on inner wall surfaces from ground level up to the level of the filled earth surface.

A small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor. Rod holes made in the channel up to the ground level 150 mm apart and the chemical emulsion poured along the channel at the rate of 7.5 litres per square meter of the vertical wall or column surface. The soil should be tamped back into place after this operation.

3.00.00 **ACCEPTANCE CRITERIA**

The Contractor shall give a 10-year service guarantee in writing supplemented by a separate and unilateral guarantee from the specialised agency for the job to keep the building free of termites for the specified period at no extra cost to the owner.

4.00.00 **RATES**

The rates shall include the cost of labour and all other inputs including concentrated chemical involved in all the operations described above including making holes, channels etc. Rates shall be of complete work per unit length or area as stated in the Schedule.

5.00.00 **METHOD OF MEASUREMENT**

Complete work of anti-termite treatment shall be measured as per items stated in the BOQ.

This includes treatment, to foundations, walls, trenches, basements, plinth, burried pipes, conduits etc. The extended portions of foundation and like beyond plinth limit shall be the part of complete work and no extra payment shall be made.

6.00.00 **I.S. CODE**

Relevant code applicable for this Specification.

IS: 6313 (Part-II) 1981	:	Code of Practice of Anti-Termite Measures in Buildings (pre-constructional)
IS : 632	:	Gamma-BHC (Lindane) emulsifiable Concentrates
IS : 8944 – 1978	:	Chlorpyrifos emulsifiable concentrates
IS : 8963	:	Chlorpyrifos- Technical specifications
IS : 6439 – 1978	:	Heptachlor Emulsifiable
IS : 2682 – 1984	:	Chlordane Emulsifiable
		Pre-constructional chemical treatment measures.

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SECTION-XV

QUALITY ASSURANCE AND INSPECTION FOR CIVIL AND STRUCTURAL WORK

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SECTION-XV

QUALITY ASSURANCE AND INSPECTION FOR CIVIL AND STRUCTURAL WORK

1.00.00 INTRODUCTION

1.01.00 This part of the specification covers the sampling, testing and quality assurance requirement (including construction tolerances and acceptance criteria) for all civil and structural works covered in this specification.

1.02.00 This part of the technical specification shall be read in conjunction with other parts of the technical specifications, general technical requirements & erection conditions of the contract. Wherever IS code or standards have been referred they shall be the latest revisions.

1.03.00 The rate for respective items of work or price shall include the cost for all works, activities, equipment, instrument, personnel, material etc. whatsoever associated to comply with sampling, testing and quality assurance requirement including construction tolerances and acceptance criteria and as specified in subsequent clauses of this part of the technical specifications. The QA and QC activities in all respects as specified in the technical specifications/ drawings / data sheets / quality plans / contract documents shall be carried out at no extra cost to the owner.

1.04.00 The contractor shall prepare detailed construction and erection methodology scheme which shall be compatible to the requirements of the desired progress of work execution, quality measures, prior approvals if any and the same shall be got approved by the Engineer. If required, work methodology may be revised/ reviewed at every stage of execution of work at site, to suit the site conditions by the contractor at no extra cost to the owner.

2.00.00 QUALITY ASSURANCE PROGRAMME

2.01.00 The contractor shall adopt suitable Quality Assurance Programme (QAP) to ensure that the equipments and services under the scope of contract whether manufactured or performed within contractor's works or at his sub-contractor's premises or at the OWNER'S site or at any other place of work are in accordance with the specifications. Such QAP shall be outlined by the contractor and shall be finally accepted by the OWNER or their authorized representative after discussions before the start of work. The QAP shall be generally in line with IS/ISO Systems.

The contractor shall furnish complete QA & QC programme for the work envisaged which may include the following

- Organization structure for the management and implementation of the proposed quality assurance programme
- Quality System Manual
- Design Control System
- Documentation and Data Control System
- Qualification data / details for Contractor's key personnel
- The procedure for purchase of materials, parts, components and selection of subcontractor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased, etc.
- System for shop manufacturing and site erection controls including process, fabrication and assembly
- Control of non-conforming items and system for corrective actions and resolution of deviations
- Inspection and test procedure both for manufacture and field activities.
- Control of calibration and testing of measuring testing equipment.
- System for Quality Audits
- System for identification and appraisal of inspection status
- System for authorizing release of manufactured product to the OWNER
- System for handling, storage and delivery.
- System for maintenance of records
- Quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of work/ equipment/component.

3.00.00 QA AND QC MANPOWER

3.01.00 The contractor shall nominate one overall QA coordinator for the contract detailing the name, designation, contact details and address at the time of post bid discussions. All correspondence related to Quality Assurance shall be addressed by the contractor's QA coordinator to OWNER. OWNER shall address all correspondence related to Quality issues to the contractor's QA coordinator. The contractor's QA coordinator shall be responsible for co-ordination of Quality activities between various divisions of the contractor and their sub-vendors on one hand & with OWNER on the other hand.

3.02.00 The contractor shall appoint a dedicated, experienced and competent QA&QC in-charge at site, preferably directly reporting to the Project Manager, supported as necessary by experienced personnel, to ensure the effective implementation of the approved QAP. An indicative structure of contractor's QA&QC manpower required to be deployed at site is enclosed at Annexure-I. Based on the finalized L-2 network and the approved Field Quality plan, the contractor shall finalize and submit a deployment schedule of QA&QC personnel along with their details to OWNER for approval/ acceptance and further shall ensure their availability well before the start of the concern activity.

3.03.00 The QA&QC in-charge shall have the organizational freedom and authority to implement the requirements of these quality assurance arrangements, free from commercial and programme restraints. The QA&QC setup of the contractor shall consist of qualified and experienced Civil, Electrical, Mechanical Engineers and Laboratory assistants with their supporting staff both at their works and site.

3.04.00 The deployment of man power for QA & QC set up shall be affected on the basis of agreed manpower deployment schedule, which shall be prepared by the contractor based on the L-2 network and the same shall be submitted to the engineer-in-charge for acceptance.

4.00.00 SAMPLING AND TESTING OF CONSTRUCTION MATERIALS

4.01.00 The method of sampling for testing of construction materials and work / job samples shall be as per the relevant IS / standards / codes and in line with the requirements of the technical specifications / quality plans. All samples shall be jointly drawn, signed and sealed wherever required, by the contractor and the engineer or his authorized representative.

4.02.00 The contractor shall carry out testing in accordance with the relevant IS / standards/codes and in line with the requirements of the technical specifications/quality plans. Where no specific testing procedure is mentioned, the tests shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer. All testing shall be done in the presence of the engineer or his authorized representative.

4.03.00 Before execution of any civil work the contractor shall conduct full-scale suitability tests on various construction and building material such as fine and coarse aggregates, cement, reinforcement, construction chemicals, supplementary cementitious materials and construction water to ascertain their suitability for use and the concrete mix designs conducted from reputed institutes such as NCB-Ballabhgarh, CSMRS-Delhi, IIT's, etc. as agreed by the engineer. The test samples for such full scale testing shall be jointly sampled and sealed by the engineer and contractor, thereafter these shall be sent to the concerned laboratory through the covering letter signed by field quality assurance (FQA) representative of the engineer.

4.04.00 The contractor shall timely initiate the action with regard to the evaluation of aggregates and other building material including concrete mix design, so as to ensure completion of these tests before start of civil works at site, thereby not affecting any project work. The test reports and recommendations for suitability of the materials including concrete mix design shall be promptly submitted by the contractor to the engineer.

4.05.00 Evaluation of aggregate for potential alkali-aggregate reactivity shall be carried out as per following scope of work

A. Evaluation of Aggregates for Mechanical / Physical Properties

a) To carry out different tests on coarse aggregate sample i.e. specific gravity, water absorption, sieve analysis, deleterious material; soundness, crushing value, impact value, abrasion value, elongation index and fiakiness index, as per IS: 2386.

b) To carry out different tests on fine aggregate sample i.e. specific gravity, water absorption, sieve analysis, deleterious material, soundness, silt content, clay content and organic impurities as per IS: 2386.

c) To prepare evaluation report based on test results of a) and b) above and to advise regarding suitability of fine and coarse aggregates.

B. Evaluation of Aggregates for Potential Alkali-Aggregate Reactivity:

a) To carry out petrographic analysis and accelerated Mortar bar Test on aggregate samples (1N NaOH at 80 deg. Centigrade for 14 days as per ASTM 1260, or the method established/ developed by CSMRS for 22days test).

b) To prepare a report based on test results of a) above and to advise regarding suitability of aggregates to be used and further testing required if any.

5.00.00 LABORATORY AND FIELD TESTING

5.01.00 The field laboratory for QA and QC activities shall be constructed and set-up by the contractor in line with the indicative field QA&QC laboratory set-up enclosed at Annexure-II. The Laboratory building shall be constructed and installed with the adequate facilities to meet the requirement of envisaged test setup. Temperature and humidity controls shall be available wherever necessary during testing of samples. The quality plan shall identify the testing equipments/ instrument, which the contractor shall deploy and equip the field quality laboratory for meeting the field quality plan requirements. The contractor shall furnish a comprehensive list of testing equipments/ instrument required to meet the planned/scheduled tests for the execution of works for OWNER acceptance/ approval. The contractor shall mobilize the requisite laboratory equipment and QA&QC manpower at least 15 days prior to the planned test activity as per the schedule of tests.

5.02.00 All equipments and instruments in the field shall be calibrated before the commencement of tests and then at regular intervals, as per the manufacturer's recommendation and as directed by the OWNER. The calibration certificates shall specify the fitness of the equipments and instruments within the limit of tolerance for use. Contractor shall arrange for calibration of equipments and instruments by an NABL / NPL accredited agency and the calibration report shall be submitted to OWNER.

5.03.00 The tests which cannot be carried out in the field laboratory shall be done at a laboratory of repute. This includes all IITs, NCB, CSMRS, reputed government / autonomous laboratories / organizations, NITs and other reputed testing laboratories. The test samples for such test shall be jointly selected and sealed by the engineer and thereafter these shall be sent to the concerned laboratory through the covering letter signed by OWNER engineer. The test report along with the recommendations shall be obtained from the laboratories without delay and submitted to OWNER.

5.04.00 Based on the schedule of work agreed with the engineer-in-charge and the approved FQP, the contractor shall prepare a schedule of tests and submit them to the engineer-in-charge and organize to carry out the tests as scheduled /agreed.

6.00.00 PURCHASE AND SERVICE

6.01.00 The major items/ equipments/ components to be manufactured in the shop of the contractor i.e. in-house items and those procured from sub-vendors / sub-manufacturer / sub-contractors i.e. bought out items (BOIs) shall be listed out by the contractor in their bid proposal.

6.02.00 An indicative list of major bought out items (not exhaustive) and services for civil works is enclosed at Annexure- III, for which the contractor shall submit the requisite details / lists of manufacturer's in their bid proposal. The list of manufacturers/ sub-vendors for all the BOIs envisaged in contract shall be included in the bid proposal by the contractor which shall be discussed / reviewed by the OWNER during post bid discussions and the list of proposed manufacturers / sub-vendors for each of the BOIs shall be agreed/ approved. If any item is left out or gets included during detailed engineering, the contractor shall propose the manufacturer's / sub-vendor's details for review / approval of OWNER, prior to initiating the procurement of such materials.

6.03.00 Where the manufacturers are placed in details required ("DR") category, the details of the manufacturers / sub-vendors placed in the "DR" category shall be submitted to the OWNER for approval in the prescribed OWNER format within the period agreed at the time of post bid discussions. The contractor's proposal shall include vendor's site facilities, expertise, facilities established at the respective works, the process capability, process stabilization, QC systems followed, experience list, etc. along with his own technical evaluation for identified sub-Contractors proposed. The formats for furnishing above details shall be given to the Contractor at post bid discussion stage. Monthly progress reports on sub-contractor detail submission / approval shall be furnished. Such manufacturers / sub-vendors approval shall not relieve the contractor from any obligation, duty or responsibility under the contract.

6.04.00 To facilitate advance planning of material testing/ approval of bought out items, well before the start of activity as per L-2 network, representative samples shall be procured by the contractor from approved sub-vendors and submitted to the engineer for his approval before bulk procurement at least two months prior to start of works. In case of manufacturers test certificate (MTC) is submitted for acceptance, it shall be clearly traceable and correlated with the consignment received at site. MTC of all bought out items shall essentially contain all the test parameters / characteristics specified in the Technical specifications / standards / codes. In case the manufacturer’s test certificate does not mention these details, sample from each lot shall be tested for these properties at the third party lab acceptable to OWNER. Approval of material / sample by the engineer shall not relieve the contractor of his responsibility, for their conformance to the specification, as well as the requisite performance and quality of material.

6.05.00 Structural steel supply is in the scope of the EPC contractor and shall be procured from approved vendors of APGENCO only as shown in the ANNEXURE-V. In case of non-availability of some of the sections with the approved vendors, the contractor may propose to procure the sections from the re-rollers of the main steel producers, the name of such re-rollers will have to be cleared by corporate quality assurance of OWNER for which details such as BIS approval, main steel producer's approval, past experience for production of sections of specified material, details of machines plants testing facilities etc., Confirmation that the process control and manufacturing of steel sections by re-rollers shall be same as that of main steel producers,

that billets for re-rolling will be sourced from main steel producers only shall be furnished with regards to re-roller.

6.06.00 Even after clearance of re-rollers, induction of billets with identified and correlated Mill test certificates (TC's) in the process of re-rolling, sampling of steel, quality checks thereof and stamping of final product for further identification and correlation with TC's prior to dispatch shall be the responsibility of the contractor and these shall be performed in presence of the authorized representative of the main Contractor.

6.07.00 Reinforcement steel supply is in the scope of the contractor and shall be procured from approved vendors of APGENCO. In case any size /diameter specified is not available with main steel producers and are proposed to be supplied from the conversion agent of the main steel producer the name of such conversion agent / re-roller shall have to be approved by OWNER for which details such as BIS approval, Main steel producer's approval, Past experience for production of sections of specified material, details of machines, plants testing facilities etc., and confirmation that the process control and manufacturing of steel sections by re-rollers is the same as that of main steel producers, that billets for re-rolling are sourced from main steel producers only shall be furnished with regards to re-roller.

7.00.00 MANUFACTURING QUALITY PLAN AND FIELD QUALITY PLAN

7.01.00 All materials / components and equipment covered under the scope of work, shall be procured by the contractor for the purpose of the contract, after obtaining the written approval of the OWNER, which are to be manufactured at shop/ factory of the vendor/sub vendor shall be covered under a comprehensive quality assurance programme. The contractor's purchase specifications and inquiries shall call for Manufacturing Quality Plans (MQP) to be submitted by the sub-contractor/ sub-supplier/ sub-vendor. The MQP called for from the sub-contractor shall detail out for all the components and equipment, various tests / inspection, to be carried out as per the requirements of this specification and standards mentioned therein, quality practices and procedures followed by contractor's / sub-contractor's / sub-supplier's quality control organization, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing. Such quality plans of the vendors / sub-vendors shall be submitted to the OWNER for approval for MQP and such approved quality plans shall form a part of the purchase order / contract between the contractor and sub-contractor. The quality plans shall be submitted on electronic form e.g. CD or E-mail in addition to hard copy, for review and approval of OWNER. After approval the same shall be submitted in compiled form on CD in addition to hard copy.

7.02.00 The contractor shall furnish copies of the reference documents/ plant standards / acceptance norms/ tests and inspection procedure etc., as referred in quality plans. These quality plans and reference

documents/standards etc. will be subject to OWNER approval without which manufacturer shall not proceed. These approved documents shall form a part of the contract. In these approved quality plans, OWNER shall identify customer hold points (CHP), i.e. test/ checks which shall be carried out in presence of the OWNER engineer or his authorized representative and beyond which the work shall not proceed without consent of OWNER in writing. All deviations to this specification, approved quality plans and applicable standards must be documented and referred to OWNER along with technical justification for approval and dispositioning.

7.03.00 Within three weeks of the release of the purchase orders /contracts for such bought out items /components, a copy of the same without price details but together with the detailed purchase specifications, quality plans and delivery conditions shall be furnished to the OWNER for reference / record by the contractor along with a report of the purchase orders placed so far for the contract.

7.04.00 Well before the start of the work, the contractor shall prepare and submit the Field Quality Plans (FQP) and obtain approval of OWNER, which shall detail out for all the works, equipments, services, quality practices and procedures etc in line with the requirement of the technical specifications to be followed by the contractor at site. This FQP shall cover for all the items / activities covered in the contract / schedule of items required, right from material procurement to completion of the work at site. An Indicative Field Quality Plan for civil works is enclosed at Annexure - IV-A (Indicative FQP for civil works) & Annexure - IV-B (Indicative FQP for structural steel works).

8.00.00 DISPOSITIONING OF NON CONFORMITIES

8.01.00 The non-conformity for the site works on being detected / noted shall be reported by the contractor in the standard format of OWNER under the system of dispositioning of non conformity report (NCR) to the engineer. The dispositioning of the NCR relating to equipment, assemblies, materials condition or process during construction / erection shall describe the proposed correction and also include the preventive / corrective action plan for future.

9.00.00 QUALITY AUDIT

9.01.00 OWNER reserves the right to carry out quality audit and quality surveillance of the quality management and control activities, systems and procedures of the contractor or their sub-contractor. The contractor shall provide all necessary assistance to enable the OWNER carry out such audit and surveillance. The contractor shall also take necessary measures, raise NCRs wherever required based on the audit findings / observations.

10.00.00 **QA DOCUMENTATION PACKAGE**

10.01.00 The contractor shall be required to submit the QA documentation in two hard copies and two CD ROMs, as identified in respective quality plan with tick (√) mark. Typical contents of QA documentation pertaining to field activities as per approved MQP, FQP and other agreed manuals / procedures, prior to commissioning of individual system shall generally contain the Quality Plan, Material mill test reports, Non-destructive examination results / reports, Heat Treatment Certificate/Record, Non-conformance Reports, CHP, Certificate of Conformance (COC)and MDCC.

11.00.00 **GENERAL QA REQUIREMENTS**

11.01.00 The contractor shall ensure that the works, BOIs and services under the scope of contract whether manufactured or performed within contractor's works or at his subcontractor's premises or at the OWNER'S site or at any other place of work are in accordance with the OWNER technical specification, applicable standards / codes, approved drawings / data sheets / quality plans and BOQ. All the works, BOIs and services shall be carried out as per the best prevalent engineering practices and to the directions of the Engineer.

11.01.01 **Storage and Handling of Construction Materials**

All materials shall be stacked and stored by the Contractor as per IS-4082 and as per the requirements specified in OWNER Technical Specification.

11.01.02 **Excavation and Filling Works**

The contractor shall submit a work methodology covering various items of works for alt stages of excavation and filling works. This methodology shall broadly include the quantity wise and classification wise identification of source of excavation and filling, suitability tests as per specification requirements, method of stockpiling, transportation, placement, spreading , compaction, equipment, list of protocols, in-situ tests, third party lab test if required, acceptance checks for final clearance.

For blasting work at site if required, the contractor shall associate themselves with the reputed specialized blasting agency such as CMRI, NIRM for trials blasts, design blasts, blasting pattern, monitoring of blast during the blasting operations at site. The contractor shall install and operate equipment {such as tri-axial seismograph) for continuous monitoring and control of blast induced vibrations, noise level/ air pressure, dust, silica and noxious gases during all blasting operations in line with the technical specification requirements in association with the specialized blasting agency. The contractor shall submit the un-priced copy of the award on the specialized blasting agencies to OWNER, highlighting the scope of services / work awarded to them by contractor. The services of such specialized blasting agency shall be available through out the period in which the blasting work is undertaken at

site. The blasting operation shall remain in charge of a responsible, competent, authorized and experienced supervisor (man-in-charge) and thoroughly acquainted workmen, All blasting work shall be done as per approved blasting scheme/ design/ pattern in line with the technical specification requirements and all statutory laws, rules, regulations, relevant standards pertaining to the acquisition, transport, storage, handling along with use of explosives shall be strictly followed by the contractor.

Tolerance for finished surface level shall be within 20 mm of the level shown in the drawing. For an unimportant area, tolerance up to +75mm shall be acceptable at the discretion of the engineer. However, these tolerances shall be applicable for localized areas only.

Acceptance criteria shall be

a) When only one set of sample is tested, then all individual samples collected an tested should pass without any deviation

b) For retest of any sample two additional samples shall be collected and tested, and both should pass without any deviation.

c) Where a large number of samples are tested for a particular test then 9 samples out of every 10 consecutive samples tested shall meet the specification requirement.

11.01.03 **Masonry and Allied Works**

The execution, finishing, testing and acceptance of masonry related works shall be as per the provisions of technical specifications / relevant practices IS code. Local depressions on account of faulty workmanship, broken / chipped edges shall not be acceptable.

All masonry shall be built true and plumb within the tolerances prescribed as below, Care shall be taken to keep the perpends properly aligned. Unless specified otherwise the tolerances in construction of masonry works shall be as below: :

Sl. No.	Type of Check	Tolerance
	Deviation in verticality in total height of any wall of a building	Shall not exceed ± 12.5mm (more than one storey) + 6mm per 3m height (within a storey)
	Deviation from the position shown on the plan of any brickwork	Shall not exceed 12.5mm (more than one storey)
	Relative displacement between load bearing walls in adjacent storeys intended to be in vertical alignment	Shall not exceed 6mm

Sl. No.	Type of Check	Tolerance
	Deviation of bed joint from horizontal in any length, and it	Shall not exceed 6mm (upto 12m) Shall not exceed 12.5mm total (in any length over 12m)
	Deviation from the specified thickness of bed-joints, cross-joints or perpends	Shall not exceed ± 3mm
	Finished plastered surface	Deviation not more than 4 mm when checked with a straight edge of 2 m length placed against the surface
	The average thickness of plaster	Not be less than the specified thickness
	The minimum thickness over any portion of the surface	Not less than the specified thickness by more than 3 mm for plaster thickness above 12mm and 1 mm for ceiling plaster

11.01.04 **Concrete Works**

For concreting works provisions of technical specifications and IS: 456 shall apply. A detailed methodology for concrete works shall be submitted by the contractor to OWNER for approval. The methodology may require change / modification based on the site conditions, for which suitable revisions shall be submitted.

The methodology for concrete works shall broadly contain the suitability of source of aggregates, cement, admixture, water and reinforcement steel, etc. The available concrete mix design recommended from a specialist institute, results of trial mix carried out at site, method / control of batching, mixing, transportation, layer wise placement, compaction, fixing / removal of form work, staging, fixing of water stops at appropriate locations along with specials, expansion joints, contraction joints and construction joints, cover blocks and method of curing, methodology of repair of newly placed hardened concrete, testing and sampling of concrete during production and placement and acceptance checks for final clearance.

The equipment, deployment of manpower and machinery shall be arranged by the contractor to ensure the continuous rate of placement of specified grade of concrete so as to prevent segregation, bleeding, formation of cold joints, temperature control for concreting in extreme weather conditions and for mass concreting works,

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition for at least seven days from the date of placing concrete in case of ordinary Portland cement, not be less than 10 days for concrete exposed to dry and hot weather conditions, at least 10 days or period may be extended to 14 days where mineral admixtures or blended cements are used. Approved curing compounds may be used in lieu of moist curing with the permission of engineer-in-charge.

Reinforcement steel shall conform to relevant IS codes. Lapping / spacing of reinforcement shall be so staggered that under no circumstances more than 50% of bars at any cross section shall be lapped. Corrosion resistance Steel shall be used for the foundations wherever specified in the technical specification. Sample test for 3% of the number of mechanical bars grips subject to a minimum of three, shall be carried out up to the yield strength of reinforcement of bars.

Test shall be conducted for the water tightness of the liquid retaining structures as per technical specifications, IS 3370 and IS 6494.

All the materials, equipments, processes used in pre cast concrete work shall conform to the requirements for the cast-in-situ concrete.

If fly ash is used in concrete, source of supply shall be checked for suitability as per IS 3812 (Part-I). Routine tests for retention of particles on 45µ sieve and loss on ignition shall be carried out on each lot of fly ash before its use. The storage of fly ash shall be similar to that of cement. Separate Silo for fly ash shall be provided in the batching plant. Validation of Mix design using fly ash shall be carried out by an approved specialist agency, before start of concrete production.

The acceptance criteria of concrete shall be in accordance with clause no,16 of IS 456. However in exceptional circumstances and that too in non-critical areas, the engineer may accept concrete work which is marginally unacceptable as per the criteria laid down in IS 456. For such accepted work, payment shall be made at a reduced rate pro rata to the concrete cube strength obtained, against that stipulated.

All records of concreting, reinforcement, testing of materials, as-built dimensions, the details of the rectification, etc, shall be maintained as given below. Four copies of such record in a bound form shall be submitted to owner for their record and future reference.

a) Testing data/report of aggregates including petrographic examination & potential reactivity of aggregate and repeated temperature cycle tests wherever specified.

b) Mix design details and record of trial mixes carried out at site

c) Testing records of admixture as per IS-9103 / ASTM C494 including third party test reports.

d) Approved scheme for concreting

e) Hourly records of concreting including pour card

f) Protocol indicating the dimensional tolerance and details of inserts

g) Records giving the details of rectification giving the location of grouting, the quantity of grout used at each location, type of grout used

h) Bar bending schedule.

i) Location and details of mechanical anchoring used for reinforcement.

j) Protocol giving the details of checking of reinforcements before concreting and conformance to the reinforcement details as shown in the construction drawings

k) Photographs showing the areas where rectification works have been carried out. Photographs should be taken before and after rectification

l) Temperature control record of concrete at the time of placement if applicable.

m) Details of curing, staging and fixing / removal of formwork, checklist for formwork as per Clause 9.9 and Annexure-C of IS 14687 including all machine foundations.

n) Batching Plant shall be calibrated regularly at least once in a 3 months Computerized output shall be taken for each batch of production of concrete. For concreting works of ash pipe pedestals, mixer with weight batcher may be used. Production and supply of concrete from batching plant shall conform to the provisions of IS 4926.

o) Dimensions (length, cross sectional dimensions, straightness, squareness, and flatness) and tolerances for pre cast members as per OWNER Technical Specification. Load test on Pre cast members (except pre- cast tiles to be laid in the reservoir) shall be carried out @ 2% up to 1000 nos., @1% from more than 1000 nos. precast members of one type. The load test shall be carried out as per the provisions of IS-456

TOLERANCES			
Description of Item/ Structural Element		**Max (mm)**	**Min (mm)**
Cast In Situ Concrete			
1.	Faces of concrete in foundations and structural members against which back fill is placed	+25	-10
2.	Eccentricity of footing as percentage of footing width in the direction of placement	2% but limited to 50mm	
3.	Top surfaces of slabs and of concrete to receive base plates to be grouted	+5	-5
4.	Alignment of beams, lintels, columns, walls, slabs and similar structural elements	+5	-5
5.	Cross sectional dimensions of walls, slabs and similar structural elements	+5	-5

TOLERANCES				
Description of Item/ Structural Element			**Max (mm)**	**Min (mm)**
6.	Deviation from specified dimensions of cross-section of columns and beams		+12	-6
7.	Alignment of holding down bolts without sleeves		+1.5	-1.5
8.	Alignment of holding down bolts with sleeves		+5	-5
9.	Level of holding down bolt assemblies		+10	-10
10.	Embedded Parts (in any direction).		+5	-5
11.	Level of embedment for equipment support		+1.5	0
12.	Level of embedment for other embedded parts		+5	-5
13.	Centers of pockets or holes with greatest lateral dimension not exceeding 150mm		+10	-10
14.	Variation in steps • Riser • Tread		 +1.5 +3.0	 -1.5 -3.0
Pre- Cast Concrete				
15.	Length:	+/-0.1 percent	+/-5	+ 10
16.	Straightness or Bow	1/750 of the length	+/-5	+/-10
17.	Cross-sectional dimensions	+/- 3 mm or +/- 0.1 percent whichever is greater		
18.	Squareness:	When considering the squareness of the corner the length of the two adjacent sides being checked shall be taken as the base line. The shorter side shall not vary in length from the perpendicular by more than 5 mm.		
19.	Flatness :	The maximum deviation from a 1.5m straight edge placed in any position on a nominal plant surface shall not exceed 5 mm.		
Placing of reinforcement and for cover			Clause 12.3.1 and 12.3.2 of IS 456	
Formwork			Clause 9.6 of IS 14687 and 11.1 of IS 456	
Batching			Clause 10.2.2 of IS 456	

11.01.05 **Structural Steel Work**

For structural steel works provisions of technical specifications and IS: 800 shall apply. A detailed methodology for structural steel works shall be submitted by the contractor to OWNER for approval. The methodology may require change / modification based on the site conditions, for which suitable revisions shall be submitted.

The contractor shall submit the welding procedures specification (WPS), heat treatment procedures, NDT procedures etc. at least ninety days before scheduled start of erection work at site. All welding and brazing shall be submitted to the OWNER and carried out as per procedure drawn and qualified in accordance with requirements of ASME Section IX/BS-4870 or other International equivalent standard acceptable to the OWNER.

All brazers, welders and welding operators employed on any part of the contract either in the contractor's / sub-contractor's works or at site or elsewhere shall be qualified as per AWSD1.1/ASME Section-IX or BS-4871 or other equivalent International Standards acceptable to the OWNER.

The records of welding procedure qualification and welder qualification test results shall be furnished to the OWNER for approval. However, where required by the OWNER, the tests shall be conducted in presence of OWNER / authorized representative.

No welding shall be carried out on cast iron components for repair. All the heat treatment results shall be recorded on time temperature charts and verified with recommended regimes.

All Non-destructive examination shall be performed in accordance with written procedures as per International Standards and as mentioned elsewhere in the technical specification. The NDT operator shall be qualified as per SNT-TC-IA (of the American Society of non-destructive examination). NDT shall be recorded in a report, which includes details of methods and equipment used, result/evaluation, job data and identification of personnel employed and details of co-relation of the test report with the job. The records of RT (Films) and UT (inspection records or printed reports if possible) shall be documented and produced to OWNER.

Low hydrogen electrode (AWS E-7018) for welding of High/Medium tensile steel, for M.S (IS 2062 Gr. A/Gr. B, IS 8500) sections thickness above 20mm shall be used. Preheating and Post weld heat treatment requirements shall be complied as specified in the technical specification / approved WPS.

The requirements of pre-heating shall be

Thickness of thickest part at the area of welding/heat affected zone	Welding using other than low hydrogen welding electrodes IS-2062	Welding using tow hydrogen welding electrodes or submerged arc welding IS 2062
Upto 20 mm (including)	None	None
Over 20 mm to 40 mm (including)	Not allowed	$20^{U}C$
Over 40 mm to 63 mm (including)	Not allowed	$66^{U}C$
Over 63 mm	Not allowed	$110^{U}C$

The following tests / checks shall be carried out for structural steel works

Sl. No.	**Tests / Checks**	**Quantum / Standard**
1.	Physical and chemical properties of material if supply in the scope of contractor	As per relevant codes, review of correlated mill test certificates or check testing in absence of MTC
2.	Ultrasonic test on plates above 40mm	As per ASTM A435
3.	Welding procedure & welders qualification test	AWSD1.1/ASME Section-IX or BS-4871 or other equivalent International Standards
Fillet Weld		
4.	Macro-etch examination on production test coupons for main fillet welds	Minimum one joint per built up beams, columns and crane girder etc.
5.	tension member of crane girder	Dye penetration test on 25% weld length
6.	All other fillet welds	DPT on 25% of the total length. Dye penetration test shall be carried out to the root run.

Sl. No.	Tests/Checks	Quantum/Standard
Butt Weld		
7.	DPT	100% after back gouging on ail butt welds except for coal bunker bins 10% after back gouging-For coal bunker bins 100% of the total length. Dye penetration test shall be carried out to the root run after back gouzing.
8.	Mechanical testing of production test coupons	Minimum one joint per built up beam, column and crane girder.
9.	Radiography test on butt welds (In case of failure of any welds in SPOT/RT or UT the % of retesting shall be doubled at that particular location. Acceptance criteria of NDT on welds shall be as per AWS D1.1. Wherever RT is not feasible UT to be carried out with the approval of the engineer)	100% RT on butt welds of tension flange (bottom flange) of crane girders 10% RT weld length of each welder on butt welds, except for crane girders and coal bunker 5% spot RT on butt welds / at inaccessible locations UT on butt welds- For coal bunker bins 100% radiography test shall be carried out for the plates of 32mm thick and above. 25% radiography test shall be carried out for the plates below 32mm thick. 100% radiography test shall be carried out of the crane girders and bunker girders irrespective of thickness of the plate.
10.	Ultrasonic testing on full penetration welds (other than butt welds)	100% UT on the web to flange joint of crane girder 10% UT on other full penetration joints
11.	Control assembly check in shop before erection	1st and further every 10th set of identical structure

Sl. No.	Tests /Checks	Quantum / Standard
12.	Dimensional tolerances during fabrication and erection	as per IS-7215 and IS-12843
13.	Surface Preparation and Paint thickness	SA 2.1/2 , By elcometer random after each coat, each member
CW Liners site fabrication (Field shop) test		
14.	WPS.PQR& welder's Qualification	100%
15.	DPT on root run	100% DPT for pipes upto 1200mm diameter
16.	DPT after back gouging	100% DPT for pipes above 1200mm diameter
17.	UT	Not recommended.
18.	RT	5% RT
19.	DPT on finished butt welds	10% DPT
20.	Hydraulic tests	1.5 times the design pressure or 2 times the working pressure which ever is higher.
CW Liners erection site test		
21.	WPS.PQR& welder's Qualification	100%
22.	DPT on root run	100% DPT for pipes upto 1200mm diameter
23.	DPT after back gouging	100% DPT for pipes above 1200mm diameter
24.	UT	Not recommended.
25.	RT	5% RT
26.	DPT on finished butt welds	10% DPT
27.	Hydraulic tests	1.5 times the design pressure or 2 times the working pressure which ever is higher. In cases where hydraulic test is not possible the same may be substituted with 100%RT
28.	Tolerances	As per approved drawings, as per IS : 7215 for fabrication and IS : 12843 for erection of steel structures

11.01.05.1 **Stoplog and Trash Racks**

Structural design shall be as per IS 5620 and IS 4622 and as per details given in technical specifications. The trash rack to be provided shall be Type-1 trash rack (removable section rack), conforming to IS: 11388 (latest). Filling valves shall be provided in the stop logs to balance the water pressure before lifting the stop log. Leakage test shall be carried out in the stop logs as per the methodology specified in the technical specification. The leakage measured shall not be more than 5 liters/ minute /meter of length of seal under maximum head. 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 contractor as per the technical specification requirements. The contractor shall submit a manufacturing and field quality plans in OWNER format incorporating all the quality aspects mentioned in the technical specifications.

The lifting beam is to be tested for twice the weight of the heaviest component to be lifted by the beam. IS 13591 shall be referred for measurement of the deflection and acceptance criteria.

11.01.05.2 **Coal Tar Anti-Corrosion Tape**

Coal tar anti corrosion tape shall conform to the requirements of technical specifications. The Manufacturers test certificate for each lot of supply of the coal tar anti corrosion tape shall contain the softening point, needle penetration, filler content, breaking load in the longitudinal direction, service temperature, direct impact test, cathodic disbanding and solubility, in case the manufacturer's test certificate does not mention these details, sample from each lot shall be tested for these properties at the third party lab acceptable to OWNER.

Tests for Adhesion**,** holiday test and thickness shall be carried out at site**.**

11.01.06 **Painting Works**

Painting works shall be carried out as per the provisions of technical specifications. A detailed methodology for painting works shall be submitted by the contractor to OWNER for approval. The methodology may require change / modification based on the site conditions, for which suitable revisions shall be submitted.

The methodology for painting works shall broadly contain the source of approved brand of paints, shot / sand blasting as specified, minimum acceptable size of shot used for blasting, application of primer, intermediate coat and final coat, experience of applicator, etc. testing of painting work and acceptance checks for final clearance. For PU coating works if specified, material shall be procured from OWNER approved source and the application of the PU coating shall be carried out by an experienced authorized applicator of the material supplier approved by OWNER. A separate quality plan and methodology for PU coating works shall be submitted by the contractor for

approval of OWNER. Based on the approved quality plan, the tests on material and works shall be got conducted at specialist laboratories like IICT Hyderabad, CECRI Karaikudi.

11.01.07 **Sheeting Works**

All bought out items shall be procured from the manufacturer's approved by engineer and tested as per relevant IS Codes/ Specification. Raw material of colour coated sheets shall meet the chemical & physical properties as per relevant standards / codes referred in the approved data sheet. It shall be tested for colour match, bare metal thickness, weight of Z/AZ coating, thickness of painting system, reverse impact, T-Bend adhesion, scratch resistance, salt spray test for 1000 Hrs. and any other test / properties as specified in the technical specifications. Colour coated sheets shall be marked with video jet printing at the interval not more than 2m bearing manufacturer's name, date and time of manufacturing. Fasteners shall also be tested for 1000 hrs salt spray test as per the requirement of technical specifications.

Bonded Mineral Wool Insulation shall meet the requirements of thickness, density, thermal Conductivity, all other tests as per the technical specifications and IS-8183.

For sheet installation no gas cut opening shall be allowed at the site, whenever opening is specified these shall be properly cut in the factory and shall be filled with lipping / flashing for true shape / dimension etc. The sheets/ packets shall be stacked neatly clear off the ground at an angle to the ground, over a base pallet to provide drainage. Water / moisture should not be allowed to stagnate on surface, or in between layers. This can damage the coating, and cause corrosion.

11.01.08 **Tile Works**

The execution, finishing, testing and acceptance of tile works shall be as per the provisions of technical specifications. The material for tile works shall be procured from the OWNER approved brand / source**.** Local depressions on account of faulty workmanship, tiles / natural stones with cracked or broken / chipped edges shall not be acceptable.

The tests shall be carried out on acid resistant bricks / tile- water absorption, compressive strength, resistance to acid, flexural strength, dimensions and all other tests as per IS 4860 and IS 4457, bitumastic ready mixed paint as per IS 158, bitumastic as per IS 9510, potassium silicate, resin type and sulphur type mortars as per IS 4832, part I, II and III, surface preparation for painting as per IS 2395, epoxy painting shall be carried for required coating thickness and dry film thickness.

11.01.09 **Fire Proof Doors**

Fire Proof doors shall be tested for the requirements mentioned in the Technical Specification. The type test of the doors shall be carried out at CBRI Roorkee for minimum 2 hours fire rating and its Fabrication drawing shall also be approved by CBRI, Roorkee. DFT of paint of Fire Proof Doors and its fittings and fixtures as per BOQ shall be checked. The doors shall be finished with suitable fire retardant painting system

11.01.10 **Water Proofing**

The execution, finishing, testing and acceptance of water proofing works shall be as per the provisions of technical specifications. The material for the works shall be procured from the OWNER approved brand / source and the works shall be executed by the authorized applicator of the supplier.

Water proofing shall be tested for water tightness by creating a pond of water minimum 25 mm height on area of 6 m x 6 m, for the period of 48 hrs on fully dried elastomeric membrane surfaces. Minimum 5% area of the roof shall be subjected to water tightness test. Such test necessarily be conducted on vulnerable areas like drain channel / drain head. No dampness shall be visible on the underneath side of roof (i.e. ceiling), parapet and wall junctions etc. which have been subjected for testing. The above testing shall be earned out prior to application of wearing course.

11.01.11 **Piling Work**

For piling works provisions of technical specifications, approved drawings, BOQs and relevant IS codes / standards shall apply. The piling works shall be executed by the agency meeting the qualifying requirements as specified. A detailed methodology for piling works shall be submitted by the contractor to OWNER for approval. The methodology may require change / modification based on the site conditions, for which suitable revisions shall be submitted.

The methodology for piling works shall broadly contain the method of boring, stability of bore hole, termination criteria, tests / checks for termination level, fabrication of cage, cage lowering, concrete batching / mixing, transportation, placing, recording of the time of construction operations, method of conducting initial and routine load tests, testing and sampling of concrete during production and placement and acceptance checks on piles for final clearance.

The equipment, deployment of manpower and machinery shall be arrangement by the contractor to prevent the collapse of bore hole and to ensure continuous rate of placement of specified grade of concrete.

The piling works shall be executed as per the technical specifications, approved drawings, relevant codes / standards, FQP and BOQ. In addition to the requirements of technical specifications, the following shall also be ensured while execution of piling works :

a) Time gap between completion of pile boring and start of concreting should be kept to the minimum. However the maximum time gap shall not be more than 6 hours.

b) Muck Debris should be removed from the pile bore by air lift technique(by keeping the tremie & air pipe as close as to bottom of pile bore) i.e. after completion of boring, after completion of SPT(wherever applicable), after lowering reinforcement cage, but before start of concreting.

c) Density of bentonite slurry shall be checked from the sample taken from the bottom of pile bore (not at 1.0 m above the bottom of the pile bore)

d) Minimum two welding sets shall be kept ready to join the two cages of reinforcement by engaging 3 or more welders. This will ensure the lowering of R/F cage in minimum time.

e) While lowering the R/F cage into the pile bore, two hooks shall always be used to ensure balanced/symmetrical insertion of cage into the pile bore.

f) Concrete cover blocks at the junction of two R/F cage shall be ensured before lowering the second segment.

g) Surge concreting of about 1.0 cum shall be ensured at the start of concreting (i.e. in the first pour), by suddenly allowing to fall through the tremie pipe from the funnel. This will help in displacing left out muck/debris in the pile bore (by the impact).

h) Continuous feeding of concrete shall be ensured by deploying at least two transit concrete mixers (if required to be deployed) and mixing done through concrete batching plant (if deployed). Cold joints in the pile shall be avoided.

i) In a pile group, SPT shall be carried out at termination level in the pile, taken up first.

j) Bentonite slurry circulation to be ensured from start of boring to start of concreting. Flushing of bentonite slurry will only ensure maintaining of density of bentonite slurry uniformly and will not allow bentonite jelly to settle at the bottom, whereas air lift technique with bentonite circulation will ensure removal of muck debris from the bottom of pile bore.

k) Properties of drilling mud shall be checked prior to commencement of the piling work and thereafter, minimum once per week or as found necessary by the engineer. One sample consisting of 3 specimens shall be tested for the above.

l) Low strain pile integrity test on all job piles and test piles shall be conducted as specified in the Technical Specification. This test shall be suitably used to identify the piles for routine tests. High Strain dynamic test shall be done as per the technical specification. The frequency of the test shall be as per the BOQ

m) For Working Piles: Minimum one sample consisting of 6 test cubes shall be made for first ten piles. Out of these 3 shall be tested for 7 days cube strength and 3 for 28 days cube strength. Minimum one sample of 6 test cubes for every 25 nos. of piles shall be tested, out of these 3 shall be tested for 7 days cube strength and 3 for 28 days cube strength

Pile Load Test

Pile load testing shall conform to the requirements of IS-2911 (Part IV) and the technical specification. Initial load tests as specified in the contract documents shall be conducted to assess the safe load carrying capacity of pile before start of work. To verify the load carrying capacity of the working piles, routine load test shall be conducted.

Pile load-testing procedure and the test setup / scheme shall be submitted for approval of OWNER. The contractor shall use the test setup having arrangement for anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge for both vertical compression and uplift (tension) Load test (initial) on piles. The cost of reaction system / piles shall deem *to* be included in the cost of test piles

All the gauges and instruments shall be calibrated before the start of the tests on test piles and working piles and the calibration record shall be verified before start of execution of the test.

11.01.12 **Water Supply, Drainage & Sanitation**

Material used for sanitary and plumbing fittings and fixtures shall conform to and be tested as per the requirements of relevant IS Codes specified in OWNER technical specification.

The obstructions in sewer lines shall be checked by inserting a smooth ball, of diameter 13 mm less than the pipe bore at the high end of the sewer or drain. If absence of any obstructions, such as yarn or mortar projecting through the joints, ball shall roll down the invert of the pipe and emerge at the lower end. The straightness shall be checked by means of a mirror at one end of the line and lamp at the other. If the pipeline is straight, the full circle of the light may be observed. The mirror will also indicate obstruction in the barrel, if the pipeline is not straight.

The service pipes shall be slowly and carefully charged with water, allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under test / working condition of pressure and flow, when all draw-off taps are closed. The service pipes shall be checked for satisfactory support and protection from damage, corrosion and frost.

11.01.13 Architectural & Misc. Works

Material used for sanitary and plumbing fittings and fixtures, floor finishes and allied work shall conform and tested as per the requirements of relevant IS Codes specified in OWNER technical specification.

Fabricated item like metal doors, windows, ventilators, louvers, rolling shutters and grills etc. shall be checked for correctness of locations and smoothness of operation and fixtures. All controls and locking devices shall give fault free performance. Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm. For double leaf doors, the gap at the meeting stiles shall not be more than 2.5 mm.

Materials used in glass and glazing shall be procured from source approved by OWNER and shall conform to the requirements of the Technical Specification and IS Codes.

False ceiling panels shall be best quality material in thickness and properties called for in the specification / schedule of items. Material Test Certificate to be submitted before bulk supply.

All bought items covered in the scope of contract shall be procured from sources approved by OWNER and shall conform to the requirements of the technical specifications and referred standards / codes.

11.01.14 Road Work

Quality Assurance and testing requirements for roadwork shall be as per the MOSRTH-Specification (Section 900), IRC specifications or CPWD specifications as specified in the technical specifications and BOQ of the contract.

The testing and sampling shall include the checks on earth work for embankment and subgrade, sub bases and bases and bituminous constructions. The sampling and testing of concrete pavements shall be as per the respective items of earthwork, subgrade / sub-base, concrete, etc.

11.01.15 Fabric Expansion Compensator

Each layer of fabric Compensator shall be checked for thickness, unit weight, tensile strength & elongation, composite layer of the expansion joint shall be tested for temperature withstandability test.

Thermal Insulation shall be checked for thickness, density, thermal conductivity test and all other tests as per IS:8183.

Tests and checks on all other items shall be carried out as per relevant codes.

11.01.16 QA Requirements for Slip form Shuttering

1. The monitoring of the leveling of the yoke and the platform of the slip form shuttering to be done in each shift to avoid tilt during the casting of the chimney shell.

2. Manning of each shift shall be done by at least two experienced operators and a foreman particularly in night shift.

3. Suitable removal/ reduction of overhung / excess yoke beam length shall be affected with the decrease in the diameter of Chimney shell, as per the approved plan.

4. The laser centering method to be deployed for chimney alignment and Monitoring of chimney centre should be done by laser instruments at least two points. Monitoring/Recording of the same shall be done in each shift of 8 hours

5. Shuttering plates to be used for slip form shall be new and the grade of steel shall conform to the specification requirements.

6. The outage of the alignment of chimney centre shall be prevented by creating a counterbalance for alignment purpose to avoid differential loading, arising out of placement of reinforcement bars at one side or unloading of concrete in a hopper at one side of the platform for slip form shuttering.

11.01.17 QA Requirements for Dyke Work/Impervious Soil Fill/ Other Fill Works

The suitability of the fill materials from each source using laboratory/ field tests shall be determined / ascertained by the contractor prior to start of filling work and shall be approved by Engineer. The fill material free from shingle, salts, organic matters, roots sod or any other foreign substances shall be used for filling.

11.01.17.1 Embankment Filling

The fill materials shall be free from debris, wood, vegetable matter and other deleterious matter. Control tests shall be carried out in laboratory from time to time to determine whether the fill produced by methods employed satisfies the requirements of the specifications. Routine field tests shall also be carried out by the Engineer and the work shall be inspected regularly. Field density test should be particularly and specially made in the following areas:

a) Where the degree of compaction is doubtful.

b) Where embankment operations are concentrated i.e. where 2 or more layers are placed one over the other on the same day.

c) To represent every 2000 cum in case of earth and/or 1000 cum in case of ash placed in the embankment.

d) Atleast one test for every full or part shift of compaction operations and

e) Atleast one test for every 250 m length of dyke in each layer. The Engineer shall determine whether the desired results are being obtained.

QA&QC test for Embankment Filling shall be carried out in line with the Technical Specification, PART-B.

11.01.17.2 **Impervious Soil Filling**

The suitability of the material from each source shall be determined by laboratory tests and shall be approved by Engineer. QA&QC test for Impervious Soil Filling shall be carried out in line with the Technical Specification, PART-B. The spreading of the next layer shall be carried out only after the underlying layer has been approved by the Engineer or his authorized representative.

11.01.17.3 **Sand Blanket, Chimney And Filter**

The material for blanket, chimney and sand filters shall consist of clean sound and well graded coarse sand. The materials shall be free from debris, wood, vegetable matter and other deleterious matter. The gradation of sand material shall meet the requirements as specified. QA&QC test for Sand Blanket, Chimney and Filter shall be carried out in line with the Technical Specification, PART-B.

11.01.17.4 **Graded Coarse Aggregate Filter**

The coarse aggregate material shall consist of durable well graded broken rock of hard stone variety from the specified quarries and shall be approved prior to being transported to the area of deposition. The materials shall range in the size from 10 mm to 75 mm and shall satisfy the specified filter criteria. QA&QC test for Graded Coarse Aggregate Filter shall be carried out in line with the Technical Specification, PART-B.

11.01.17.5 **Rock-Toe, Rip-Rap Works, Rr Masonary**

Rock toe shall be formed with rock material consisting of sound, durable and well-graded broken rock obtained from approved quarries and shall be of approved quality. The materials shall range in size from 10 to 45 cm. QA&QC test for rock-toe, rip-rap works hall be carried out in line with the Technical Specification, PART-B.

11.01.17.6 **Slope Protection Works**

Slope protection works with dry brick packing or ash-cement/ soil-cement mortar ash cement concrete on the slopes, confined within brick masonry panel walls shall be constructed with approved quality of materials. Slope protection works with turfing on downstream slope shall be as per IRC standards. Slope protection works with ash cement concrete on the downstream slopes shall be constructed with approved quality of materials. QA&QC tests for slope protection works shall be carried out in line with the Technical Specification, PART-B.

11.01.17.7 **Bentonite Liner**

Construction Quality Control (CQC) tests as indicated in Table shall be performed by the Contractor's Quality Control Team at regular intervals upon completion of the Soil-Bentonite liner.

QCQ Requirements for Impervious Liner

Parameter	**Test Frequency per layer**
Moisture Content	1 per 5,000 Cum
Field Density	1 per 5,000 Cum
Falling Head Permeability	1 per 25,000 Cum

All CQC test results shall achieve the required values as established by the engineer. Failure to achieve these values shall require re-working of the Impervious mixture in the failed areas.

12.00.00 **SHOP TEST EOT CRANES, OTHER CRANES & HOIST**

1.0 **Hooks**

1.1 All tests including proof load test as per relevant IS/BS/DtN shall be carried out.

1.2 MPI/DPT shall be carried out after proof load test.

2.0 **Steel Casting**

2.1 DPT on machined surface shall be carried out.

3.0 Girders, end carriage.crab, gear box and rope drum

3.1 The plates of thickness 25mm and above shall be ultrasonically tested.

3.2 NDT requirements on weldments shall be as follows:

a)	BUTT WELDS IN TENSION	:	100% RT AND 100% DPT
b)	BUTT WELDS IN COMPRESSION	:	10% RT AND 100% DPT
c)	BUTT WELDS IN ROPE DRUM	:	100% RT AND 100% DPT
d)	FILLET WELDS	:	RANDOM 10% DPT

4.0 Forging (Wheel, Gears, Pinions, Axle, Hooks & Hook Trunion)

4.1 All forgings greater than or equal to 50 mm diameter or thickness shall be subjected to ultrasonic testing.

4.2 DPT/MPI shall be done after hardfacing and machining.

5.0 Wire rope shall be tested as per relevant standard.

6.0 Reduction gears shall be tested for reduction ratio, backlash & contact pattern. gear box shall be subjected to no-load run test to check for oil leakage, temperature rise, noise and vibration.

7.0 The cranes shall be completely assembled at shop for final testing. all tests for dimension, deflection, load, overload, hoisting motion, cross travel etc. as per is-3177 shall be carried out at shop.

8.0 All electric hoists shall be tested as per is-3938 and chain pulley blocks shall be tested as per is-3832.

13.00.00 **CATHODIC PROTECTION**

Quality of cathodic protection system shall be as per given table.

IMPRESSED CURRENT CATHODIC PROTECTION

Transformer Rectifier Unit

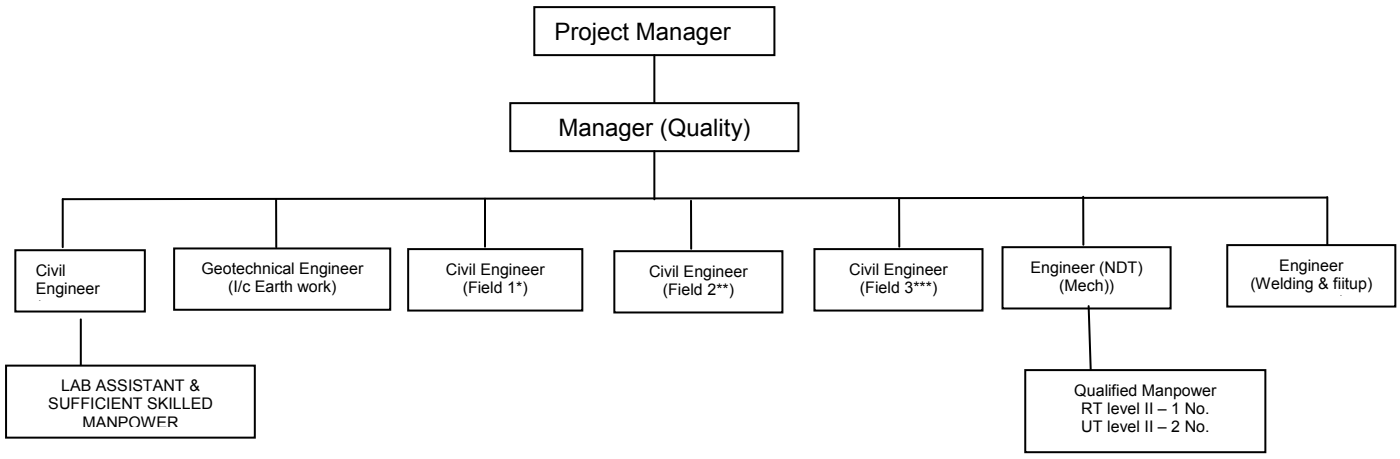
Attributes Characteristics → / Items / Components / Sub-assembly ↓	Make, Model, Type, Rating & Finish	Chemical & Mechanical Tests	Sheet Steel Pretreatment & Painting process checks	Operational & Functional Checks	Conform to relevant Standard	Dimensional check and Paint shade, thickness, adhesion & Finish checks	Complete physical examination for constructional features of TRU as per OWNER specification	Efficiency Test on TRU & Transformer	Heat Run Test	Ratio & Polarity Test on TRU	HV & IR Test
Rectifier Transformer (IS : 2026)	Y				Y			Y			Y
Electronic Components	Y				Y						
PCB & Electronic Cards	Y				Y						
Control & Selector Switches (IS : 6875)	Y			Y	Y						
Indicating Meters (IS : 1248)	Y			Y	Y						
Indicating Lamps (IS : 13947)	Y			Y	Y						
Air Break Switches / Fuses (IS : 13947/13703)	Y			Y	Y						
Control Terminal Blocks (IS : 13947)	Y				Y						
Control Transformer (IS : 12021)	Y			Y	Y						
Push Buttons (IS : 4794)	Y			Y	Y						
MCB (IS : 8828)	Y			Y	Y						
PVC insulated Copper control wires (IS : 694)	Y				Y						
Sheet Steel (IS : 513)	Y	Y	Y		Y						
Synthetic Rubber Gaskets	Y	Y			Y						
Annunciator	Y			Y							
Transformer Rectifier Unit	Y					Y	Y	Y	Y	Y	Y

Notes

1. This is an indicative list of tests / checks. The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

2. Makes of all major Bought Out Items will be subject to OWNER approval.

QA & QC ORGANISATION SETUP



NOTE :

1. The above organization setup is minimum however their deployment shall be as per the agreed deployment schedule. The contractor shall prepare a manpower deployment schedule in line with the finalized work plan and the same shall be submitted to the engineer-in charge for acceptance/ approval.

2. The contractor shall mobilize the QA& QC manpower in line with the finalized manpower deployment schedule and shall ensure their availability well in advance (15 days approx.) of the beginning of the concerned activity/ work.

3. The contractor shall further mobilize required number of skilled & supporting staff and additional resources, if any to meet the work schedule.

4. For concrete work 2 Nos. (one for foundation work & one for superstructure)

5. ** For lines and levels -1 No.

6. *** For Finishes and cladding work -1 No

TYPICAL QA/QC LAB EQUIPMENT

Sl. No.	Equipment	Nos.
1	Vicat Apparatus with deskpot	2
2	Le chatelier flask	2
3	Le chatelier Mould	2
4	Cube Moulds for cement testing	12
5	Vibration Machine	1
6	Length comparator	2
7	Shrinkaqe Bar mould	2
8	Sieve shaker	1
9	Sieves for sand, coarse & fine aqgregate	1 set for each
10	Sieves for coarse aggregate for Road	1 set
11	Proctor testing equipment '	2 sets + 18 cores
12	Slump testing equipment	6 sets
13	Oven	2
14	Physical balance	1
15	Rapid moisture meter	2
16	Thermometer	4
17	Burret	2
18	Measuring cylinders	9
19	Measuring flasks	3
20	Compression testing machine	2 sets of 2000 kN capacity each
21	Cube moulds	30
22	Electronic balance	2 (12 kg capacity), 2 (200 mg capacity)
23	pH balance	As per requirement
24	Radiographic facilities	As per requirement. Party should deploy BARC approved agency for carrying out RT
25	Mechanical weighinq machine	1 (100 kg capacity)
26	Ultrasonic testing machine	As per requirement
27	D.P. Test kit	10
28	Vernier 300 mm. 600 mm	2
29	Micrometer (0.25 mm) out side (25.00)	2
30	Radioqraphy film viewer	2
31	Inside Micrometer 25-750 dia	2
32	Digital elcometer for paint thickness	2
33	Baking oven for electrode	3
34	Portable ovens	2
35	Rebar detector to locate the reinforcement before core cuttinq operation	1
36	Concrete coring machine (55mm, 60mm upto 150 mm dia core bit)	1
37	Rebound hammer	1
38	Ultrasonic pulse velocity tester	May be arranged from specialist laboratory.

1. The equipments listed above are indicative and required to be mobilised as minimum requirement, additional equipment if any .required for successful completion of work shall be provided /arranged by the contractor.

2. All test reports/ inspection reports have to be computerized and maintained on LAN with an access to the owner

3. Computers - 2 Nos. shall be deployed with Windows operating system and connected to the OWNER server

4. Based on the schedule (L2/L3 Network), Quality control & Quality Assurance work plan shall be finalized by the contractor and the same shall be submitted to the engineer-in-charge for acceptance/approval. The Finalized work plan shall be maintained on the computer to be accessed by the owner for database and day to day monitoring.

INDICATIVE LIST OF BOUGHT OUT ITEMS FOR CIVIL WORKS

Sl. No.	Bought Out Item	Proposed Make	Proposed list of Manufacturers
1.	Cement, if procured by Contractor		
2.	Structural and Reinforcement Steel, if procured by Contractor		
3.	Construction Chemicals- admixtures, waterproofing, accelerators, Epoxy Resin, grouts etc.		
4.	Bitumen, Bitumen Impregnated Fiber Board Joint Filler, Joint Sealing Compound, Bituminous Compound, Joint Sealant		
5.	Colour Coated Sheets		
6.	Paint and Painting System, PU Coating		
7.	Floor Tiles / Flooring/ Acid & Alkali resistant tiles		
8.	Glass and Glazing		
9.	False Ceiling - Glass Reinforced Gypsum System, Mineral Fiber Board System, Pre-painted Coil Coated Steel System		
10.	PVC water stops, hydrophilic strips,		
11.	Particle Boards, Plywood, Fire proof doors		
12.	Roof Water Proofing		
13.	Electro-Forged Gratings		
14.	Anodized Aluminum Sections		
15.	Fittings and fixtures for water supply works		
16.	PVC Pipes and accessories		
17.	Polyethylene water storage tank		
18.	Heavy duty anchor fasteners		
19.	Stop log. Trash Rack, Lifting Beam etc.		
20.	PTFE Bearing		
21.	Flexible Open Bellow Strap		
22.	HDPE Liner		
23.	Cathodic protection system		
24.	Anti weed treatment		
25.	HSFG Bolts		
26.	Any other specific high value and critical bought out Item required, meeting the specification requirements		

Note : The Bidders are required to indicate the list of proposed manufacturers/ sub-vendors for each of the BOI in their Bid proposal, which shall be discussed for finaiization at post bid stage.

LOGO	SUPPLIERS NAME AND ADDRESS:	INDICATIVE FIELD QUALITY PLAN									ANNEXURE-IVA
		ITEM : CIVIL WORK SUB-SYSTEM: GEOTECH INVI, FOUNDATIONS, EXCAVATION & FILL, SITE LEVELLING, CONCRETE, ROAD, BUILDING ETC.		QP NO.: REV. NO.; DATE: PAGE:		1 0 Page 18 of 18	PROJECT: PACKAGE: CONTRACT NO. MAIN CONTRACTOR				
Sl. No	Activity and operation	Characteristics / instruments		Class of check	Type of Check	Quantum Of check	Reference Document	Accept ance Norms	Format of Record	D*	Remarks
1	2	3		4	5	6	7	8	9		10
14.4											
i		moisture content (for concrete and mortar only)	as required	B	Physical	Once per week	IS:2386, IS:363 and Technical Specifications		SR/TR		
ii		gradation- grain size analysis	sieve set	A	Physical	Once for each source	IS.-2386 Part I. IS :9429 & IS :383 and Technical Specifications		SR/TR	√	
iii		specific gravity	pycnometer	A	Physical	Once for each source	IS:2386 part-I and Technical		SR/TR	√	min 2.40
14.5 Rock Material for Rip Rap, Rock Toe and Random Rubble Masonry											
i		Specific gravity	as required	A	Physical	Once for each source	IS:1122 and Technical Specifications		SR/TR	√	Min 2.5
ii		sulphate soundness	Chemicals, oven balance etc,	A	Physical	Once for each source	IS:1126and Technical Specifications		SR/TR	√	Maximum 10% weight loss after five cycles
iii		Impact Value	Impact Value testing appratus	A	Physical	Once for each source	IS:2386 and Technical Specifications		SR/TR	√	Max. 30%
iv		Water absorption	Balance, oven	A	Physical	Once for each source	IS:2386 and Technical Specifications		SR/TR	√	Minimum 2.5%
v		slake Durability	as required	A	Physical	Once for each source	IS:10050 and Technical Specifications		SR/TR	√	Minimum 85 % after two cycles of 10 minutes
vi		placement profile thickness	as required	B	Physical	Random in each shift	IS:8237 and Technical Specifications		SR/TR	√	
15.0	GEOTECHNICAL INVESTIGATION WORK										
i		Deployment of approved Geotechnical Investigation Agency - Equipments, Manpower etc	As required/agreed	A	Physical	Once before commencement of work	As per technical specifica!tons and relevant IS Codes		SR	√	
ii		Execution of Geotechnical Investigation locations, type etc as per scheme	As required / agreed	B	Physical	Each Location	As per technical specifications and relevant IS Codes		SR	√	
iii		Collection of disturbed and undisturbed samples, their packing and storage	As required / agreed	B	Physical	each sampling	As per technical specifications and relevant IS Codes		SR		
iv		Conducting filed tests as per investigation scheme- such as, SPT/ERT/SCPT/PLT/PMT etc	As required / agreed	B	Physical	each field test	As per technical specifications and relevant IS Codes		SR		
V		Submission of Field Borelogs in approved format	As required / agreed	B	Review	Within 24 hours after completion of each BH	As per technical specifications and relevant IS Codes		SR	√	
vi		Submission of laboratory test schedule and selection of samples for laboratory testing	As required / agreed	A	Review and acceptance	as per consultation with Engineer during dispatch of samples to approved laboratory	As per technical specifications and relevant IS Codes		SR	√	
VI!		Submission of Final Geotechnical investigation report along with recommendations	As required / agreed	B	Physical	After completion of investigation work and review of draft reports	As per technical specificalions and relevant IS Codes			√	
		Legend to be used: Class #: A - Critical, B-Major, C=Minor, SR, TR, MTC, LB									

LOGO	SUPPLIERS NAME AND ADDRESS:	INDICATIVE FIELD QUALITY PLAN						ANNEXURE IVB			
		ITEM : STRUCTURAL STEEL WORK		QP NO.:			PROJECT:				
				REV. NO.:		0	PACKAGE:				
		SUB-SYSTEM: FABRICATION & ERECTION		DATE:			CONTRACT NO.				
				PAGE:		7 of 7	MAIN CONTRACTOR				
Sl. No	Activity and operation	Characteristics / instruments		Class* of check	Type of Chech	Quantum Of check	Reference Document	Acceptance Norms	Format of Record		Remarks
1	2	3		4	5	6	7	8	9	D*	10
ii		Tolerance OD / ovality	steel tape	B	Measurement	100%	As per approved drawing		SR		
13.8	HYDRO TESTING										
		Leakage tightness	Hydro test Arrangement	A	Leakage tests	100%	Tech Specificatiort		SR	√	For shop welded joints before encasement in concrete/ painting and erection joints
14.00	STOP LOG GATE, TRASH RACK AND LIFTING BEAM										
14.1	MATERIAL										
		Check Quantity (in case of receipt) and completeness and damage, surface defects		C	Visual	100%	Challan / Release No damage, surface defect note		SR	√	
14.2	ERECTION										
		Alignment levelling	Plumb, Piano wire,water level	C	Measurement	100%	Specfication/ Approved drawing		Inspection Report		Welding, if any, involved at site will be done by welders and procedure qualified as per ASME-IX in presence of OWNER's Engineer
14.3	PAINTING / SURFACE PREPARATION										
i		Shade		B	Visual	100%	Specfication/ Approved drawing		Inspection Report		The type of painting/ surface treatment of parts shall be as per Technical
ii		DFT	Elcometer	A	Measurement	Random	Specfication/ Approved drawing		-do-	√	
14.4	TESTING										
i.	Free movement of stop log / trash rack in guides under dry and under lull water condition	Lowering or raising for full length for 2/3 times		A	Physical	100%	Smooth operation, Tech. Specification, iS:4622		-do-		
ii	Leakage for stop Log	Measurement of leakage	As read,	A	Physical	100%	Leakage rate within limit		-do-	√	Maximum leakage rate 5 litre/minute/metre length of seal under max-head as per IS:4622
iii	Load test for lifting beam	Load Test	As reqd.	A	Physical	100%	No deflection /No Deformation		-do-	√	
		LEGEND: D * Records, identified with Tick" (√) shall be essentially included bv supplier in QA									
		Legend to be used: Class #: A= Critical, B=Major, C=Minor, SR, TR, MTC, LB									
Manufacturer/ Sub supplier	Main-supplier	Categorization Witnessing & Accepting (As per owner QA&I System) Category 'A' FQA Engineer In association with Executing Engineer, Category 'B' Executing Engineer, Category 'C' Executing Engineer ;SR - Site Register, TR= Test Report,MfrTC = Manufacturer's Test Certificate									
Signature		This document shall be read in conjunction with owner Tech. Specifications, BOQ, Drawings									

VOLUME : VII-C

SECTION-XVI

TECHNICAL SPECIFICATION FOR MASONRY AND ALLIED WORK

CONTENT

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2.00.00	INSTALLATION	VII-C/S-XVI : 1
3.00.00	RATES	VII-C/S-XVI : 7
4.00.00	METHOD OF MEASUREMENT	VII-C/S-XVI : 7
5.00.00	I. S. CODES	VII-C/S-XVI : 9

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SECTION-XVI

TECHNICAL SPECIFICATION FOR MASONRY AND ALLIED WORK

1.00.00 SCOPE

This specification covers furnishing, providing, installation, repairing, finishing, curing, protection, maintenance and handing over of masonry and allied works for use in structures and locations covered under the scope of the Contract.

2.00.00 INSTALLATION

2.01.00 Soling

2.01.01 Brick Soling

The ground shall be dressed, consolidated by ramming or by light rolling and a 12 mm thick cushion of sand laid. On the sand cushion the bricks shall be laid with fine joints and placed firmly in position by hammering with wooden mallet. The surface shall be free from undulations. The 'frog' side shall be on the underside. The joints shall be broken the in all direction and bricks cut as required. The pattern of laying and number of layers shall be as per Schedule of Item. Orientation shall be as desired by the Engineer. After lying of each layer of bricks sand shall be spread over and worked into the joints to pack the bricks tight.

2.01.02 Stone Soling

The stones for soling shall be selected on the basis of thickness of soling specified in the Schedule of Items. The larger stones shall be laid and the gaps filled by smaller stones. The interstices shall then be firmly packed with sand by flooding with water.

2.02.00 Brick Edging

Excavation shall be done close to the brick dimensions and in perfect alignment. Bricks shall be firmly placed by hammering with wooden mallets and sides and joints packed firmly with earth so that the edging is not disturbed easily. Alignment and level shall be acceptable to the Engineer.

2.03.00 Masonry

2.03.01 General

All masonry work shall be true to lines and levels as shown on drawings. All masonry shall be tightly built against structural members and bonded with dowels, inserts etc. as shown on drawings.

2.03.02 Mortar

Mix for mortar shall be specified in the Schedule of Items.

When lime is used hydrated lime shall be mixed with water to form putty and stored with care to prevent evaporation for at least 24 hours before use. Quick lime shall be slaked with enough water to make a cream, passed through a No. 10 sieve and stored avoiding evaporation for seven days before use.

Lime putty and sand in proper proportion shall be mixed on a watertight platform with necessary addition of water and thoroughly ground in a mortar mill. This mix shall be transferred to a mechanical mix, required quantity of cement added and the content mixed for at least 3 minutes. Mixtures of lime putty and sand may be stored avoiding drying out. For cement sand mortar cement and sand in requisite proportions shall be mixed dry in a mechanical mixer and then water added and mixed further. Minimum quantity of water shall be added to achieve working consistency.

Surplus mortar droppings from masonry, if received on surface free from dirt may be mixed with fresh mortar if permitted by the Engineer who may direct addition of additional cement without any extra payment. No mortar, which has stood for more than half an hour, shall be used.

Lime shall not be used where reinforcement is provided in brick work.

2.03.03 Brick Masonry

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt earth etc.

Bricks shall be laid in English bond unless specified otherwise. Broken bricks shall not be used. Cut bricks shall be used if necessary to complete bond or as closers. For brick work in half brick wall, bricks shall be laid in stretcher bond. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment. Bricks shall be laid with frogs upwards over full mortar beds. Bricks shall be pressed into mortar and tapped into final position so as to embed fully in mortar. Inside faces shall be buttered with mortar before the next bricks is placed and pressed against it. Thus all joints between bricks shall be fully filled with mortar. At the joint of brick masonry with RCC column/beam/wall, the mortar shall be with rich grade to avoid shear cracks.

Mortar joints shall be kept uniformly 10 mm thick. All joints on face shall be raked to minimum 10 mm depth using raking tool while the mortar is still green to provide bond for plaster or pointing. The inside face of the brick work shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow space are left inside the joints. Where plaster or pointing is not provided, the joints shall be struck flush and finished immediately. Brickworks two bricks thick or more shall have both faces in true plane. Brickwork of lesser thickness shall have one selected face in true plane.

2.03.04 **Exposed Brickwork**

Brickwork in superstructures, which is not covered by plaster, shall be as shown on drawing and executed by especially skilled mason. Courses shall be truly horizontal and vertical joints truly vertical. Wooden straight edges with brick course graduations and position of windowsills and lintels shall be used to control uniformity of brick courses. Masons must check workmanship frequently with plumb, spirit level, rule and string. All brickwork shall be cleaned at the end of days work. If face bricks are specified in the Schedule of Item, the brickwork shall be in composite bricks, with face bricks on the exposed face and balance in routine bricks, but maintaining the bond fully. Where face bricks are not specified, bricks for the exposed face shall be specially selected from routine bricks. All exposed brickwork on completion of work shall be rubbed down, washed clean and pointed as specified. Where face bricks are used carborandum stone shall be used for rubbing down.

2.03.05 **Reinforced Brickworks**

Reinforcements shall be as specified in the Schedule of Items. All reinforcements shall be thoroughly cleaned and fully embedded in mortar. Where M.S. bars are used as reinforcement, these shall be lapped with dowels if left in R.C. Columns or welded to steel stanchions.

2.03.06 **Cavity Wall**

It is wall comprising of two leaves, each leaf being built of masonry units and separated by a cavity so as to provide an air space within the wall and tied together with metal ties or bonding units to ensure that two leaves act as one structural unit. The width of the cavity shall not be less than 50mm and not more than 115mm. Each leaf of the cavity wall shall not be less than 75mm. The space between the leaves being either left as cavity or filled with non-load bearing insulating and water proofing material.

2.03.06.01 **Metal Ties**

These may be of galvanized iron, wrought iron, gun metal, brass, copper, stainless steel or ant such corrosion resistant metal, made of flats 20 x 5 mm cranked or twisted at their mid point with ends split and fish tailed. The ties shall be built into horizontal bed joints during erection, placed sloping towards the exterior side to prevent water from flowing along it from outer to inner leaf side.

2.03.06.02 **Bonding Units**

These shall be preferably precast R.C.C. units.

Length of the Bonding units will be sum of thickness of both leaves plus width of cavity if the leaves plus width of cavity if the leaves are 75mm or 115mm. If the leaves are more than 115mm thick, then the length of a unit will be 2x115+width of cavity. Precast RCC units shall be provided with 2 no. , 6mm mild steel reinforcement bars tied with 2 no. 3 mm. dia. wire/hard drawn wire cross bars placed in the centre of units.

Cement concrete used in the bonding units shall not be leaner than 1:3:6 (1cement: 3coarse sand: 6 graded stone aggregate 20mm nominal size)

2.03.06.03 **Spacing**

Metal ties/bonding units shall be spaced not more than 90cm apart horizontally and 45cm vertically and staggered in each course. Additional ties shall be used near openings.

2.03.06.04 **Restrictions**

Cavity walls shall not normally be built more than 7.5 metres in height and 9 metres in length. Where large lengths and heights are desired, the wall shall be divided into panels with strengthening measures such as pillars etc. Cavity shall be covered at the top with at least two courses of masonry unit and/or a coping over it.

Adoption of cavity walls is not recommended when heavy concentrated load from beam etc. are to be supported by walls.

2.03.07 **Stone Masonry**

Stones shall be thoroughly soaked before laying. Stones shall be laid on their natural quarry beds. Individual stones shall be fitted with mallet and properly wedged to reduce thickness of mortar joints. Thickness of joint shall be not less than 8 mm and not greater than 25 mm. Al least two stones shall run the full width of the wall for every square meter of surface area.

2.03.08 **Exposed Stonework**

Stonework, which is to be kept exposed, shall be as shown on drawing or described in the Schedule of Items. Especially especially skilled mason shall execute it. Stones used for exposed face shall be specially selected. All exposed stone faces shall be kept clean and free from mortar and pointed up neatly as the work proceeds in a manner called for in the drawings or the Schedule of Items or instructions. A sample wall, 10sq.m. In area shall be built and approved by the Engineer and all works shall match with this sample.

2.03.08 **Hollow and Solid concrete block Masonry**

Hollow and solid concrete block shall conform to the requirement of I.S 2185. Hollow concrete block shall be sound, free from broken edges; free from cracks, honeycombing and other defects, which may give a defective work, impaired the required strength.

Dimensional stability: concrete masonry units shall be made of proper sizes and shape to suit the construction need and shall be in neutral of the following sizes:

The nominal size of concrete block /solid concrete block.

Length : 400,500,600.

Height : 200,100

Width : 50, 75,100,150,200,250,300.

In addition block shall be manufactured in half-length of correspondence to full length. Maximum tolerance of length shall be (+) 5mm and in height &with shall be + 3mm.

The average crushing strength shall be determined as per I.S 2185 and shall be of Load bearing wall density of block shall be not less than 1500 kg /mm^3 and minimum average compressive strength of units shall be 3.5 to 7 N/mm^3 and minimum strength of individual unit shall be 2.8 to 5.6 for block density less than 1500 kg /mm^3 but not less than 1000 kg /mm^3 average compressive strength of units shall be 2.0 to5 N/mm^3 and minimum strength of individual unit shall be 1.6 to 4.0 N/mm^3

For non load bearing wall block density shall be not less than 1000kg / mm^3 and minimum average compressive strength of units shall be1.5 N/mm^3 and minimum strength shall be 1.2 N/mm^3

2.03.08 **Composite Masonry**

Where stonework facing with brick masonry backing is specified the bond between them shall be achieved by bond stones of dimensions and frequency as desired by the Engineer.

2.03.09 **Expansion & Separation Joints**

Location of joints shall strictly be as shown on drawings or as instructed by the Engineer. Expansion joints shall be as shown on drawings and specified in the Schedule of Items. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall meet the approval of the Engineer.

Separation joints shall be with standard waterproof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Engineer.

2.03.10 **Moldings, Cornices, Drip Course**

These shall be made as shown in drawings. Bricks or stone shall be cut and dressed as required. If no subsequent finish is envisaged, these shall be rubbed to correct profile with carborandum stone.

2.03.11 **Curing**

Masonry shall be cured by keeping it wet for seven days from the date of laying. In dry weather at the end of days work top surface of masonry shall be kept wet by ponding.

2.03.12 **Embedding of fixtures**

All fixtures shall generally be embedded in mortar and masonry units shall be cut as required.

2.03.13 **Encasing of Structural Steel**

This shall be done by building masonry work, around flanges, webs etc. of steel members and filling the gap between steel and masonry by minimum 12 mm thick rich mortar. Encased members shall be wrapped with minimum 18G chicken wire mesh when shown on drawings or instructed by the Engineer, before plastering work.

The minimum lap in chicken wire mesh shall be 50 mm.

2.04.00 **Damp Proof Course**

Unless otherwise specified Damp-proof course shall be 40 mm or as per schedule thick 'artificial stone' in proportion 1:1-1/2:3 cement sand stone-chips (10 mm down) with admixture of a waterproofing compound as approved by the Engineer. The percentage of admixture shall be as per manufacturer's specifications but not less than 2% by weight of cement. The top surface shall be double chequered and cured by ponding for seven days.

2.05.00 **Damp Proof Membrane**

Damp proof treatment using fiber or Hessian base bitumen felt shall be 6, 8 or 10 course treatments as specified in IS: 1609. The number of courses shall be as mentioned in the Schedule of Items. Sequence or work shall be as directed by the Engineer. Extreme care shall be taken to prevent damage to felt during and after lying. The Contractor shall be obliged, at his own expense, to rectify any leakage appearing within 5 years of installation by removing and renewing the coats at the point of leakage.

Where shown on drawing, damp proof membrane with one layer bitumen paper or one layer alkathene sheet shall be laid with minimum 150mm lap under slabs on grade.

3.00.00 **RATES**

Rates shall be unit rates for the complete work as detailed out in the Specification unless any particular portion is specifically excluded in the Schedule of Items.

4.00.00 **METHOD OF MEASUREMENT**

4.01.00 **Soling**

Soling of different types as enumerated in the Schedule of Items shall be measured on actual area basis. Deductions shall not be made for areas less than 0.1 Sq.M.

4.02.00 **Brick Edging**

Edging shall be measured on running length unless included in other relevant items.

4.03.00 **Masonry**

4.03.01 Thickness of brick walls shall be measured in nominal brick sizes.

4.03.02 For masonry work exceeding 150 mm in thickness, actual volume of work shall be measured and deductions for openings, lintels, sills, conduit ducts, pipes etc. shall be made. No opening less than 0.1 Sq.M. in area shall however be deducted.

4.03.03 No deductions shall be made for embedded fixtures nor any extra be paid for the mortar used for fixing or for necessary cutting of bricks.

4.03.04 For encasing of steel beams, columns etc. The sizes as shown on drawings shall be measured and deductions made for the volume of encased steel.

4.03.05 No extra payment shall be made for cutting of masonry units.

4.03.06 Walls 150 mm in thickness or less shall be measured for actual area of works and deductions made as in Clause 5.1.4.3.2.

4.03.07 Exposed brickwork using selected ordinary brick or face bricks for the exposed face shall be measured in area as an extra over the ordinary brickwork if so provided in the Schedule of Items. It shall be measured by volume including the composite backing if so provided in the Schedule. Deductions shall be made as described in Clause 5.1.4.3.2.

4.03.08 Reinforcements shall be measured and paid separately under relevant items in the schedule unless included in the items for masonry work.

Laps in wire mesh reinforcements shall not be measured. Reinforcing mesh shall be measured on actual area basis. Reinforcing bars shall be measured by weight.

The weight shall be arrived at on the basis of sectional weights as per I.S. No extra shall be paid for necessary modifications of existing dowels, if any, to tie up with the Contractor's work.

4.03.09 **Exposed Stonework**

Exposed Stonework using selected stone for exposed face shall be measured in area as an extra over ordinary stonework if so provided in the Schedule of Items. Deductions shall be made as described in Clause 5.1.4.3.2.

4.03.10 **Composite Masonry**

Composite masonry shall be measured for volume including backing if so provided in the Schedule of Items. If not, brickwork and stonework shall be measured separately and paid under relevant items.

4.03.11 **Expansion and Separation Joints**

Joints shall be measured for length or area for the complete work as shown on drawings including filler boards, sealant strips, sealing compounds, painting, cover etc. If so provided in the Schedule of Items unless any particular work is specifically excluded from the item.

4.03.12 **Mouldings, Cornice, Drip Course**

Mouldings, cornice, drip course unless indicated specifically under separate items shall be considered to be included in masonry items. However, cut in bricks or stone shall be neglected in measurements.

4.03.13 **Embedded Fixtures**

Inserts etc. Shall be measured by weight or by number and paid separately under relevant item in the Schedule of Items.

4.04.00 **Damp Proofing**

Damp proofing shall be measured and paid in net area. No deductions shall however be made for openings less than 0.1 sq. M. in area. No separate payment shall be made for preparation of base, formworks and additive for cast-in-situ damp proofing unless specified otherwise.

5.00.00 **I.S. CODES**

Some of the important relevant codes for this section are: -

IS : 1127	:	Recommendations for dimensions and workmanship of natural building stones for masonry work.
IS : 2185	:	Code Practice for hollow concrete block.
IS : 1597	:	Code of Practice for Construction of stone Masonry.
IS : 1609	:	Code of Practice for laying Damp-proof treatment Using bitumen felts.

IS : 2212	:	Code of Practice for Brickwork.
IS : 2250	:	Code of Practice for preparation and use of Masonry Mortar.
IS : 5134	:	Bitumen Impregnated Paper & Board.

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SECTION-XVII

TECHNICAL SPECIFICATION
FOR
FINISH TO MASONRY AND CONCRETE

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SECTION-XVII

TECHNICAL SPECIFICATION FOR FINISH TO MASONRY AND CONCRETE

1.00.00 SCOPE

This Specification covers furnishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of finishing items for masonry and concrete. This shall also include the work to be done to make the surface suitable for receiving the finishing treatment.

Before commencing finishing items the Contractor shall obtain the approval of the Engineer regarding the scheduling of work to minimize damage by other trades. He shall also undertake normal precaution to prevent damage or disfiguration to work of other trades or other installation.

2.00.00 INSTALLATION

2.01.00 Scaffolding

For all exposed brick work or tile work double scaffolding independent of the work having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

For all other work in buildings, single scaffolding shall be permitted. In such cases the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not are allowed in pillars/columns less than one metre in width or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purpose shall be filled and made good before plastering.

Note : In case of special type of brick work, scaffolding shall be got approved from Engineer-in-Charge in advance.

2.01.00 Preparation of Surface

The cement plaster shall be 6 mm, 12mm, 15mm, 18mm or 20mm as specified in the item.

All joints in masonry walls shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Walls shall be brushed down with stiff wire brush to remove all loose dust from joints. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. All laitance shall be removed from concrete to be plastered.

For all types of flooring, skirting and dado work, the base cement concrete slab or masonry surface shall be roughened by chipping and cleaned of all dirt, grease or loose particles by hard brush and water. The surface shall be thoroughly moist to prevent absorption of water from the base course. Any excess of water shall be mopped up.

At any point, the level of base shall be lower than the theoretical finished floor level by the thickness of floor finish. Any chipping or filling to be done to bring the base in the required level shall be brought to the notice of the Engineer and his approval shall be taken regarding the method and extent of rectification work required.

Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as to the acceptability of the base.

2.02.00 **Plastering**

2.02.01 **Mortar**

Mortar for plastering shall be as specified in the Schedule of Items.

For sand cement plaster, sand and cement in the specified proportion shall be mixed dry on a watertight platform and minimum water added to achieve working consistency.

For lime gauged plaster, lime putty or hydrated lime and sand in the required proportion shall be mixed on a watertight platform with necessary addition of water and thoroughly ground in mortar mill. This mix shall then be transferred to a mechanical mixer to which the required quantity of cement is added and mixed for at least 3 minutes.

No plaster, which has stood for more than half an hour, shall be used; plaster that shows tendency to become dry before this time shall have water added to it.

2.02.02 **Application of Plaster**

Ceiling plaster shall be completed before commencement of wall plaster.

Plastering shall be started from the top and worked down towards the floor. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied, horizontally and vertically, at not more than 2 metres intervals over the entire surface to serve as gauges. The surface of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and sideways movements at a time. Finally the surface shall be finished off true with trowel or wooden float according as a smooth or a sandy granular texture is required. Excessive troweling or over working or over working the float shall be avoided.

All corners, arises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, arises, provision of grooves at junctions etc. where required shall be done without any extra payment. Such rounding, chamfering or grooving shall be carried out with proper templates or battens to the sizes required.

When suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped cleaned and wetted with cement slurry before plaster is applied to the adjacent areas, to enable the two to properly join together. Plastering work shall be closed at the end of the day on the body of wall and not to nearer than 15 cm to any corners or arrises. It shall not be closed on the body of the features such as plasters, bands and cornices, nor at the corners of arrises. Horizontal joints in the plaster work shall not also occur on parapet tops and copings as these invariably lead to leakages. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

No portion of the surface shall be left out initially to be patched up later on. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

Thickness

Where the thickness required as per description of the item is 20mm the average thickness of the plaster shall not be less than 20mm weather the wall treated is of brick or stone. In the case of brick work, the minimum thickness over any portion of the surface shall be not less than 15mm while in case of stone work the minimum thickness over the bushings shall be not less than 12mm.

Curing

Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitable protected from all damages at the contractor's expense by such means as the Engineer-in-Charge may approve. The dates on which the plastering is done legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

2.02.03 **Finish**

The plaster shall be finished to a true and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surface shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

Precaution

Any cracks which appear in the surface and all portions which sounds hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer-in-Charge.

i) When ceiling plaster is done, it shall be finished to chamfered edge at an angle at its junction with a suitable tool when plaster is being done. Similarly when the wall plaster is being done, it shall be kept separate from the ceiling plaster by a thin straight groove not deeper than 6mm drawn with any suitable method with the wall while the plaster is green.

ii) To prevent surface cracks appearing between junctions of column/beam and walls, 150mm wide chicken wire mesh should be fixed with U nails 150mm centre to centre before plastering the junction. The plastering of walls and beam/column in one vertical plane should be carried out in one go. For providing and fixing chicken wire mesh with U nails payment shall not be made separately.

iii) Due to faulty construction, if the plaster thickness increases more than 20 mm, the contractor shall provide chicken mesh to hold the plaster, at his own cost.

Deductions in measurements, for opening etc. will regulated as Follows :

a) No deduction will be made for openings or ends of joints, beams, posts, girders, steps etc. up to 0.5 sqm in areas and no additions shall be made either, for the jambs, soffits and sills of such openings. The above procedure will apply to both faces of wall.

b) Deduction for opening exceeding 0.5 sqm but not exceeding 3 sqm each shall be made for reveals, jambs, soffits sills, sills, etc. of these openings.

i) When both faces of walls are plastered with same plaster,

ii) Deductions shall be made for one face only.

iii) When two faces of walls are plastered with different types of plaster or if one face is plastered and other is pointed or one face is plastered and other is unplastered, deduction shall be made from the plaster or pointing on the side of the frame for the doors, windows etc. on which width of reveals is less than that on the other side but no deduction shall be made on the other side.

iv) Where width of reveals on both faces of wall is equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be.

v) For opening having door frame equal to or projecting beyond thickness of wall, full deduction for opening shall be made from each plastered face of wall.

c) For opening exceeding 3 sqm area, deduction will be made in the measurements for the full opening of the wall treatment on both faces, while at the same time, jambs, sills and soffits will be measured for payment

In measuring jambs, sills and soffits, deduction shall not be made for the area in contact with the frame of doors, windows etc.

Cement Plaster with a Floating coat of Neat Cement

The cement plaster shall be 12, 15, or 20mm thick, finished with a floating coat of neat cement, as described in the item.

Specifications for this item of work shall be same as describe above except for the additional floating coat which shall be carried out as below.

When plaster has been brought to a true surface with the wooden straight edge, it shall be uniformly treated over its entire area with a pest of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quality of cement applied for floating coat shall be 1 kg per sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described in above shall apply.

18mm Cement Plaster (Two Coat Work)

The specification for scaffolding and preparation of surface shall be as described above.

Mortar

The mix and type of the aggregate specified in the description of item shall be used for the respective coats. Generally the mix of the finishing coat unless otherwise described in the item.

Generally coarse sand shall be used for the under coat and fine sand for the finishing coat , unless otherwise specified for external work and under coat work, the fine aggregate shall conform to grading zone IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

Application

The plaster shall be applied in two coats i.e. 12 mm under coat and then 6mm finishing coat and shall have an average total thickness of not less than 18mm.

12mm under coat

This shall be applied as specified earlier except that when the plaster has been brought to a true surface a wooden straight edge and the surface shall be left rough and furrowed 2 mm deep with a scratching tool diagonally both ways, to form key for the finishing coat. The surface shall be kept wet till the finishing coat is applied.

6mm finishing coat

The finishing coat shall be applied after the under coat has sufficiently set but not dried and in any case within 48 hours and finished in the manner specified earlier.

Specifications for curing, Finishing and Precautions shall be as describe earlier.

6mm Cement Plaster on Cement Concrete and Reinforced Cement

Concrete Work

Scaffolding

Stage scaffolding shall be provided for the work. This shall be independent of the walls.

Preparation of Surface

Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed with wire brushes. In addition concrete surfaces to be plastered shall be pock marked with a pointed tool, at spacing of not more than 5 cm. Centers, the pock being made not less than 3mm deep. This is to ensure a proper key for the plaster. The mortar shall be washed off and surface, cleaned off all oil, grease etc. and well wetted before the plaster is applied.

Mortars

Mortar of the specified mix using the types of sand described in the item shall be used.

Application

To ensure even thickness and true surface, gauges of plaster 15 x 15 cm. shall be first applied at more than 1.5m intervals in both directions to serve as guides for the plastering. Surface of these gauged areas shall be truly in the plane of the finished plaster surface. The plaster shall be then be applied in a uniform surface to a thickness slightly more than the specified thickness and shall then be brought to true and even surface by working a wooden straight edge reaching across the gauges. Finally the surface shall be finished true with a trowel or with wooden float to give a smooth or sandy granular texture as required. Excess troweling or over working of the floats shall be avoided. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

Plastering of ceiling shall not be commenced until the slab above has been finished and centering has been removed. In the case of ceiling of roof slabs, plaster shall be commenced until the terrace work has been completed. These precautions are necessary in order that the ceiling plaster is not disturbed by the vibrations set up in the above operations.

Finish

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

Thickness

The average thickness of plaster shall not be less than 6 mm. The minimum thickness over any portion of the surface shall not be less than 5mm.

Curing

The specification as stated earlier

Precautions

The specification as stated earlier

Deductions

Deduction shall not be made for openings or for ends of columns, or columns caps of 0.5sqm each in area and under. No additions will be made either for the plastering of the sides of such openings. For openings etc. of areas exceeding 0.5 sqm deduction will be made for the full opening but the sides of such openings shall be measured for payment

2.02.04 **Other Finish**

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

a) **Standard Finish**

Wherever punning is indicated, the interior plaster shall be finished rough. Otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

b) **Neat Cement Finish**

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg. Per Sq.M. or as per schedule and rubbed smooth with a trowel.

c) **Coloured Plaster Finish**

This shall be done in the same way as specified in clause 6.1.2.2.2 but using coloured cement in place of ordinary cement. When coloured plastering is specified in more than one coat, the topcoat only shall be made with coloured cement.

Coloured cement shall be either ready mixed material or may be obtained by mixing pigments and cement at site, as approved by the Engineer. The pigments to be mixed with cement shall conform to Appendix-A of IS: 2114 latest edition.

Samples of colouring material shall be submitted to the Engineer for approval and material procured, shall conform in all respects to the approved samples, which shall remain with the Engineer. All coloured cement and/or pigments shall be stored in an approved manner in order to prevent deteriorations.

d) **Pebble-dash Finish (In Situ Work)**

The specification shall be the same as for rough cast plaster, except that the washed pebble or crushed stone graded from 12.5 mm to 6.3mm or as specified shall be dashed over the plaster base and the vacant spaces if any shall be filled in by pressing pebbles or crushed stone as specified by hand, so that the finished surface represents a homogeneous surface.

Specification for scaffolding, preparation of surface and mortar shall be as described earlier.

e) **Rough-Cast Finish**

Rough cast finish comprises of a mixture of sand and gravel in specified proportions dashed over a freshly plastered surface.

Preparation of surface

The joints shall be raked out, dust and loose mortar, shall be brushed out. The surface shall be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

Mortar

Mortar of specified mix using the type of sand described in the item shall be used, where coarse sand is to be used, the fineness modulus of the sand shall not be less than 2.5mm

Application

The plaster base over which roughcast finish is to be applied shall consist of two coats, under layer 12mm thick and top layer 10mm.

12mm Under Layer

This shall be applied in the same manner as specified in earlier under 18mm cement plaster except that the finishing, after the mortar has been brought to a level with the wooden straight edge, shall be done with wooden float only.

Top Layer

The top layer shall be applied a day or two after the under layer has taken initial set. The latter shall not be allowed to dry out, before the top layer is laid on. The mortar used for applying top layer shall be sufficiently plastic and of rich mix 1: 3 (1 cement: 3 fine sand) or as otherwise specified so that the mix of sand and gravel gets well pitched with the plaster surface. In order to make the base plastic, about 10% of finely grouted hydrated lime by volume of cement, shall be added when preparing mortar for the top layer.

Finish

It shall be ensured that the base surface which is to receive rough cast mixture is in plastic state. The rough cast mixture shall consist of sand or gravel or crushed stone of uniform colour from 2.36 mm to 12.5mm or as specified and in the proportions as specified accurately to the effect required. The mixture gets well pitched into the plaster base. The mix shall again be dashed over the vacant spaces if any so that the surface represents a homogeneous surface of sand mixed with gravel. A sample of rough cast plaster shall be got approved by the Engineer-in-charge.

Specification for other details like precautions etc. as described earlier.

f) **Scraped Finish**

Ordinary plaster as described under Clause 6.1.2.2.2 after being levelled and allowed to stiffen for a few hours shall be scraped with a steel straight edge to remove the surface skin. The pattern shall be as approved by the Engineer.

g) **Textured Finish**

Mortar consisting of 1 part cement and 3 parts sand by volume shall be applied in a manner as specified under “Plastering” Clause 6.1.2.2.2. Ornamental treatments in the form of horizontal or vertical rib texture fan texture etc. shall be applied by means of suitable tools to the freshly applied plastered surface, as approved by the Engineer.

h) **External Quality Glass Mosaic Tiles**

Glass mosaic tiles to be laid in pattern and profiles on a bed of cement mortar 1:3 (with coarse sand) and set in cement paste or adhesive of approved quality & make, joints filled and finished by neat in pigmented cement or sealant of approved quality & brand and cured including necessary adjustment at edges corners etc. complete, strictly as per the manufacturer's specification & details. in walls, ceiling, soffits up to all elevations in straight or curved surface as murals or wall claddings per drawing & instruction of the Engineer-in-charge.

The following important steps to be followed for installation of “Glass Mosaic” tiles

Preparing the surface

The surface to be tiled must be clean, smooth and clean of dust. It must be in plumb and should be dry.

Application of adhesive

A good quality Latex-Modified thinest to be applied as approved by Engineer-in-charge for fixing of mosaic tiles. Thinset should be compatible with the substrate and environment (i.e. wet areas or exterior areas). The adhesive should be thick enough to avoid mosaic sheets from slipping once placed on the wall. Spread the adhesive uniformly (about 3mm thick) on the wall using the straight edge of the trowel. With the toothed edge of the trowel, comb the adhesive through.

Installation mosaic mounted on paper

Mosaic sheets with the paper side to be faced up. After pressing the sheets firmly in one direction, rubbers float to be used to tap the sheets. A wooden float may also be used but never a metal one. It is to check that all sheets are placed at the exact same distance from each other as the tiles.

After the mosaics have started to set, but before they become fully bonded the paper the paper should be removed. A damp sponge to be used on the surface of the sheets to ensure easy removal of the paper. Paper to be removed carefully by pulling one corner of the paper diagonally across the sheet. This must be done gently to ensure that no tiles are dislodged in the process. Realign any tiles with a spatula and remove excess adhesive at this point. Let the adhesive dry for approximately 24 hrs before beginning the grouting process.

Installation of mosaic mounted on mesh

Mosaic sheets with the mesh backing to be installed by pressing directly on the adhesive. A rubber or wooden float to be used to tap the sheets to ensure a flat and even surface. It is to check that all sheets are placed at the exact same distance from each other as the tiles. Adhesive to be applied as much as possible so that it can be covered with in 10 to 20 minutes or until surface is still wet and tacky. Tiles to be allowed to set until firm. Clean excess adhesive from the surface of the tile to set firm. Clean excess adhesive from the surface of the tile with wet cloth or sponge while the setting material is fresh. Leave the surface to dry before beginning the grouting process.

Grouting

Sponge & warm water to be used to remove any excess adhesive on the sheets. The surface must be free from dust. Using a hard rubber float, spread the grout horizontally and vertically on the mosaic sheet. Cover an area of not more than 2 sq mtr. at a time. Excess grout to be removed with the rubber float by working diagonally across the mosaics. After grouting, wait approximately 20 minutes before cleaning the excess grout.

Material specification

Glass mosaic tiles to be either gloss or mat finish quality with the size 20x20mm to 25x25mm, weight 7.5 kg to 8.7 kg per sqm, thickness 3.8 to 4.5mm, water absorption < 0.1%. It should have excellent stain resistant, UV resistant, frost resistant, thermal shock resistant and chemical resistant property. Size and type of tiles (Gloss or matt finish) to be as per drawing and approval of the Engineer-in-charge.

i) **1st Quality Ceramic Glazed External Wall Tiles**

Ceramic exterior wall tiles of work size 150 x 300mm (textured surface) with thickness varies from 8.5mm to 10mm on a single tile due to 3D surface, applicable only for wet cladding. It should conform to ISO 13006 / EN 159 Group B III. The linear thermal expansion of tiles should be 9 X $10^{-6}K^{-1}$, Max.

Application

Surfaces to be tiled must be dry, clean and free from all contamination and should be dried and cured for at least two weeks.

The adhesive should be added to clean water and mixed thoroughly until a slump-free mortar is obtained. The adhesive is immediately ready – for- use and has a pot life of 3 hours. No further water should be added.

1. Spread not more than 1 sq.m. at a time , apply the adhesive to the wall surface.

2. Comb the adhesive to the required depth (between 3-6 mm) using a suitable trowel.

3. Press the tiles firmly into position with a slight twisting action, checking periodically that good contact is maintained with the back of each tile. Leave no voids behind the tiles when solid-bed fixing.

4. Tiles should be fixed within 20 minutes of the adhesive being applied, depending on the porosity of the surface and atmospheric conditions. Tiles can be adjusted up to 5-10 mins. after fixing.

5. Leave adequate joints (2-3 mm) between individual wall tiles by using spacer & to be grouted with polymer grout. This has to be maintained to avoid expansion – contraction problem due to climatic change as it will be exposed to sun.

6. Clean off surplus adhesive from the tile face and between joints.

7. Do not use in damp conditions.

8. Grouting should not be carried out for at least 24 hours.

j) **Heritage Granular Finish Work**

Heritage granular finish should be with special silica sand coloured wide inorganic pigments along with acrylic co-polymer bonding agent containing biocides / fungicides and stabilizing adhesive. Application thickness will be 0.8mm to 1.2 mm as per JISA 6909.

The application to be done on plastered surface at all elevations as per design, drawing, manufacturers specification and direction of Engineer-in-charge, complete in all respect

2.03.00 **Pointing to Masonry**

All joints of brickwork shall be raked out to a depth of 10 mm with a hooked tool made for the purpose while the mortar is still green. The brickwork shall then be brushed down with a stiff wire brush, so as to remove all loose dust from the joints and thoroughly washed with water. Mortar consisting of 1 part cement and 3 parts clean, sharp, well graded sand by volume shall be pressed carefully into the joints and finishes with suitably tools to shape as shown on the drawings. Any surplus mortar shall be scraped off the wall face leaving the surface clean.

The pointed surface shall be kept wet for at least three days for curing.

2.04.00 **Plaster with Metal Lath**

The supports, hangers, brackets, cleats etc. shall be as shown on drawings and/or as approved by the Engineer. These shall have a coat of prime paint before and another coat of approved paint after erection.

The metal lath shall be expanded metal, with 12 mm x 38 mm mesh, 16 BG thick and 3 mm wide strands. Side laps shall be minimum 12 mm and end laps 25 mm minimum. The plastering shall be minimum 20 mm thick measured from the back of lath and applied in two layers. The mortar for plastering shall consist of 1 part cement, 1/2 part lime and 4 parts sand by volume, or 1 part cement and 4 parts sand by volume mixed as specified in plastering, Clause 6.1.2.2.1. The application, finish etc. shall be as specified under relevant clause above. Where called for in the Schedule of Items, a 2 mm Plaster of Paris punning shall be applied over plaster as a finishing coat to give perfectly smooth and even finish.

2.05.00 **Lime Punning**

For plastered surfaces, where an even smooth surface is specified, lime punning with 5 parts of shell lime properly slaked, strained and aged, mixed with 1 part clean, washed, sieved, fine sand by volume shall be done. The thickness of lime punning shall be not less than 2 mm and more than 3 mm. The plastered surface shall be saturated with water before application of the lime punning. The punning shall be applied by skilled workman and given a smooth and even finish free from undulations, cracks etc. and to the satisfaction of the Engineer.

2.06.00 **Plaster of Paris Punning**

Plastered surfaces, where specified shall be finished with Plaster-of-Paris punning. The material shall be from approved manufacturers and approved by the Engineer. The thickness of the punning shall be 2 mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation, cracks etc.

Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 Sq.M. area and approval of the Engineer taken. The work shall then be taken in hand as per approved sample.

2.07.00 **Stone Facing**

Stone facing where specified shall be done as shown on design drawings and approved shop drawings. The stone shall be as specified on drawings and/or schedule of items. Samples of stone shall be submitted to the Engineer for approval and then bulk purchase made. The Contractor shall submit three copies of shop drawing for the Engineer's approval before commencing the work.

The thickness of facing stone shall be not less than 25 mm unless otherwise specified on drawings.

The stone slabs shall be cut and finished to sizes as per pattern shown on drawings. They shall be fastened to wall with suitable noncorrodable anchorage as approved by the Engineer. Where mild steel clamps, stays etc. are used for anchorage, they shall be galvanised (weight of zinc coating shall not be less than 700 gms per square meter of surface) to prevent rust stains developing on the finished surface. There shall be at least 12 mm gap between the stone and masonry, which shall be filled up and packed by a mortar of 1 part cement and 3 parts of sand by volume. After the mortar is set and cured for at least four days, the exposed surface shall be rubbed and polished as approved by the Engineer. The completed surface shall be neat, or uniform texture and acceptable to the Engineer.

Where pointing is specified on drawings it shall be done by mortar as specified on drawings and/or Schedule of Items.

2.08.00 **White Cement Putty Punning**

Plastered surfaces, where specified shall be finished with White Cement Putty punning. The material shall be from approved manufacturers and approved by the Engineer. The finish shall be smooth, even and free from undulation, cracks etc.

Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 sq.m. area and approval of the Engineer taken. The work shall then be taken in hand as per approved sample.

	PROPERTY	
1.	Tensile Adhesion Strength (N/MM^2) @ 28 Days	> 1.0
2.	Compressive Strength (N/MM^2) @ 28 Days	> 9.0
3.	Setting Time (Minutes) - Initial Final	=> 100 =< 500
4.	Water Absorption Coefficient - $Kg/M^2.H^{1/2}$	< 1.0
5.	Water Capillary Absorption (ML) @ 24 Hrs.	0.8
6.	Water Retentivity %	> 98

Surface Preparation

All loosely adhering materials on the plastered wall surface is to be removed with the help of emery stone, putty blade or wire brush and clean water. The substrate should be cleaned, free from dust, grease and loose materials. Dry and absorbent surface should be moistened with sufficient quantity of clean water.

Mixing

White cement putty should be mixed slowly with 30-35% of clean water to form a paste. Mixing is to be continued for 10-15 minutes to form a uniform paste.

Application method

First coat shall be applied on well moistened plastered wall surface from bottom to upward direction uniformly with putty blade. After drying of first coat the surface shall be rubbed gently with wet sponge or putty blade to remove loose particles. Surface shall be allowed 3 hours to dry before applying the second coat. After complete drying of second coat, loose particles shall be removed by gently rubbing the surface with wet sponge or putty blade. After mixing the putty should be utilized within 2 hours. Total thickness of coats shall not be more than 1.5mm or as per manufacturer specifications.

2.09.00 **Cement Water Proofing Compound**

It shall be used for cement mortar for plastering or concrete work.

Water Proofing Compound

Integral cement water proofing compound conforming to IS 2645 and of approved brand and manufacturer, enlisted by the Engineer-in-Charge from time to time shall be used.

The contractor shall bring the materials to the site in their original packing. The containers will be opened and the material mixed with dry cement in the proportion by weight, recommended by the manufacturers or as specifically described in the description of the item. Care shall be taken in mixing, to see that the water proofing material gets well and integrally mixed with the cement and does not run out separately when water is added.
It shall be measured by weight.

The rate shall include the cost of all labour and materials involved in all the operations described above.

3.00.00 **ACCEPTANCE CRITERIA**

Finish to masonry and concrete shall fully comply with the Specifications, approved samples and instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as mentioned in the body of the specification or as shown on drawings.

4.00.00 **RATES**

Rates shall be for the complete work as detailed out in the specification unless any particular portion is specifically excluded in the Schedule of Items.

5.00.00 **METHOD OF MEASUREMENT**

a) All surface finish shall be measured on actual area laid. No deductions shall be made for openings, pipes, and sleeves etc. upto 0.1 Sq.M. in area.

b) Unless separate item is provided for special corner or edge finish, drip course, grooves, mouldings, curbs etc. these shall not be measured separately. Where separate item is provided in the Schedule of Items, such work shall be measured for length.

c) No separate payment shall be made for finishing round openings, sleeves, pipes, etc. No separate payment shall be made for formwork, templates etc. required for achieving true lines and profiles as shown on drawing.

d) Finishes applied integrally with walls, floors, steps and ceilings shall be measured separately and paid under relevant items.

e) Any reinforcement incorporated in the finish shall be measured and paid separately under relevant items.

f) Unless otherwise mentioned in the Schedule of Items, hangers, supports and laths for lath plastering shall be measured and paid separately under relevant items.

6.00.00 **I. S. CODE**

Important relevant code for this Section :

a) IS : 1661 : Code of practice for cement and cement-lime plaster finish on walls and ceilings.

b) IS : 4101 : Code of practice for external facings and veneers.

c) IS : 1200 (Pt-XII) : Method of Measurements of Building and Civil Engineering Works: Part: XII- Plastering and Pointing

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SECTION-XVIII

TECHNICAL SPECIFICATION
FOR
SINGLE AND SANDWICH METAL CLADDING

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2.00.00	PRODUCTS	VII-C/S-XVIII : 3
3.00.00	DOUBLE SKIN INSULATED METAL CLADDING	VII-C/S-XVIII : 4
4.00.00	EXECUTION	VII-C/S-XVIII : 5
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SECTION-XVIII

TECHNICAL SPECIFICATION FOR SINGLE AND SANDWICH METAL CLADDING

1.00.00 **GENERAL**

1.01.00 **Description**

1.01.01 This section covers, providing, furnishing and installation of sandwich/double skin metal cladding with insulation for wall/roof as shown in contract drawings including making cut outs for various openings for doors, windows, ducts, pipes, conductors etc and fixing of such components with the cladding arrangement with necessary flashing, sealant as required as per contract drawings. The contractor shall furnish all labour, materials, tools and equipment required to complete the work.

1.02.00 **Applicable Codes and Standards**

1.02.01 The following codes and standards are intended to provide an acceptable level of quality for materials and products. The contractor may propose alternative codes and standards provided they give an equivalent degree of quality as the referred codes and standards and are submitted for consultants/owner's approval.

1.02.02 ASTM - American Society for Testing Materials.

1.02.02.1 A446 - Zinc-coated (Galvanized) steel sheets of structural quality. Coils and cut lengths.

1.02.02.2 A611 - Steel, cold rolled sheet.

1.03.00 **Submittals**

1.03.01 The contractor shall submit to the owner the following items for review before commencing work.

1.03.01.1 **Samples**

a) Three 300 x 300 mm pieces of each type of pre-coated and preformed metal sheet for top skin and bottom skin.

b) Type of insulation proposed for use and its thickness and density.

c) Fabricated sandwich metal cladding- Sample size shall be 300 x 300 mm three nos.

d) Edge sealing and flashing.

1.03.01.2 Manufacturer's literature indicating the nature of preformed profiled, colour coating, manufacturer's recommended installation, instructions and maintenance procedure.

1.03.01.3 Manufacturer's certification of compliance with each delivery.

1.03.01.4 **Shop Drawings**

Showing fabrication details of sandwich/double skin metal cladding with Insulation, preformed sheet profile and total colour thickness for profiled top skin and slightly ribbed bottom skin, thickness and nature of insulation, installation and erection, anchorage, fasteners and details of accessories, metal flashing and its fixing including various openings for doors, windows, louvres, pipes etc.

1.03.02 **Test Reports**

Two copies of Test Reports and Source of Quality Control Tests.

1.03.03 **Supplier Certificates**

Two copies of technical data showing that the proposed finish product is suitable for the environmental conditions of the job site and that the materials meet specification requirements.

1.04.00 **Product Handling**

1.04.01 Delivery of Materials to job site in manufacturer's original unopened packaging.

1.04.02 Identify contents with name of manufacturer, brand name, thermal value and applicable standard.

1.04.03 Store materials in an area protected from adverse climatic conditions, moisture and open flame or spark and shall be stored off the ground with one end elevated for drainage. The sheets shall be protected from inclement weather with a waterproof covering with ventilation to avoid condensation.

2.00.00 **PRODUCTS**

2.01.00 **General**

2.01.01 All goods and products covered by these specifications shall be procured from manufacturer duly approved by the owner

2.01.02 Roof insulation shall have a minimum R-value of 2.083 M^2 ^oK/Watt. Thickness of sandwich cladding shall be as required to meet the specified "R" values.

2.01.03 Sandwich material shall be of "Rib and Flute" design to ensure wide spanning and quick recovery after being subjected to excessive load. Double skin materials shall be interlocking type 150mm wide strip and inner sheet shall be mild rib & flute type profile to ensure quick recovery after being subjected to excessive load.

2.01.04 **Material**

2.01.04.1	Base Material	High tensile steel
2.01.04.2	Metal protection	Galvalume
2.01.04.3	Organic coating	Silicon Modified Polyester (SMP) Fluoro polymer (PVF_2) and plastisols to resist aggressive climate of the jobsite

2.01.05 Material shall be prefabricated sandwich panel with polystyrene insulation/high density rock wool slab insulation shall be conformed to relevant ASTM or alternative codes and standard. Insulation shall be bonded to steel sheet with industrial grade adhesive. Sheeting material shall be preformed and precoated profile sheeting of thickness 0.60 mm or as recommended by manufacturer to resist the climate of the jobsite for Top skin (Weather side) and Bottom skin or inner side slightly ribbed type and minimum 0.5 mm thick or as recommended by manufacturer of similar pre coated panel.

2.01.06 Insulating core shall vary from 25 mm to 100 mm thick according to the climatic requirement of the site and shall be either polystyrene block or rock wool slab made to profile of the sheet. The maximum density shall be 32.35 Kg / M^3 for polystyrene and shall have minimum R-value 2.083 M^2 ^oK/Watt.

2.01.07 Panel size shall be largest available size.

2.01.08 Warranty for precoated profiled metal sandwich /double skin cladding shall be for a minimum period of 40 years.

2.01.09 **Sealants**

Penetration and end laps in sheeting shall be sealed with a non-hardening approved sealant as recommended by the manufacturer.

2.01.10 Profile HDPE Filler

2.01.10.1 Profile HDPE Filler shall be die cut in profile to match the profile of the sheet.

2.01.10.2 Metal flashing shall be of similar material and colour of top skin.

3.00.00 **DOUBLE SKIN INSULATED METAL CLADDING**

3.01.00 **General**

3.01.01 Metal cladding may be of double skin separated by an approved insulation in between. External sheet shall be of interlocking type.

3.01.02 Providing, erecting, fitting & fixing at all elevations double skin insulated roofing / wall cladding with Luxalon or equivalent 150 F and profiled steel sheets made out of 0.55mm (TCT) permanently colour-coated galvalume steel (150gsm Zinc Aluminium alloy coating total of both as per AS 1397:1993) having 550 MPa yield strength. Colour coating shall comprise of Polyester coating of approved colour. The Polyester colour coating shall comprise of 15-20 micron finished coat over 5 micron primer coat on the exposed side and manufacturer's back coat of 5 microns over a primer coat on the inner side.

The external sheet shall be Luxalon or equivalent 150 F fixed on to the hat sections with the help of specially designed carriers to hold the external Luxalon cladding. The inner sheet shall have 980mm cover width, 28mm high crest at 195mm c/c. with special male / female side-laps and anti-siphoning features to prevent leakage. Two small ribs are there in between the two profiles. The inner sheet along with sub-girths of size 50mm x 50mm x 50mm manufactured out of 1.6mm GI sheet in 'C' / 'Z' shape would be fixed to the purlin by means of self-drilling fasteners (12G - 14TPI x required length). Outer sheeting shall be fixed with the help of concealed compatible interlocking clips and wafer-head Zinc-coated self-drilling fasteners / screws on to the sub-girths. The clips shall be concealed and no fasteners are to penetrate the external sheeting.

An insulation of 50mm thick Rockloyd Resin-bonded Rockwool of density 48 kg./m3 conforming to IS:8183 shall be provided and fixed between two sheets.

3..01.03 Providing and fixing of double skin prefabricated factory assembled rock wool insulated wall cladding system comprising of profiled external sheet manufactured out of 0.55mm TCT (Total Coated Thickness) permanently colour coated zincalume steel (150 gsm. zinc – aluminium alloy coating total of both sides as per AS 1397: 1993) having 550 Mpa yield strength. The colour coating shall comprise of SMP / super polyester PVF2. The inner sheeting shall be 0.50mm/0.6mm TCT of SMP / super polyester PVF2 coated zincalume steel 150 gsm. (Zinc – aluminium alloy coating mass total of both sides as per AS 1397:1993) having 550 Mpa yield strength or 180gsm galvanised of 240 mpa. The colour coating shall comprise of 20 microns finish coat over a 5-micron primer coat on the exposed side and a back coat of 5 microns over a primer coat of 5 micron on the reverse side. The external sheet shall have 500mm cover width, 47mm high crests at 250mm centres with special male / female side laps and anti-siphoning feature to prevent leakage. The inner sheet shall have 980mm cover width 28mm high crests at 195mm centres with special male / female side laps and anti-siphoning features to prevent leakages. The inner sheet shall be fixed to the structure by means of self drilling fasteners no. 12-24 x 25 mm conforms to AS: 3566 Class-3 long at valley. Outer sheeting shall be fixed with the help of concealed compatible interlocking clips and wafer head zinc coated self drilling fasteners / screws 4.2 x 25mm long on to the steel runner. The clips shall be concealed and no fasteners are to penetrate the external sheeting. Insulation of density 100 Kg/m3 and average thickness 50 mm. conforming to IS 8183 having a thermal conductivity value of 0.034 W/mk at 50 degree C mean temperature. Wherever single skin metal cladding shall be used over brickwork, the material shall be same as the outer skin of insulated metal cladding system.

4.00.00 **EXECUTION**

4.01.00 **Inspection**

4.01.01 the contractor shall examine the area, which will be covered, and the masonry wall where the edge of the sandwich/double skin cladding will be fixed and the structural alignments.

4.01.02 Contractor shall correct any unsatisfactory conditions prior to start of work.

4.02.00 **Installation**

4.02.01 Sandwich panel shall be fixed over structural members with joints overlapped and fastened using stainless steel fasteners self-drilling type or as recommended by the manufacturer.

4.02.02 Double skin wall cladding shall be installed strictly as per manufacturer specification and details.

4.02.03 All end laps of profiled sheeting and joints of flashing shall be sealed properly with non-hardening natural cure silicon sealant or as recommended by the manufacturer.

4.02.04 Accessories like fasteners, tape, and foam fillers, flashing etc. as required shall be provided as per recommendation of manufacturer.

4.03.00 **Clean-Up**

Remove sealant splatters and smears remove steel particles generated by drilling to avoid damage.

5.00.00 **RATES**

Rates shall be for unit rate for complete item described in the Schedule and shall include all wastages.

6.00.00 **METHOD OF MEASUREMENT**

a) No allowance shall be made for laps.

b) Roofing and side sheeting shall be measured for net area of work done. Corrugated / Trough sheeting shall be measured flat and not girthed. Openings less than 0.1 Sq.m shall not be deducted.

c) Special features like flashings, ridge pieces, caves, corner pieces, north-light curves etc. shall be measured for length of installation.

d) Gutter and down comers shall be measured for length along their centre lines and bends, junctions, shoes ends, etc. shall not be considered for measurement.

e) Opening area of Doors, Windows, Louvers, Cutouts which falls under metal clad area shall be measured for deduction form total metal clad / clad area.

f) Curved roofing sheets shall be measured for area of curve.

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SECTION-XIX

TECHNICAL SPECIFICATION FOR CARPENTRY AND JOINERY

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3.00.00	ACCEPTANCE CRITERIA	VII-C/S-XIX : 17
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SECTION-XIX

TECHNICAL SPECIFICATION FOR CARPENTRY AND JOINERY

1.00.00 SCOPE

This shall include supply, fitting and fixing of timber frames to doors and windows with M S holdfasts, paneled or flush doors, windows, shutters, partitions, wall paneling, pelmets, shelves, furniture, etc. as shown in drawings, including a prime coat of approved paint, varnish, or fixing of decorative plastic laminate where called for in the schedule. This shall also include the supply and fixing of all hardware and fixtures shown in drawing or specified in the "Schedule of Fixtures".

2.00.00 INSTALLATION

2.01.00 Materials

a) **Timber**

Unless otherwise specified, all timber shall be best quality well seasoned C P teakwood free from decay, fungal growth, boxed heart, pitch pockets or steaks on the exposed edges, splits, large or loose, knots cracks or other defects. Where specified, timber shall be treated with approved wood preservative before use. Before starting the carpenter's work, the Tendered shall have the rough timber approved by the Engineer.

b) **Plywood**

Plywood boards are formed by gluing and pressing three or more layers of veneers with the grains of adjacent veneers running at right angles to each other. The veneers shall be either rotary cut or sliced and shall be sufficiently smooth to permit an even spread of glue. Face veneers may be either decorative on both sides or one side commercial and the other decorative. Ply wood shall be BWP grade or BWR grade as per IS 303. Plywood shall be commercial quality or with decorative surface veneer. Unless specifically permitted otherwise, the adhesive used in plywood shall be phenol formaldehyde resin of B W R grade conforming to IS: 848.

c) **Decorative Laminated Plastic Sheets**

The colour, pattern, finish and texture shall be approved by the Engineer and the bulk supply procured in sheet sizes which will ensure the least number or joints in one surface.

d) **Flush Doors**

Flush door shutters shall have a solid core with commercial or decorative or non-decorative (Paintable type as per IS 2202 Part I) faces and hardwood edges. The core for solid core doors shall be of block board or wood particleboard. Manufacturer's literature and test certificates shall be submitted for the approval of the Engineer. The Contractor shall give a guarantee that the adhesive used is phenol formaldehyde of BWR grade, conforming to IS: 848. The thickness shall be as specified in the "Schedule of Items". The moisture content in timbers used in the manufacture of flush door shutters shall be not more than 12 percent when tested according to IS 1708.

Face Panel

The face panel shall be formed by gluing, by the hot-press process on both faces of the core, either plywood or cross-bands and face veneers. The thickness of the cross bands as such or in the plywood shall be between 1.0mm and 3.0mm. The thickness of the face veneers as such or in the plywood shall be between 0.5 mm and 1.5mm for commercial veneers and between 0.4 mm and 1.0mm for decorative veneers, provided that the combined thickness of both is not less than 2.2mm. The direction of the veneers adjacent to the core shall be at right angles to the direction of the wooden strips. Finished faces shall be sanded to smooth even texture. Commercial face veneers shall conform to marine grade plywood and decorative face veneers shall conform to type I decorative plywood in IS 1328.

Lipping

Lipping, where specified, shall be provided internally on all edges of the shutters. Lipping shall be done with battens of first class hardwood or as specified of depth not less than 25mm. For double leaved shutters, depth of the lipping at meeting of stiles shall be not less than 35 mm. Joints shall not be permitted in the lipping.

Rebating

In the case of double leaves shutters the meeting of stiles shall be rebated by 8mm to 10mm. The rebating shall be either splayed or square type as shown in the drawing where lipping is provided. The depth of lipping at the meeting of stiles shall not be less than 30 mm.

Opening for glazing

When required, glazing shall be provided and unless otherwise specified the opening for glazing shall be 250mm in height and 150mm or 200mm in width unless directed otherwise. The bottom of the opening shall be at a height of 1.4 m from the bottom of the shutter. Opening for glazing shall be lipped internally with wooden batten of width not less than 25mm. Opening for glazing shall be provided where specified or shown in the drawing.

Tolerance

Tolerance on the width and height shall be +3 mm and tolerance on nominal thickness shall be ± 1.2mm. The thickness of the door shutter shall be uniform throughout with a permissible variation of not more than 0.8 mm when measured at any two points.

Adhesive

Adhesive used for bonding various components of flush door shutters namely, core, core frame, lipping, cross-bands, face veneers, plywood etc. and for bonding plywood shall conform to BWP type, phenol formaldehyde synthetic resin adhesive conforming to IS 848.

e) **Panelled Glazed or Panelled and Glazed Shutters**

Panel door shall be of teakwood shutter frame unless otherwise noted and panels with teakwood/commercial ply/teakwood particleboard as per “Schedule of Items” and as per drawing or as recommended and approved by Engineer in charge.

Panelled or glazed shutters for doors, windows, ventilators and cupboards shall be constructed in the form of timber frame work of stiles and rails with panel inserts of timber, plywood, block board, veneered particle board, fiber board wire gauze or float glass. The shutters may be single or multipanelled, as shown in the drawings or as directed by the Engineer-in-Charge. Timber for frame work, material for panel inserts and thickness of shutters shall be as specified. All members of the shutters shall be straight without any wrap or bow and shall have smooth well planed face at right angles to each other.

Other considerations shall be as mentioned in item (d) above.

Window and Ventilator Shutters

Window and Ventilator shutters shall conform to IS 1003 (Part 2)

f) **Laminated Veneer Lumber (LVL)**

Laminated Veneer Lumber door frames and shutters shall conform to IS 14616

Material

i) **Laminated Veneer Lumber (LVL)**

Laminated Veneer Lumber is made of rubber wood silver oak, eucalyptus, Poplars, acacias etc. veneers glued tighter having grains of all the veneers in one direction under high temperature and pressure to develop high Modulus of Rapture & Modulus of elasticity. Veneers for LVL shall be of thickness between 1.5 to 2.5mm.

ii) Veneers shall be free from knot holes, decayed knots except pin knots, unfilled splits wider than 3 mm, concentrated borer holes, shakes, objectionable decay or termite attack, except that for the face veneers none of these defects or cross grain exceeding 1 in 10 shall be permitted. The nominal thickness of all the veneers used shall be identical and uniform within a tolerance of ± 5 percent.

iii) **Adhesives :** Only BWP grade adhesive conforming to IS 848 shall be used for making LVL.

iv) **Preservatives :** Veneers used for LVL shall be given preservative treatment before lamination, with a preservative that is compatible with the adhesive to be used. Only fixed type of water soluble preservatives, CCA or CCB, or non-leachable, solvent soluble preservatives as per IS 401 shall be used for treating the veneers. Retentions of preservatives shall be as per IS 401 depending upon the proposed end use.

All the Veneers shall be given preservative treatment by one of the water soluble fixed type treatment, Copper Chrome-Boron Composition. (CCB) as per IS 401. The treated Veneers shall than be dried having moisture content less than 6%. The Veneers shall be glued together, by keeping all the grains in one direction, with BWP grade synthetic resin adhesive conforming to IS 848. The Veneers having moisture content less than 6% so glued, shall be pressed in hot press at high temperature of 140 degree C to 180 degree C. and pressure 1.4 to 1.8 MPa. The net absorption of preservative in LVL when tested as per IS 2753 shall not be less than 8.0 kg/m^3 Veneers shall be scarf joined only length wise and not in the direction of width with EWP type synthetic resin adhesive. However, the length of individual Veneer shall not be less than 600mm.

Moisture Content

The average moisture content of three test specimens, when determined in accordance with IS 1734 (Part 1) shall be between 5 to 15%.

g) **Laminated Veneer Lumber (LVL) Door Shutters**

This specification lays down requirements regarding types, sizes, material, construction, workmanship and finish, performance evaluation, sampling, measurements, rates and testing of Laminated Veneer Lumber (LVL) door shutter for use in domestic buildings, offices, schools, hospitals, etc. This specification does not cover large size door shutters for industrial and special buildings such as workshops, garages, godowns etc.

The material of each lot shall be supported by a certificate to that effect:

Each lot of LVL materials shall be accompanied by the test reports. Fabricated shall take up manufacturing of shutters only if provisions of clause mentioned above fulfilled, failing which, shutters so manufactured are liable for rejection.

Panelling Materials

Plain Particle Board : Plain particle boards used for panels shall be FPT-1 conforming to IS 3087 and shall have been bonded with BWP type of synthetic resin adhesive as per IS 848.

Pre-laminated Particle Board : Pre-laminated particle boards used for panels shall conform to IS 12823. The plain particle boards used in pre-laminated particle boards shall be as per stated above.

Medium Density Fiber Board : Medium density fibre board used for panels shall confirm to exterior grade as per IS 12406 made from agro-forest products or agricultural wastes or natural fibers.

Pre-laminated Medium Density Fiber Board : Pre-lamination in pre-laminate medium density fiber board shall confirm to the requirements such as Abrasion Resistance, Resistance to Steam, Crack Resistance, Resistance to Cigarette Burn and Resistance to Stain as specified in IS 12823. The medium density fiber board used in pre-laminated medium density fiber board shall be as per stated above.

Glass: Glass for glazing shall confirm to IS 2835 or IS 2553. The use of other types of glass, such as frosted glass, wired glass may also be specified by the Engineer-in-Charge.

Wire Gauze : Wire gauze shall generally confirm to IS 1568 and shall be regularly woven with equally spaced galvanized mild steel wires of 0.63 mm nominal diameter in both warp and weft directions to form aperture of average width 1.40 mm.

h) **Construction and Workmanship**

Laminated Veneer Lumber (LVL) paneled, glazed and panelled and glazed shutter shall be constructed in he form of LVL framework of stiles and rails with panel inserted conforming (as per stated above) of plain or perlaminated particle board, plain or perlaminated medium density fibre board, wire gauze or glass. The panels shall be fixed by either providing grooves in stiles and rails and beadind as specified. The stiles top rails, lock rails and bottom rails shall be jointed to each other by mortice and tenon joints. Rails having width of 150 mm or more shall have plain double tenon joints. Other rails shall have single tenon joints. The bottom lock and top rails shall be inserted 25+3 mm short of the width of stiles to form a stub mortice & tenon joint. After assembling shutters complete with panels, Bamboo pins of 6 mm dia shall be fitted on each tenon and mortice joint by drilling suitable size of holes (2 pins per joint for rail width upto 150 mm and 3 pins for rails of greater width). All the four edges of shutter shall be beaded with 12 mm thick rubberwood /plantation wood lipping. Lipping shall be seasoned and chemically treated. Lipping on top and bottom rails shall be of one piece and lipping on stiles may be in two pieces. All lippings shall be glued to shutter with water resisting glue (Synthetic rubber passed adhesive) at the rate of 0.15 kg/m^2.

All members of the shutters shall be straight, smooth and with well planed faces at right angles to each other. Any wrap and bow shall not exceed 1.5 mm. The right angle for the shutters shall be checked by measuring the two diagonals from one extreme corner to the opposite one and the difference between the two diagonals shall not be more than 3 mm.

Beading : All the panels except glass and wire gauze shall be fixed with grooves but additional beading may be provided either on one side or on both the sides, if so specified. In so far as glass and wire gauze panels are concerned, beading shall be provided without grooves. In such a case where beading is provided without the grooves, the beading shall be only on one side, the other side being supported by rebate from stiles. The beading shall have a size not less than 15 mm x 10 mm. It can be fixed by suitable handless nailing or screwing. The beading shall be of plantation timber section, preservative chemically treated of fixed type as per IS 401–1982.

Stiles, top rails, bottom rails and lock rails of shutters shall each be made in one piece of LVL, only.

Muliions and glazing bars shall be stubtenoned to the maximum depth which the size of the member wood permit or to a depth of 25 mm, whichever is less.

The minimum depth of grooves of stiles and rails shall be 12 mm for all types of panelling. The panels shall be framed into grooves to the full depth of groove leaving an air space of 1.5 mm and the faces shall be closely fitted to the sides of the groove.

LVL shutters shall be manufactured in factories under controlled conditions.

i) **Panelling**

Plain and perlaminated Particle Board Panelling : The panels shall be made of one piece of plain or prelaminated particle board of thickness 12 mm or more.

Wire Gauze Panelling : Wire gauze panel shall be so designed that no single panel shall exceed 0.5 sqm. in area.

j) **Rebating**

In case of double leaved shutters, the meeting of the stiles shall be rebated either splayed or squire type as per IS 1003 (part-1).

k) **Gluing of Joints**

The contact surfaces of tenon and mortice shall be treated before putting together as per IS 1003 (part-1). All the tenon and mortice joints should be glued together and pinned to full thickness of the door with Bamboo pins.

l) **Tolerances**

Tolerance on the size of door shutter shall be +3 mm and in thickness +1.2 mm.

m) **Location of Fittings and Accessories**

Each door shutter shall be fixed to the frame with four hinges, unless otherwise specified by the Engineer-in-Charge, of the type specified.

The lock rail of door shutters, where provided, shall be so placed that its centre line is at a height 850+5 mm from the bottom of the shutter. Hinges and other fixtures shall be fixed to shutter with full threaded steel screws after coating the screws with adhesive such as fevicol etc. For fixing of hinges, holes of 3.5 mm diameter and 52 mm length shall be bored and No. 10 full threaded parallel shank steel screws, 50

mm long, coated with adhesive shall be used. In no circumstances screws shall be hammered into board.

Cleats and blocks made of LVL wood shall be fixed to door shutter, if required, by the user as per size and shape approved. Pull bolt or sliding door bolt etc. shall be provided in the door shutter at a height of 850 mm from bottom of shutter. These shall be fixed to shutter as per method of fixing described above.

For rescrewing, a plastic sleeve of appropriate diameter shall be inserted into the hole and then fixing with full threaded screws shall be done. Fittings other than hinges shall be provided as per scheduled by the user. The fittings shall conform to specifications as described above.

Panelled shutter may be provided with louvers of vision panels as specified. Where such a provision is made, the position, size and shape of louver or vision panel opening shall be as specified.

n) **Finish**

All the four edges of the shutter shall be squire. The shutter shall be free from twist or warp in its plane. Panels of the door shutters shall be flat and well sanded to a smooth and level surface. All the surfaces shall be delivered without protective coat of wood primer polish or varnish.

o) **Glazing**

Glazing in the shutters of door and window shall be as per in specifying sizes of the openings or panels of glass, the first dimension shall be width. The glass shall be embedded in putty and secured to the rebate by the wooden beading of suitable size and shape.

p) **Fixtures**

Fixtures for doors, windows, furniture, etc. shall be as shown on drawing or specified in the “Schedule of Fixtures”. However minimum number of fixtures shall be as follows :

1. **For external single leaf door :**

- 6Nos hold fast or anchor bolts.
- 3Nos 100mm long SS hinge
- 10mm dia & 300mm long SS tower bolt on inside face.
- Mortise lock & latch either barrel type or rectangular type.
- SS doorknob or handle on both faces.
- SS Door stopper with EPDM stay piece.

- Heavy duty automatic door closer.
- Rain drip

2. **For external double leaf door :**

- 6Nos hold fast or anchor bolts.
- 3Nos 100mm long SS hinge on both shutters.
- 10mm dia & 300mm long SS tower bolt on inside face on both shutters.
- Mortise lock & latch either barrel type or rectangular type.
- SS doorknob or handle on both faces.
- SS Door stopper with EPDM stay piece.
- Heavy duty automatic door closer on active shutter.
- Rain drip

3. **For external single leaf window :**

- 6Nos hold fast or anchor bolts.
- 3Nos 100mm long SS hinge
- 10mm dia & 300mm long SS tower bolt on inside face.
- SS pull ring minimum 6mm thick and 50~75mm dia.
- SS window stay piece.

2.02.00 **Partitions**

These shall be conform to drawings an all details. No unsightly nail marks etc. shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

a) **Materials**

Gypsum Board conforming to IS 2095 (Part-1)

Non asbestos multi-purpose cement board conforming to IS 14862
Tapered edge calcium silicate board

Tapered Edge Calcium Silicate Board is manufactured from Siliceous and Calcareous materials reinforced with fibers. The boards are made in a laminar process and then autoclaved to give a stable crystalline structure. It is lightweight and can be fixed to either side of timber, aluminium or lightweight galvanized metal sections. The partitions are non-load bearing and can easily be assembled at site.

b) **Installation**

The G.I. frame and board partitions shall be fixed as per nomenclature of the item and directions of Engineer-in-Charge.

c) **Jointing & Finishing**

Joints of the boards are finished with specially formulated joining compounding and fiber tape to provide seamless finish. Board surface can be decorated with any type of paint, wall paper, wood veneer & hard laminates. Services should be incorporated before commencement of board fixing.

d) **Fitting and Fixtures**

It is easy and simple to attach different fittings to wall panelling boards. Inclined nails can be fixed to the boards itself for light materials. For heavier materials the fastening should be centered on internal stud work or steel or wood frame behind the boards, fixed before boarding. Services should be incorporated before commencement of board fixing.

e) **Tolerance**

Tolerance in dimensions shall be ± 5 mm.

2.03.00 **UPVC-Door Frames**

a) **Material**

Polyvinyl chloride Resin suspension grade is the basic raw material for forming PVC compound. PVC resin then is mixed with chemicals like Calcium, Stearate, Hydrocarbon Wax, Titanium Dioxide, Calcium Carbonate, Acrylic processing aids. Further, additives like impact modifiers, pigments, epoxy plasticizer, UV stabilizer, lubricants, chemical blowing agent etc. are added. The purpose of adding the chemicals and additives is to impart cellular structure, strength, surface finish, colour and resistance to fading by light rays. These chemicals are mixed in the desied proportion and shall be used in the formulation of PVC material and for free and smooth extrusion of PVC profiles.

b) **UPVC Door Frame**

UPVC door fame shall be made of PVC material conforming to IS 10151. The door frame shall be made from extrude UPVC section having overall dimensions of 48 x 40 mm or 42 x 50 mm having wall thickness of 2.0 mm ± 0.2 mm. Corners of the door frame to be jointed by M.S. galvanized brackets. Joints mitred and plastic welded. The hinge side vertical outer frames shall be reinforced by galvanized M.S. Tube of size 19 x 19 mm of wall thickness 1 mm ± 0.1 mm and a tie rod shall be provided at the bottom of the frame. The frame shall be fabricated in factory as per nomenclature of the item and directions of Engineer-in-Charge.

c) **Fixing of Frames**

The frames are to be fixed in prepared openings in the walls. All civil work and tiling should be completed before the fixing of the frames. The fames are to be fixed directly on the plastered wall. In case tiling is to be done in the place the fames are to be fitted, a 50 mm strip should be left untiled at the location where the frames are to be fitted. The frames are erected in the prepared opening such that the vertical members of the door frame are embedded 50 mm in the floor. The frame shall be fitted truly in plumb. One bolt shall be fixed at 200 mm from the top member and one bolt shall be fixed at 200 mm from the floor. The third anchor bolt shall be fixed in the centre. The top horizontal member shall be fixed using two 65/100 size anchor bolts or screws at a distance of 200 mm from both the corners.

2.04.00 **PVC Door Shutters**

The shutters shall be fabricated at factory as per nomenclature of the item and directions of Engineer-in-Charge. Shutter shall be made of PVC material conforming to IS 10151.

24 mm thick PVC Door Shutter
30 mm Thick PVC Door Shutter
Sampling and Criteria for Conformity

a) **General Precautions**

The test specimens shall not have been exposed to a temperature below 400C for 24 hours immediately preceding the test and shall be free from all / visible moisture. The specimen shall be inspected and any specimen with visible flaws shall be discarded.

If the test specimen fails because of mechanical reason, such as failure of testing equipment or improper specimen preparation, it shall be discarded and another specimen taken.

b) **Sampling**

Sampling criteria for conformity shall be in accordance with IS 4020 (Part-I)

Lot in any Consignment of shutters shall be of the same grade and type and manufactured under similar conditions of production which shall be grouped together to from a lot.

The number of shutters to be selected at random from a lot shall depend upon its size.

c) **Fixing of Shutters**

PVC door shutters shall be side hung on three bolt hinges of size 100 mm, one at the centre and the other two at 200 mm from the top and bottom of the shutter. The flat of the hinges shall be neatly counter sunk in to the recesses cut out to the exact dimensions of the hinge flap. The door shall be drilled on the thickness to fit hinges. Screws for fixing the hinges shall be screwed in with screwdrivers and not hammered. The length of the screws should be 8 mm / 30 mm. The hinges used should be of stainless steel.

d) **Tolerance**

The tolerance on the width and the height of the door shall be ± 5 mm and the tolerance on the nominal thickness of the door shall be ± 2 mm.

e) **Fittings**

Fittings shall be provided as per scheduled of fittings decided by Engineer-in-Charge. In moisture prone areas M.S fittings and screws should not be used. Hardware such as handles, tower bolt, stopper, buffer etc. should be directly screwed (not pre-drilled) and fitted on the door.

2.04.00 **PVC Door Frame**

Solid PVC Door Frames consisting of section 50 x 47 mm shall be fabricated from 5 mm PVC sheet having density of 600 kg./cum. The sheet used may be in plain colour, printed design or prelam veneer shade as approved by the Engineer-in-Charge. The weight per running metre of the door frame including reinforcement should be a minium of 1.5 kg./sqm. The depth of the rebate of door frame shall be 10 mm. Frames shall have smooth surface, without any warping or bending in any member. All the parts of the door frame are to be jointed to each other using solvent adhesive conforming to IS 14182. A tolerance of ± 3 mm. shall be permitted in the specified dimension of PVC section in the door frames.

The solid PVC door frames shall be fabricated in factory as per nomenclature of the item and directions of the Engineer-in-Charge.

Fixing of Frames : As stated earlier

2.04.00 **Panel PVC Door Shutter**

Panel PVC Shutters are factory made shutter and shall be brought to site fully assembled. The Solid Panel PVC Door shall be fabricated from 5 mm PVC sheet. The sheets used may be in plain colour, printed design or prelam veneer shade as approved by the Engineer-in-Charge. The shutters shall be fabricated at factory as per nomenclature of the item and directions of the Engineer-in-Charge.

a) 30 mm thick panel PVC door shutters.

2.05.00 **Fibre Glass Reinforced Plastic (FRP) Door Frames**

Door frames shall be three legged of cross section 90 mm x 45 mm having single rebate of size 32 mm x 15 mm to receive shutter of 30 mm thickness. The frame shall be made of laminate of thickness of 2 mm and shall be filled with wooden blocks of exterior grade MDF or seasoned and treated hard wood inside the laminate in all the three legs of the frame. The frame to be moulded by either hand lay up to resin transfer moulding process. The process shall consist of laying gelcoat at 1000 gms./sqm. and laid over with layer of FRP Mat (CSM mat) gelcoat and FRP (CSM Mat) are defined in IS 14856. The CSM mat shall be bonded with Isophatholic resin in the ratio not less than 1:2 (One part of Mat to two parts of Isopathlic resin and fillers & additives) by weight. The edge shall be sealed with gelcoat and FRP mat to obtain smooth finish. Sufficient roving shall be laid in the corner to have smooth curve while laying the CSM mat.

a) FRP door shall be manufactured as per specifications laid down in IS 14856, nomenclature of items & direction of Engineer-in-Charge.

b) **Tolerance :** Tolerance of size of frame to be ± 2 mm. and on size of rebate to be +1 mm.

c) **Finish :** The surface of the moulded frame shall be free from any visible defects such as small pores, crazing, blistering, wrinkling, impurities, defective impregration, colour bolts and aggregate defects, as mentioned in IS 14856. Scattered pin holes duly repaired and finished by applying resin and not noticeable shall be acceptable. Frame laminate shall be flat and shall have smooth and level surface. Laminate shall be finished in colour and shade as approved by Engineer-in-Charge.

d) **Fixing of Frame :** As stated earlier.

2.06.00 **Fibre Glass Reinforced Plastic (F.R.P.) Shutters**

a) F.R.P. Shutters shall be manufactured conforming to the specifications as per IS 14856 and nomenclature of item & direction of Engineer-in-Charge.

b) Blocks of any seasoned hard wood of bulk density not less than 450 kg / cum At 12 per cent moisture content or any other material of sufficient thickness and length shall be provided inside the shutter at suitable place to hold fittings and fixtures such as aldrops, tower bolt, handle, sliding door bolt, mortice lock etc. Blocks for hinges shall be provided at three locations, unless otherwise specified by the purchaser. One at the centre and other two at 200 mm from the top and the bottom of the shutter. Blocks shall be provided at predetermined places in the shutter so as to fix hinges mortice locks, tower bolts, aldrops, door closures, etc. The finished surface shall be buffed and polished with wax.

c) **Location of Fittings and Accessories :** The lock rail of door shutters shall be so placed that is centre line is at a height 850 + 5 mm from the bottom of the shutter. Door shutter shall be fixed to the frame with three hinges, unless otherwise specified by the purchaser, of the type specified. These locations shall be, one at centre and other two at 200 mm from the top and the bottom of the shutter, where blocks have already been provided and suitable location by depressing the profile has been made. Screws for fixing the hinges shall be screwed in with screwdrivers & not hammered. The length of screw should be 8/30 mm. The hinges used shall be stainless steel or aluminium.

d) **Sampling & Criteria for conformity :** As stated earlier

e) **Finish :** Stated earlier

f) **Fixing of Shutter :** Stated earlier

g) **Tolerance:** Stated earlier

2.07.00 **Solid PVC Fome Profile Doors**

a) **Solid PVC Foam Profile Frame**

Solid PVC foam profile frame doors are made from solid PVC foam profiles 60 x 30 mm with integral skin cut to required size. Doors are provided with naturally strong stiffener frame and sandwich panelled to offer sound and heat insulation with pressure laminate/infill panel to provide scratch resistance surface. The frame shall be fabricated in factory as per nomenclature of the item and directions of the Engineer-in-Charge. PVC door frame should have shore hardness more than 70.

b) **Fixing of Frames:** Stated earlier

2.08.00 **Solid PVC Foam Shutters**

Solid PVC foam shutters are made from solid PVC foam profiles with integral skin. Door are provided with naturally strong stiffener frame and sandwich paneled to offer sound and heat insulation with pressure laminate/infill panel provides scratch resistance surface. Door shutters can be nailed, screwed, drilled, glued, sawn lapped or welded just like wood and characterized by excellent screw holding strength (200 kgf.).

a) **28 mm Thick Door Shutters**

Profile is cut in required length to make vertical & horizontal site. Mitered cut joint are made using solvent based PVC adhesive & epoxy solvent. GI 'C' stiffener 39 x 19 x 19 or 40 x 20 x 19g. M.S. Pipe is fixed in the grooves made in frame. Telescopic polymeric corners are provided at corners are provided at corners for better rigidity. Infill panel 3 mm thick HPL sheet is fixed with is fixed with csk screws of required size to the profile frame as specified. Mirror image of shutter frame is jointed using solvent based PVC adhesive as well as csk type sheet metal screws of required size at four corners at top & bottom. Additional bonding strength is provided by using silicon sealant epoxy sealant at joints. Lock rail is provided by using PVC profile & 'C' type GI stiffener 40 x 10 in the groove & fixed with adhesive to frame & infill. Decorative corner moulding is fixed to impart elegant look.

The fabrication shall be done in done in factor as per nomenclature of the item and directions of Engineer-in-Charge.

b) **Sampling and Criteria for conformity :** Stated above

c) **Fixing of Shutters:** Stated above

d) **Tolerance:** Stated above

e) **Fittings:** Stated above

2.09.00 **Factory Made Fibre Glass Reinforced Plastic Chajja**

F.R.P. chajja shall be 4 mm thick of required colour/size, design and drawing as approved. The chaja shall have smooth gradual slope curvature for easy drainage of water & shall be factory manufactured as per nomenclature of item & directions of Engineer-in-Charge.

Material

1) Glass Fibre (chopped strand mat) shall be as per IS 11551
2) Unsaturated Polyester Resin shall be as per IS 6746
3) Surface Burning Characteristics of Building Material – ASTM E84-77a
4) Unsaturated Polyester Resin Gel coat shall be as per IS 6746
5) Curing Agents – Cobalt Napthanate and MEKP
6) Test of Products – IS 14425
7) Glass Fiber Roving – IS 11320

The F.R.P. chajja laminate shall be water and chemical resistant and shall have very high transit strength to weight ratio and high modules of elasticity, good textile processing and excellent fiver reinforcement properties. The laminate shall have low coefficient of thermal expansion and a high thermal conductivity and high dielectric constants. The F.R.P. laminate shall be diversionally stable, shall have moisture and corrosion resistance.

Tolerance

Tolerance of ± 10 mm in overall size of FRP chajja is permissible.

2.10.00 **Workmanship**

2.10.01 **General**

Skilled carpenters as per details shown on drawing or instructed by the Engineer shall do the work.

Framing timber and other work shall be close-fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc. that will come in contact with masonry after fixing shall be given two coats of approved paint before fixing. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood, which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood and particleboard. The edge of all plywood, block board and particle board shall be finished with teakwood lipping unless otherwise shown on drawings.

Fixing for frames and partitions shall generally be with 40 mm x 6 mm x 300 mm long MS holdfasts bifurcated at end and grouted with 1:2:4 cement concrete. The gap between masonry and external door and window frame shall be caulked with polysulphide mastic. M. S. grills or guard bars shall be provided to windows where called for in the drawings or schedule of items.

2.10.02 **Finish**

All carpentry work after finishing shall be sand papered smooth. Prime coat paint shall be given after inspection of the Engineer to all surfaces other than those, which shall be subsequently polished or covered with laminated plastic sheet.

2.10.03 **Surface Treatment**

When shown on drawings or called for in Schedule, decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of approved brand and brought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instructions. The edge of sheets shall be protected by teak lipping or bevelled as shown on drawings.

3.00.00 **ACCEPTANCE CRITERIA**

3.01.00 **Door and Window Frames**

All frames shall be square and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

3.02.00 **Door and Window Shutters**

Shall be of proper size, shape and design and free of warp. When fixed to frames, these shall operate smoothly without jamming and all latching or locking devices shall engage properly without undue pressure.

3.03.00 **Pelmets, Furniture, etc.**

3.03.01 **General**

These shall conform to drawings in all details. No unsightly nail marks etc. shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

3.03.02 **Pelmets**

Shall be checked for rigidity of fixing and adequate clearance of fixture.

3.03.03 **Cupboard Shutters**

Shall operate smoothly without jamming and locks, holding chains, bolts and double ball catches shall engage securely. Single ball catches shall not be used.

3.03.04 **Drawers**

Shall operate smoothly and have backstops to prevent them from being pushed too far. Locks shall engage securely.

3.03.05 **Loose Furniture**

When placed on level surface tables tops etc. shall be horizontal and the pieces stand stably on legs or supports.

4.00.00 **RATES**

Rates shall be unit rates including preservatives, shop coats, primers varnishing, polishing etc. against items mentioned in Schedule. No separate payment will be made for fixing caulking etc. unless separately provided for in Schedule.

5.00.00 **METHOD OF MEASUREMENT**

5.01.00 **Door and Window Frames, Handrails etc.**

Woodwork in frames handrails etc. shall be measured for the volume of timber used, i.e. the minimum theoretical rectangular section from which the shape can be obtained multiplied by the length of timber required. In computing the length, timber required for tennons, scarves, embedding to walls over the finished length shall be added. Mitred pieces shall be measured along the longest length.

5.02.00 **Holdfasts**

Shall be measured for actual number used.

5.03.00 **Door and Window Shutters**

Shall be measured for actual outer area of shutters for different thickness and types described in Schedule.

5.04.00 **Glass and Glazing**

Shall be measured and paid separately under relevant items.

5.05.00 **Fittings and Fixtures**

Shall be measured separately in actual numbers used for different sizes and types described in Schedule.

5.06.00 **M S Grills and Guard Bars**

Shall be measured and paid separately under relevant items.

5.07.00 **Partitions, Paneling, etc.**

Shall be measured for actual area excluding door shutters. Door shutters shall be measured and paid separately under relevant items.

5.08.00 **Pelmet, Shelves, etc.**

Shelves shall be measured for actual area of finished surface. Pelmets shall be measured for length of different types enumerated in the Schedule.

5.09.00 **Furniture**

Shall be measured for actual number of each type.

6.00.00 **IS CODES**

Some of the important relevant Codes for the Sections are:

IS : 4021 - Timber door, window and ventilator frames

IS : 1003 - Timber paneled and glazed shutters.

IS : 2191 - Wooden flush door shutter (Cellular and hollow core type)

IS : 2202 - Wooden flush door shutters (Solid core type)

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SECTION-XX

TECHNICAL SPECIFICATION
FOR
METAL DOORS, WINDOWS, VENTILATORS, LOUVRES, CURTAIN WALL, STRUCTURAL GLAZING, ETC.

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SECTION-XX

TECHNICAL SPECIFICATION FOR METAL DOORS, WINDOWS, VENTILATORS, LOUVRES, CURTAIN WALL, STRUCTURAL GLAZING, ETC.

1.00.00 SCOPE

The work in general shall consist of supplying and/or erecting and installing of all metal doors, windows, ventilators, louvers, glazed partitions, etc. as shown on drawings with all materials complete excluding supply of glass and glazing. The scope of work shall also include the assembly and the Owner from the store at site shall supply erection of all doors, windows, louvers, glazed partitions, etc. for which fabricated materials. Supplying and/or fixing of all door and window accessories and hardware are also included in the scope.

2.00.00 INSTALLATION

2.01.00 Materials

Steel sections used for fabrication of doors, windows etc. shall be standard rolled steel sections specified in IS: 1038 and IS: 1361 or as specified in drawing and schedules.

Steel sheets for frames, shutters, louver blades etc. shall be of gauge mentioned in drawings and schedules.

Aluminium sections for fabricating doors, windows, partitions, etc. shall be extruded sections conforming to IS: 733 and 1285 for chemical composition and mechanical properties. The stainless steel screws shall be grade AISI 304.The alloy used shall conform to IS Designation HE 9-WP of IS: 733.

Hardware and fixtures shall be as specified in “Schedule of Fixtures” and the best quality from approved list of manufacturers shall only be used. The Tenderer shall specifically state the list of manufacturer’s materials he proposes to use. “Schedule of Fixtures” is for the purpose of stating the minimum requirement and improper alignment or faulty operation due to inadequate strength of hardware or fixture shall entirely be the Contractor’s responsibility.

All hardware and fixtures shall be able to withstand repeated use. Door closers shall conform to IS: 3564 and shall be suitable for doors weighing 61-80 Kg. unless otherwise stated in schedule. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the closer replaced free of charge. Concealed door closers shall be either floor mounted or transom mounted, suitable for installation with metal doors. It shall conform to the performance requirements & endurance test stated in IS: 3564 Appendix- A.

The Contractor shall submit **three** samples of each type of hardware to the Engineer for approval. The approved samples shall be retained by the Engineer for comparison of bulk supply. The samples shall be returned to the Contractor towards the end for incorporation in the job.

The mastic for caulking shall be of best quality from a manufacturer approved by the Engineer. In general, the mastic for fixing of metal frames shall be as per IS: 1081 and/or as approved by the Engineer.

2.02.00 **Fabrication**

2.02.01 **Steel Doors, Windows, Ventilators, Louvers, etc.**

a) **Door Frames**

Frames shall be fabricated from 16 G sheets. They shall be mortised, reinforced, drilled and tapped for hinges and lock and bolt strikes. Where necessary, frames shall be reinforced for door closers. Welded construction with mitered corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose “T” masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be supplied. Frames shall be brought to site with floor ties/weather bars installed in place.

b) **Double Plate Flush Door Shutters**

Door shutters shall be 45 mm thick, completely flush design and shall comprised of two outer sheets or 18 G steel sheets, rigidly connected and reinforced inside with continuous vertical 20 G stiffeners, spot welded in position at not more than 150 mm on centers.

Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally as shown on drawing by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and heads, shall have proper level on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting stile edges beveled or rebated. Where shown on drawing or called for in the schedule of items the

doors shall be sound deadened by filling the inside voids with mineral wool or other suitable approved materials.

Doors shall be mortised, reinforced, drilled and tapped in shop for hinges, locks and bolts. They shall also be reinforced for closers, push-plates and other surface hardware where necessary. Any drilling and tapping required for surface hardware shall be done at site. Where shown in drawing, provision shall be made for fixing glazing, vision panels, louvers etc. glazing mouldings shall be of 18 G steel or extruded aluminium sections with profiles shown in drawing and suitable for fixing 6 mm glass. Louvres blades shall be V or Z shaped and made out of 16 G sheets.

c) **Single Sheet Door Shutters**

Single sheet doors shall be made from best quality 18 G mild steel sheets and shall present a flush surface on the outside. The inside shall be stiffened with semi-tubular edge and central stiffening rail, which shall convey the lock and other furniture. The frames shall be made from best quality 16 G mild steel sheets.

Wherever required as shown on drawings, provisions for fixing glass panes, louvers, etc. shall be made.

The manufacturing shall be done as specified in “Double Plate Flush Door Shutters”.

d) **Sliding Doors**

These shall be manufactured as per drawings and specification. These shall be fabricated from mild steel sheet.

The shutter shall be double or single leaf shutter as specified. The shutters shall be fabricated of specified size of M.S. angle iron frame diagonally braced with the same size of M.S. angle riveted/ welded together with 3mm gusset plate at junction to form a rigid frame. Sliding doors shall be either double plate or single plate construction as called for in drawings and schedules made out of 18 gauge steel sheets with adequate stiffeners. The Contractor shall specify the weight of the door in his shop and submit the manufacturer’s catalogue of the sliding gear he proposes to use. Where shown on drawings or call for in the Schedule of Items, these shall be provided with top and bottom guide rails of specified size angles or T-irons and 25mm diameter pulley or with 25mm diameter ball bearing at the bottom and guide block with steel pulleys at the top. The shutters shall be provided with locking arrangement, handles, stoppers, and holdfasts, other fittings as specified in the description of item. Doors shall close positively to exclude rainwater from seeping in. When called for in schedule, sliding doors shall withstand specified wind

loads without buckling or jamming. The door shall slide freely under all ambient conditions.

The guide rail shall be sufficiently long and continued along the wall on both ends so that the sliding shutters can against the walls, giving full opening when so required.

FIXING : The guide rail shall be fixed to the floor by means of anchor bolts embedded in the cement concrete floor. The steel section at the top shall be suitably supported from the walls. Two channel sections shall be suitably fixed vertically below the extreme clamps in the wall and floor to avoid the shutter from going out of the supports at top and bottom. A suitable clamping arrangement will be provided at either end of the opening to avoid the shutters from rolling back into the opening.

The adjoining work damaged in fixing shall be made good to match the existing work.

e) **Door Threshold**

Door threshold shall be provided as shown on drawing. Doors without threshold shall have bottom tie of approved type.

f) **Steel Windows, Sashes, and Ventilators etc.**

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions and as shown on drawings. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc. or as shown on drawings or called for in the Schedule of Items.

All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are shown on drawings, the individual window units shall be joined together with requisite transoms and mullions as shown on drawings. All windows shall be outside glazed fixed with putty or metal glazing beads as shown on the drawings and/or specified under Schedule of Items. Where aluminium glazing beads are specified they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Indal Section No. 2209) unless otherwise shown on drawings. Aluminium beads shall be given one coat of zinc chromate primer before fixing to windows.

2.02.02 **Aluminium Door, Windows and Frames**

Extruded sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors, frames, mullions, transom etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum 0.6 mm thickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

Where required factory made evenly baked powder coated coloured aluminium extruded sections shall be used. DFT shall not be less than 0.8 mils. Colour shall be as per Colour Schedule or as per instruction of the Engineer-in-Charge.

All work shall be fitted and shop assembled to a first class job and ready for erection. Shop joints shall be made to hairlines and then welded or braced by such method as will produce a uniform colour throughout the work. Work on the above, other than described, shall be carefully fitted and assembled with neat joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and on edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. Glazing beads shall be snap fit type without visible screws and shall be of sizes to accommodate 6 mm thick glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

2.02.03 **Fire Door**

Hollow metal fire rated doors should be as per IS 3614 Part-1 & Part-2.It should be made of pressed Galvanised steel conforming to IS 277. It should be tested at CBRI or ARAI for maximum rating of 2 hrs with vision panel. Test certificates should be available for vision lites/ panels as part of the fire door assembly. Independent glass test certificates will not be accepted. Manufacturer test certificate shall cover doors both single and double leaf and all doors supplied should be within the tested specimen, deviation in specification and sheet thickness other than what is mentioned in the test certificates will not be allowed. Proper label conforming the type of door and the hourly rating is mandatory.

Door Frame : Door frame shall be double rebate profile of size 143 x 57 mm made out of 1.60mm (16 gauge) minimum thick G.I. sheet (zinc coating not less than 120gm/sqm) duly filled with vermiculite based concrete mix. Suitable for mounting 60 minutes fire rated door shutters. The frame is fitted with intumuscent fire seal strip of size 10 x 4 mm (minimum) all-round the frame and fixing with dash fastener of approved size and make, including applying a coat of approved brand fire resistant primer. Frames shall be metered and field assembled with self tabs. All provision should be mortised, drilled and tapped for receiving appropriate hardware. Rubber door silencers should be provided on the skirting jamb. Frames should be provided with

black plate bracket for installation on a finished plastered masonry wall opening. Once frame installed should be grouted with cement & sand slurry of approved proportion necessary for fire doors on the clear masonry opening.

Door Shutter : Door shutters will be 50 mm thick (unless otherwise stated in the drawing) of 60 minutes fire rating conforming to IS: 3614(Part-II) tested and certified as per laboratory approved by Engineer-in-Charge with suitable mounting on door frame, consisting of vertical styles, lock rail, top rail 100 mm wide, bottom rail 200 mm wide, shall fully flush double skin door with or without vision lite. Door shall be manufactured from 1.6 mm (16 gauge) minimum thick SWG G.I. sheet (zinc coating not less than 120gm/sqm) duly filled FR insulation material and fixing with necessary stainless steel ball bearing hinges of approved make (if mentioned in the drawing) including applying a coat of approved fire resistant primer. The internal construction of the door should be rigid reinforcement pads for receiving appropriate hardware. All doors shall be factory prepared for receiving appropriate hardware and provided with necessary reinforcement hinges, locks and door closers. The edges should be interlocked with a bending radius of 1.4 mm. For pair of doors astragals has to be provided on the meeting stile for both active and inactive leaf. 200 x 300mm Vision lite wherever applicable should be provided as per manufacturer's recommendation with a beeding and screws from inside. The glass should be 6 mm clear borosilicate fire rated glass of relevant rating of the door.

The door leaf and frame shall have passed minimum 250hours of salt spray test.

Paint : All doors and frames shall be finished with etched primer coating, stove zinc phosphate primer and thermosetting polyurethane aliphatic grade paint of approved colour.

Rate : Rate should include supply and installation of door and hardware set as mentioned in the door and hardware schedule.

2.03.00 **Structural Glazing**

Aluminium semi unitised vertical Structural glazing system with single glass vision panel and spandrel panel of approved make having main frame of verticals and horizontals made out of specially designed extruded aluminium sections to withstand wind pressure of 175 kg/sq.m at a height of 40m and fabricated, fixed at all levels, elevation and heights to the Masonry / RC walls with necessary clamps, brackets and anchor fasteners. All clamps and brackets shall be Mild Steel Hot dip galvanized minimum 80 microns thick and shall conform to IS: 4759-1996. The extruded aluminium section shall be anodised in approved colour with a anodic coating of minimum 20 microns. Extruded section shall be of 6063 T5 or T6 alloy conforming to ASTM B 221. Any other fastening straps, nuts, bolts, rivets, washers, Fire stops at all floor levels etc. shall be in stainless steel SS 304 grade. All tapes shall be of approved make.

The system shall be designed to withstand a wind pressure of 200 kg/Sqm and shall be fixed to the masonry/RC walls with necessary clamps, brackets and anchor fasteners, clamps and brackets shall be Hot dip galvanized minimum 80 microns thick, all complete as per manufacturer's manual and specifications. The spandrel panel shall have 50mm thick fiber glass insulation of 48 kg/cum density of approved make conforming to IS-8183 and 1.0 mm thick Twiga black tissue conforming to BS 476 Part 7. This insulation shall be enclosed in a GI tray fabricated out of 1mm thk. GI sheet and fixed to the glazing framework with stainless steel fasteners.

The gap between the GI framework and the concrete framework shall be sealed with Aluminium flashing fixed with stainless steel fasteners. All gaps shall be sealed with Silicone sealant of approved brand. Insulation should be provided in between the Structural glazing aluminium frame work (i.e., behind the spandrel glazed panel) and the structure. Providing 6 mm thick toughened fully tempered hard coated glass of blue/green/blue-green or approved colour having VLT = 35 to 50 % ,External reflectance= 6 to 15% ,Internal reflection = 8 to 15%, Solar factor = 0.36 to 0.43, U Factor = 2.8 to 3.0 W/sqm K etc.

2.04.00 **Aluminium Curtain Wall System**

2.04.01 **General**

1) Aluminium Curtain Wall System shall be designed for the following effects :

   a) Permanent Deformation, thermal expansion.

   b) Wind and seismic load

   c) Air and water infiltration or leakage.

   d) Lateral deflection per floor height

2) Unless otherwise specified the design of the system shall be prepared by the specialized firm for executing such works and submitted to the EIC / Department for approval after detailed scrutiny and checking design calculations and drawings.

3) The work shall bear five years guarantee. It will be obligatory on the part of the contractor to execute the work systematically and conduct the necessary mock-up unit tests, before taking up the work to the satisfaction of EIC / Department.

2.04.02 **Specification for Materials used for Curtain Wall**

1	Glazing	Glazing work shall be as specified in the description of the item and / or as described under the chapter Glass & Glazing of this book.
2	Framing system	Aluminium anodized extruded sections manufactured by reputed approved manufacturers, for all types of members like brackets, mullions, transom etc.
3	Sealant	As specified in the item or silicon sealant
4	Insulation	50 mm thick rock wool of minimum density 48 kg/cum sandwiched with black polythene sheet 100 micron on one side and aluminium foil of 100 micron on the other side or as specified by manufacturer at spandrel area. The surface after fixing insulation shall be plain without any distortion
5	Heat Reflective Toughened Glass	As specified elsewhere in the specification. Colour of any shade approved by the Engineer-in-Charge.

2.04.03 **Aluminium Alloy Extruded Sections**

Extruded sections to be used for fabrication of framing system for curtain walls shall be manufactured and supplied by approved reputed companies. In absence of specific extruded section, sections available conforming to BIS specification, manufactured by approved reputed companies, shall be used in the works. Dimensions and weights of the sections shall be as per approved drawings.

2.04.04 **Components, General specifications, Glazing, Panelling etc. for Curtain Wall System :** These shall be generally as per relevant Chapters in this book.

2.04.05 **Scope of Work**

2.04.05.01 **Preliminary Requirements**

i) The contractor shall design, test, fabricate, deliver, install and guarantee all construction necessary to provide a complete curtain wall system, all in conformity with the drawings and approval of the Engineer-in-Charge.

ii) Specification and all relevant construction regulations including providing any measures that may be required to that end, notwithstanding any omissions or inadequacies of the drawings,

iii) **The curtain wall system shall also include the following activities :**

a) Metal frames, glass glazing, spandrels, ventilators, finish hardware, copings, metal closure, windows etc.

b) All anchors attachments, reinforcement and steel reinforcing for the systems required for the complete installations.

c) All thermal insulation associated with the system. (d) All fire protection associated with the system.

d) All copings and closure and metal cladding to complete the system.

e) All sealing and flushing including sealing at junctions with other trades to achieve complete water tightness in the system.

f) Isolation of dissimilar metals and moving parts,

g) Anticorrosive treatment on all metals used in the system, (i) Polyester powder coating aluminium sections,

iv) **The contractor shall also be responsible for providing the following :**

a) Engineering proposal, shop drawings, engineering data and structural calculations in connection with the design of the curtain wall system.

b) Mock-ups, samples and test units.

c) Performance testing of the curtain wall framing and glazing assembly. (d) Co-ordination with the work of other trade.

d) Insulation with glass wool 48 kg/cum at spandrels area.

e) All final exterior and interior cleaning and finishing of the curtain wall system.

f) Protection.

g) As built record drawings and photographs.

h) Guarantees and warranties.

i) All hoisting, scaffolding, staging and temporary services.

j) Conceptualising and design of a suitable maintenance system for curtain glazing,

v) The water tightness and structural stability of the whole curtain wall system shall be the prime responsibility of the contractor. Any defect or leakage found within the guarantee period shall be sealed and made good all at the risk and cost of the contractor.

vi) The curtain wall system shall be designed to provide for expansion and contraction of components which will be caused by an ambient temperature range without causing buckling, stress on glass, failure of joint sealants, undue stress on structural elements or other detrimental effects, specific details should be designed to accommodate thermal and building movements.

2.04.06 **Design Requirements**

i) Curtain wall shall comply with all government codes and regulations, building bye-laws, if any.

ii) All curtain walling, individual aluminium and glass components and all completed work shall be designed and erected to comply with the following requirements.

2.04.06.01 **Basic requirement**

The basic design and architectural requirements shall consist of the size of window, net glass area, ventilator, configuration of windows and spandrels to be retained. However the contractor may propose alternatives on the construction details for approval of the Engineer-in-Charge, provided that all basic functional and architectural requirements are fulfilled.

2.04.06.02 **Quality Consideration and other Activities**

i) The contractor while submitting the detailed design calculations should submit the following information on the quality of materials to be used and other aspects as detailed below:

1) Metal quality, finishes and thickness

2) Glass quality, coating and thickness and proposed manufacturer's brand names.

3) Aluminium extruded sections including mullions and transoms together with structural calculations and proposed manufacturer's brand name and also the name of agency proposed for fabrication work.

4) Arrangement and jointing of components.

5) Field connections especially mullion to mullion and transom to mullion.

6) Fixing and anchorage system of typical wall unit together with structural calculations.

7) Drainage system and provision in respect of water leakage in the curtain wall system.

8) Provisions for thermal movements.

9) Sealant and sealing methods.

10) Glazing Method

11) Wind load and seismic load and any other specific load considered in the design

ii) Design concept over lighting protection link-up system of the curtain wall for connection and incorporation into the lighting conductor system of the building (Lighting conductor system of the building shall be done by other approved specialized agency).

iii) The maximum permissible structural tolerances of the building that the system has been designed to accommodate in case these tolerances exceed those specified in the specification.

2.04.06.03 **Tolerances :** Any parts of the curtain wall, when completed, shall be within the following tolerances:

1) Deviation from plumb level or dimensioned angle must not exceed 3 mm per 3.5 m length of any member, or 6 mm in any total run in any line.

2) Deviation from theoretical position on plan or elevation, including deviation from plumb, level or dimensioned angle must not exceed 9mm total at any location.

3) Change in deviation must not exceed 3mm for any 3.5 m run in any direction.

2.04.06.04 **Samples :** The contractor shall also submit samples of aluminium extruded sections; mullion and transom sections in lengths of 300 mm with the same finish and workmanship as per the tender proposals and 300 mm x 300 mm samples of glass for approval of the EIC. (samples to include exposed screws and other exposed securing devices if any).

2.04.06.05 **Ancillary Requirements to be fulfilled by the contractor**

i) The contractor / approved specialized agency shall submit a maintenance manual for the curtain wall system inclusive of all metal parts, glass and finish etc.

ii) During detailed design scrutiny and also during the actual execution of the work any additions and extra provisions that will have to be made as per theoretical requirements or site conditions shall be implemented and executed by the contractor at his own cost, without claiming any thing extra under any circumstances.

2.04.07 **Execution of work**

2.04.07.01 Performance Testing - General Requirements

i) Mock-up units shall be constructed by the contractor and tested to determine the structural stability as well as air and water infiltration or leakage at glazing beads and all other joints designed into the face of the building.

ii) After the approval of structural calculations and the drawing for construction of the curtain wall, one test unit for performance testing of the curtain wall shall be constructed by the contractor at an independent laboratory or at a laboratory approved by the Engineer-in-Charge.

iii) Erect mock-up under manufacturer's / Fabricator's direct supervision and employ workmen as they would be employed during the actual erection at the job site.

iv) The contractor shall submit to the Engineer-in-Charge the test procedures to be adopted, test schedule and location for testing before the work of actual testing is taken up.

v) Prior to the fabrication of test units, the contractor shall submit shop drawings and design calculations of the test unit for approval of the Engineer-in-Charge.

vi) The contractor shall not start the work of erection of curtain wall on site till the approval for the successful completion of the mock up test and clear instruction in writing to start the work is received from the Engineer-in-Charge.

vii) The decision of the Engineer-in-charge in respect of the procedure to be adopted, in conducting the mock-up test and the judgment over the net results, shall be final and binding on the contractor.

2.04.07.02 **Test of Wind Pressure**

i) The equivalent load of wind pressure or wind suction shall be given to the test unit as increasing or decreasing the inside pressure in the "pressure chamber" at which the test unit is fixed.

ii) The static wind pressure shall be applied up to 1.5 kpa at maximum wind pressure.

iii) The variation of dynamic pressure shall be of any approximate sine curve line.

iv) Deflection on each observational points of the test unit shall be observed and recorded under static pressure as described above.

v) Any damage and harmful permanent deformation on any parts except sealing materials shall not be found at maximum wind pressure.

vi) The deflection on the main structural parts in this condition shall not exceed :

1) 1/175 of the span between supports or 20 mm, whichever is less for vertical elements.

2) 1/250 of the span between supports for horizontal elements.

3) The extent of recovery of deformation, 15 minutes after the removal of the test load, is to be at least 95%.

2.04.07.03 **Test of Lateral Deflection per floor height**

i) Lateral deflection per floor height shall occur on the test unit, when the structural frame which fixes the test unit is deflected horizontally.

ii) The deflection of every ± 2.5 mm shall be increased up to ± 13 mm on the test unit (static deflection test)

iii) The dynamic deflection shall be applied up to ± 13 mm.

iv) The variation of dynamic deflection shall be of an approximate sine curve line, one period of 3 seconds.

v) The dimensions of the deflection on each observational point of the test unit shall be measured under the condition as described above and the damage shall be observed.

vi) Any damage and harmful permanent deformation shall not be found in any parts of the curtain wall except the damage to sealant at maximum deflection.

2.04.07.04 **Water-tightness Test**

i) Water shall be sprinkled to the Test Unit' under wind pressure.

ii) Pressure shall not be applied to the test unit.

iii) The volume of the sprinkling water in one minute shall be 5 litres per sqm minimum.

iv) All water leakage and drainage system at the joint and the open able sash of the curtain wall system shall be observed from the outside of the chamber.

v) Hold the test two times, in sequence as described below, conforming to the above mentioned conditions.

vi) Water leakage shall not be observed inside at all parts of the test unit during first water-tightness test.

1) Install the test unit.

2) Hold first water-tightness test.

3) Hold test of wind pressure as described above.

4) Hold second water-tightness test.

5) Lateral deflection test.

2.04.07.05 **Test Report :** The contractor shall submit five copies of test report to the Engineer-in-charge.

2.04.07.06 **Cost of Performance Test**

i) The contractor shall allow in his tender for the cost of the performance testing and fabrication, erection, corrections to and demolition of the test units including any special provision required in the testing laboratory for the tests mentioned above.

ii) The contractor shall allow for amendments and adjustments to the mock-up unit as instructed and required by the Engineer-in-Charge / Architect or the consultant.

iii) If the mock-up test unit fails to pass the initial testing, the contractor shall make the necessary corrections to the test unit and shall get the test unit retested by the testing laboratory until it passes the test.

iv) Cost of corrections to the test unit and the cost of retesting shall be borne by the contractor.

v) The contractor shall be allowed six calendar months time after the work is awarded to set up the test unit and conduct the required test as described above to the satisfaction of the Engineer-in-charge.

vi) In case the contractor fails to conduct the necessary tests as described above or fails to meet the required test results, without any genuine cause within the allotted period of six months, the Engineer-in-charge shall be free to rescind the contract with all costs including the forfeiture of E.M.D. and any other securities deposited by the contractor under the condition of contract.

2.04.07.07 **Record of Test and Drawings**

i) The testing laboratory shall keep the approved copy of the shop drawing and calculations of the test unit at testing laboratory during testing of test unit.

ii) The testing laboratory shall accurately and nearly record on the above mentioned shop drawings all changes, revisions, modifications etc. made to test unit, which shall become the record drawing.

iii) On completion of testing and after approval of the test reports the testing laboratory shall submit the final record drawings to the Engineer-in-charge.

2.04.07.08 **Fabrication and Erection**

i) Frames shall be square and flat, both the fixed and openable frames shall be constructed of sections, which have been cut to length, mitred and mechanically jointed at the corners, Sub-dividing bar of units shall be tenoned and riveted into frames.

All frames shall have corners welded to true right angles. For jointing hollow sections flash butt welding, argon arc welding or mechanical jointing by inserts shall be used. (Gas welding or brazing shall not be done). Concealed screws shall be used for joining the sub-units.

ii) The grid for the curtain wall system shall be fabricated carefully with aluminium extruded sections like mullions and transom in the exactly same pattern as per the final drawings with amendments if any received from the laboratory after conducting the mock-up unit test.

iii) The sizes of different members of the curtain wall system shall be exactly as adopted for the mock-up unit tests and the grid shall be fixed to the building member as shown in the drawing, received after conducting the mock-up unit test.

iv) Care should be taken to see that any gap between the frame and support and the frame **itself is sealed with silicon sealant.**

v) Finish of grid frame shall be either anodized, organic coating, backed enamel finish or as specified in the item of work, no visual variation in anodizing / colour shall be accepted.

vi) Care shall be taken to see that the curtain wall system is not deformed, damaged during erection and it shall be protected from direct contact with wet or intermittent wet cement concrete mortar etc.

2.04.08 **Representative of the contractor**

Full time attendance of a qualified civil engineer with sufficient experience in construction of curtain wall system shall be provided for erection of test unit, all testing and later on actual construction.

2.04.09 **Performance Guarantee**

The contractor shall provide a performance guarantee as indicated in the Schedule of Quantities for a period of five years, to provide for expenses to cover the risk and cost of rectification of defect, noticed during the five years guarantee period. Guarantee period shall start from the date of completion and handing over of the project.

2.04.10 **Measurements**

i) The breadth and the height of the finished work including the openable windows shall be measured in metres and cm and the net quantity for payment shall be calculated in sqm up to two places of decimal.

ii) The area to be considered for measurement shall be the net area of the exterior face of the curtain wall as fixed including the openable windows, if any, as part of the curtain wall.

2.04.11 **Rate**

The rate shall include the cost of all operations described above including the cost of materials, labour, design, shop drawings, erection and testing, mock-up test units, fabrication, erection, finishing, scaffolding, undertaking performance guarantee etc. No other claims of any kind pertaining to this work shall be entertained.

2.05.00 **Aluminium Sun Louver With Stringer System**

Plain panel Aluminium Sun Louver system as per manufacturers specification of approved colour, shall consists of panel 84 mm wide x 16 mm deep x 0.6mm thick in standard length of upto 6m. The panel shall be coil coated in a continuous paint line, double baked and roll formed from stove enameled corrosion resistant aluminium Alloy AA 5050/3005 for higher strength and roll forming characteristics. The panel shall be clipped on to a backed & enamelled aluminium stringer 33mm wide x 86mm deep made from 0.95mm thick backed & enamelled aluminium alloy AA 5050 (sl.mg.) in standard length of 5 m in white colour with cutouts to hold the panels in a module of 86mm c/c. The first stringers shall be fixed at 150mm from both ends and thereafter at a distance of 0.75mm c/c depending on wind load. The stringer shall be fixed to a suitable sub-structure/wall with Nut/Bolt and washer.

Paint Finish

Panel shall have exterior paint finish which will be of 3 layers:

The Anorcoat Pretreatment

The colour coating and

Transparent top coat

The paint used shall be epoxy based & finished with a polyamide/Nylon coating. The paint system shall have the following characteristics.

Coating thickness	:	24-32 Microns
Gloss	:	28 (+/-5)
Gloss Variation	:	+/-3 units (within delivery)
Adhesive Impact/Bending	:	No Loss of Adhesive
Durability	:	Higher Category
Humidity Resistance	:	Blisters less than size 2

2.06.00 **Shop Coat or Paint**

The shop paint for steel doors, windows, etc. shall be best lead or zinc chromate primer paint from approved manufacturer conforming to IS 2074. All surfaces shall be thoroughly cleaned of rust, grease, loose mill scales etc. and given one coat of shop paint. Portions like mullions, transoms etc. that will be inaccessible after assembly of units shall be given an extra coat of paint before assembly.

Where called for in the Schedule of Items all steel doors, windows, etc. shall be hot dip galvanised to give a coating weight of 1-1/2 - 2 Oz per sft. One coat zinc chromate primer coat shall then be applied as shop paint.

Portions of aluminium frame which come in contact with masonry construction shall before shipment from workshop be protected with a heavy coat of alkali paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer.

2.07.00 **Handling & Storage of Fabricated Material**

All metal doors, windows, etc. shall be packed and crated properly before dispatch to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in undamaged condition.

When taking delivery of items supplied by Owner, the Contractor shall satisfy himself that the items supplied are upto the specified standard. Any defect detected shall promptly be brought to the notice of the Engineer.

All metal doors, windows, etc. shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminum products by rust, mortar, etc.

2.08.00 **Assembly & Erection at Site**

In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081 and as shown on drawings. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvers, etc. including transoms and mullions for composite units in respective places as shown on drawing keeping proper lines and levels, and in approved workman like manner to give trouble free and leak-proof installations. The installation shall be done according to the instructions of the manufacturer, and/or as approved by the Engineer. If required by the Engineer, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take every precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor and made good again as per original, after installation without any extra charge.

After installation of steel doors, windows, etc. all abrasions to shop-coat of paint shall be retouched and made good with the same quality of paint used in shop coat.

All coupling mullions, transoms, frames, etc. in contact with adjacent steel and other members, shall be well bedded in mastic. The Contractor shall bring to the site the mastic cement in original sealed containers of manufacturer and shall apply it as per the instructions. For all frames supplied by either the Owner or the Contractor mastic shall be supplied by the Contractor and caulking done properly as per drawings, specifications and as per instructions of the Engineer.

Door shutters, partitions hardware fixtures etc. shall be fixed only after major equipments have been installed in rooms.

Wherever required nylon cords of approved quality shall be supplied along with pivoted sashes and shall be of adequate length to terminate one metre from the floor. Loose ends of cords shall end in metal or plastic pull as approved by the Engineer.

3.00.00 ACCEPTANCE CRITERIA

3.01.00 For Fabricated Items

a) Overall dimensions shall be within ± 1.5 mm of the size shown on drawings.

b) Mullions, transoms etc. shall be in one length and permissible deviations from straightness shall be limited to ± 1.5 mm from the axis of the member.

c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm. For double leaf doors, the gap at the meeting stiles shall not be more than 1.5 mm.

d) Door leaves shall be undercut where shown on drawings.

e) Doors, windows, frames, etc. shall be on a true planes, free from warp or buckle.

f) All welds shall be dressed flush on exposed and contact surfaces.

g) Correctness of location and smoothness of operations of all shop installed hardware and fixtures.

h) Provisions for hardware and fixtures to be installed at site.

I) Glazing beads shall be cut with mitered corners.

j) Glazing clips, fixing devices etc. shall be supplied in adequate numbers.

k) Shop coats shall be properly applied.

l) Exposed aluminium surfaces shall be free from scratches, stains and discolouration. Anodised surfaces shall present a uniform and pleasing look.

3.02.00 **For Installed Items**

a) Installations shall be at correct location, elevation and in general on a true vertical plane.

b) Fixing details shall be strictly as shown on drawings.

c) Assembly of composite units shall be strictly as per drawings with mastic caulking of transoms and mullions, gaskets, weather strips etc. complete.

d) All frames on external walls shall be mastic caulked to prevent leakage through joint between frames and masonry.

e) All openable section shall operate smoothly without jamming.

f) Locks, fasteners, etc. shall engage positively. Keys shall be non-interchangeable.

g) Cutting to concrete or masonry shall be made good and all abrasions to shop paint shall be touched up with paint of same quality as shop paint.

h) Aluminium doors, windows, etc. shall be free from scratches stain or discolouration.

4.00.00 **INFORMATION TO BE SUBMITTED**

4.01.00 **With Tender**

a) Names of manufacturers for doors, windows, etc.

b) Manufacturer's catalogue for all hardware and fixtures proposed to be used.

4.02.00 **After Award**

a) Before starting fabrication of all metal doors, windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

b) He shall submit a programme of work to be done for the approval of the Engineer.

c) Before bulk supply, he shall submit for the approval of the Engineer samples of all bought out items and samples of each type of fabricated items. The samples shall be retained by the Engineer for comparison of bulk supply and returned to the Contractor towards the end for final incorporation in the job.

5.00.00 RATES

Rates shall be unit rates for items described in schedule.

6.00.00 METHOD OF MEASUREMENT

a) Supply and installation of doors shall be measured in number of each type used. The types shall be as shown on drawings and described in Schedule of Items.

b) Supply of windows shall be measured in number of each type of unit used either single or in combination.

c) Installation including assembly and erection of windows shall be measured in number of types of combinations mentioned in the Schedule of Items.

d) Supply and installation of louvers shall be measured for area of opening in which the louver is to be installed.

e) Supply of mullions and transoms shall be measured for net length of different types shown on drawings and described in Schedule. In computing the length, the length required for embedding in concrete or masonry shall not be considered. No extra payment shall be made for end or cover plates.

f) Vision panels, louvers to doors and insulation between door faces shall be measured for actual area and paid separately over the basic rate doors.

g) Glazing beads, weather stripping, fixing devices etc. shall not be measured separately but shall be included in the supply rate of respective items.

h) And curing or grouting to concrete and masonry or welding and drilling to steel required for installation shall be included in the installation rate. No separate payment shall be made for caulking and jamming or frames or making good to concrete or masonry.

I) Glass and glazing shall be measured and paid under relevant items.

j) Door and window fixtures, locks, door closures etc. shall be measured in actual numbers use.

7.00.00 I.S. CODES

Following are some of the important I.S. Codes as relevant to this section :

Steel doors, windows and ventilators	-	IS : 1038
Steel windows for industrial buildings	-	IS : 1361
Aluminium doors windows and ventilators	-	IS : 1948
Aluminium windows for industrial buildings	-	IS : 1949
Steel doorframes	-	IS : 4351
Code of practice for fixing and glazing of Metal (steel and aluminium) doors, windows, And ventilators.	-	IS : 1081
Wrought Aluminium and Aluminium Alloys, Bars, Rods and Sections (For General Engineer Purposes) – Specification	-	IS : 733
Wrought Aluminium and Aluminium Alloy sheet, and strip for General Engineer Purposes - Specification	-	IS : 737
Wrought Aluminium and Aluminium Alloy, Extruded Round Tube and Hollow sections (For General Engineering Purposes) –Specification	-	IS : 1285
Anodic coating on Aluminium and its Alloys – Specification	-	IS : 1868
Specification for Aluminium equal leg angles	-	IS : 3908
Specification for Aluminium unequal leg angles	-	IS : 3909

Dimensions for wrought Aluminium and Aluminium Alloys bars, rods and sections.	-	IS : 3965
Method of testing anodic coating on aluminium and Its alloys	-	IS : 5523
Measurement of coating thickness by Eddy Current Method	-	IS : 6012
Floor springs (Hydraulically regulated) for heavy doors Specifications		IS : 6315
Dimensions of extruded hollow section and tolerances	-	IS : 6477

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SECTION-XXI

TECHNICAL SPECIFICATION FOR ROLLING STEEL SHUTTERS, GRILLS AND COLLAPSIBLE DOORS

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SECTION-XXI

TECHNICAL SPECIFICATION FOR ROLLING STEEL SHUTTERS, GRILLS AND COLLAPSIBLE DOORS

1.00.00 SCOPE

This specification covers the design, supply of materials, fabrication, delivery and erection of Rolling Shutters/Grills/partly closed and partly grilled/collapsible doors with motor drive and/or manual operation including all accessories as hereinafter specified.

2.00.00 INSTALLATION

2.01.00 Components

a) Slats for rolling shutters shall be made from tested bright cold rolled, annealed M.S. strips, not less than 0.9 mm thick of CR grade for shutters upto 4.5 M wide and not less than 2.25 mm thick of CR grade for shutters 5.5 M wide and above, machine rolled at 75 mm rolling centers, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.

b) Rolling grills shall be constructed out of 6 mm dia. rods at 35 mm on centres running horizontally flexible connected with vertical links spaced not more than 200 mm centres. Alternatively, rolling grills shall be made from perforated slats of approved design reinforced with 6 mm dia. rods.

c) End locks shall be heavy type M.C.I./C.I. and shall be provided at each end of alternate slats unless specified otherwise in the Schedule.

d) Bottom bars shall be finished with two angles not less than 6 mm thick for external shutters. When shown on drawings, a flexible weather strip shall be applied to make tight contact with the floor.

e) Guides shall be of such depth as to retain the shutter under a wind pressure of 100 Kg/Sq.M or as specified in Schedule.

f) Shafts shall be of steel pipe of sufficient size to carry the torsional load with a maximum deflection of 1/360th of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.

g) Hoods shall be formed of not less than 20 gauge steel, suitable reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as described in Schedule or as described by the Engineer.

i) Power unit shall be suitable for 3 phase, 50 cycle, 400 volt A.C. power supply and shall be either floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metres per second. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built-in overload protection, a geared limit switch and one push button station located inside the building unless otherwise stated in Schedule or drawing.

It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge, electrically connected to stop the travel of the door on meeting an obstruction.

j) Operating chains shall be of tested quality, heavily galvanised and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength gray cast iron, machine moulded from machine out patterns.

2.02.00 **Manually Operated Shutters / Grills**

Manually operated shutters shall be easily operable by one person. The speed of operation shall be about 1.3 metres per second. In general manually operated shutters shall be push pull type for openings upto 9 sq. metre in area. Larger shutters shall be either chain or gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as described in Schedule or as desired by the Engineer.

2.03.00 **Power Operated Shutters / Grills**

These shall be operable from a push button station conveniently located beside the door or as shown on drawings. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for in Schedule, externally mounted shutters shall be operated by control mechanism located inside the building.

2.04.00 **Rolling Shutters without grill**

Rolling shutters shall conform to IS 6248. These shall include necessary locking arrangement and handles etc. These shall be suitably fixing in the position as specified i.e. outside or inside on or below lintel or between jambs of the opening. The door shall be either push and pull type or operated with mechanical device supplied by the firm. Shutters up to 10 sq. metre shall be of push and pull type and shutters with an area of over 10 sq. metre shall generally be provided with reduction gear operated by mechanical device with chain or handle, if bearings are specified for each of operation, these shall be paid for separately.

Shutter : The shutter be built up of inter locking lath section formed from cold rolled steel strips. The thickness of the sheets from which the lath sections have been rolled shall be not less than 0.90mm for the shutters up to 3.5m width and not less than 2.25 mm thick of CR grade for shutters 5.5 M wide and above. Shutters above 9 metres width should be divided in 2 parts with provision of one middle fixed or movable guide channel or supported from the back side to resist wind pressure of 100 kg/sq.m. The lath section shall be rolled so as to have interlocking curls at both edges and a deep corrugation at the centre with a bridge depth of not less than 12 mm to provide sufficient curtain of stiffness for resisting manual pressures and normal wind pressure. Each lath section shall be continuous single piece without any welded joint. When interlocked, the lath sections shall have a distance of 75 mm rolling centers. Each alternate lath section shall be fitted with malleable cast iron or mild steel clips securely riveted at either ends, thus locking in the lath section at both ends preventing lateral movement of the individual lath sections. The clips shall be so designed as to fit the contour of the lath sections.

Spring : The spring shall be coiled type. The spring shall be manufactured from high tensile spring steel wire or strips of adequate strength conforming to IS 4454 - Part I.

Roller and Brackets : The suspension shaft of the roller shall be made of steel pipe conforming to heavy duty as per IS 1161 to carry the tortional load with a maximum deflection of $1/360^{th}$ of span. For shutter up to 6 metre width and height not exceeding 5 metre, steel pipes of 50mm nominal bore shall be used. The shaft shall be supported on mild steel brackets of size 375 x 375 x 3.15 mm for shutters up to clear height of 3.5 metre. The size of mild steel brackets shall be 500 x 500 x 10 mm for shutters of clear height above 3.5m and up to 6.5 m. The suspension shaft clamped to the brackets shall be fitted

with rotatable cast iron pulleys to which the shutter is attached. The pulleys and pipe shaft shall connected by means of pretensioned helical springs to counter balance the weight of the shutter and to keep the shutter in equilibrium in any partly open position.

When the width of the opening is greater than 3.5 mtr, the cast iron pulleys shall be interconnected with a cage formed out of mild steel flats of at least 32 x 6 mm and mild steel dummy rings made of similar flats to distribute the torque uniformly. Self aligning two row ball bearings with special cast iron casings shall be provided at the extreme pulley and caging rings shall have a minimum spacing of 15 mm and at least 4 number flats running throughout length of roller shall be provided.

In case of shutters of large opening with mechanical device for opening the shutter the roller shall be fitted with a purion wheel at one end which in contact with a worm fitted to the bracket plate, caging and pulley with two ball bearing shall be provided.

Guide Channel : The width of guide channel shall be 25mm the minimum depth of guide channels shall be as follows :

Clear width of shutter	Depth of guide channel
Up to 3.5 m	65mm
3.5m up to 8m	75mm
8m and above	100mm

The gap between the two legs of the guide channels shall be sufficient to allow the free movement of the shutter and at the same time close enough to prevent rattling of the shutter due to wind.

Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to the wall or column by means of bolts or screws. The spacing of cleats shall not exceed 0.75 m. Alternatively, the guide channels may also be provided with suitable dowels, hooks or pins for embedding in the walls.

The guide channels shall be attached to the jambs, plumb and true either in the overlapping fashion or embedded in grooves, depending on the method of fixing.

Cover : Top cover shall be mild steel sheets not less than 0.90mm thick and stiffened with angle or flat stiffeners at top and bottom edges to retain shape.

Power unit : Power unit shall be suitable for 3 phases, 50 cycles, 400 volt A.C. power supply and shall be either floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metres per second. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built-in overload

protection, a geared limit switch and one push button station located inside the building unless otherwise stated in Schedule or drawing.

It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge, electrically connected to stop the travel of the door on meeting an obstruction.

Lock plates with sliding bolts, handles and anchoring rods shall be as per IS 6248.

Operating chains shall be of tested quality, heavily galvanised and with all ends rounded to assure smooth operation and hand protection.

Reduction gears shall be high strength gray cast iron, machine moulded from machine out patterns.

Fixing : The arrangement for fixing in different situations in the opening shall be as per IS 6248.

Brackets shall be fixed on the lintel or under the lintel as specified with rawl plugs and screws bolts etc. The shaft along with the spring shall then be fixed on the brackets.

The lath portion (shutter) shall be laid on ground and the side guide channels shall be bound with ropes etc. The shutter shall then be placed in position and top fixed with pipe shaft with bolts and nuts. The side guide channels and cover frames shall then be fixed to the walls through the plate welded to the guides. These plates and brackets shall be fixed by means of steel screws bolts, and rawl plugs concealed in plaster to make their location invisible. Fixing shall be done accurately in workmen like manner that the operation of the shutter is easy and smooth.

Measurements :

Clear width and clear height of the opening for rolling shuttering shutter shall be clear width and the clear distance between the sill and the soffit (bottom of lintel) of the opening shall be the clear height.

The area shall be calculated in square metres correct to two places of decimal.

Unless included in the main team, whether stripping at bottom bar and mullions shall be measured separately for length.

Cylinder locks shall be for actual numbers used. Pad locks shall be supplied by others.

Rate

The rate shall include the cost of materials and labour involved in all the operations described above including cost of top cover and spring except ball bearing and mechanical device of chain and crank operation, which shall be paid for separately.

2.05.00 **Rolling Grills – Shutters**

Rolling grill shutter is meant to provide visibility or ventilation or both, the degree of protection and safety is less as compared to a rolling shutter. The situations where a certain amount of ventilation combined with safety is required rolling shutter-cum-grill may be provided in which the rolling shutter may have a rolling grill portion either at the top or at the bottom or at both places. In addition, the rolling grill portion may also be provided in the middle of the shutter. The total height of the grill portion in all the segments of rolling shutter-cum grill shall not exceeded 1.0m and the height of the grill portion in any individual segment shall not be more than 0.5m.

Rolling grills shutters are similar in design, construction and operation to rolling shutters and all the provisions of Para 10.8 shall be applicable to rolling grills shutters except in respect of the shutter portion and shall conform to IS 6248.

Shutters

Rolling grill shutter and the rolling grill portion of the rolling shutter-cum grill shall be fabricated with 8 mm diameter mild steel round bars. Straight bars and bars bent to the required profile are placed alternatively and held in position with 20mm wide and 5mm thick mild steel flat links. Straight bars shall be spaced not exceeding 150mm centre to centre and the bars bent to required profile shall be placed symmetrically between two consecutive straight bars. Unless otherwise specified or directed by the Engineer-in-charge, bars placed alternatively with straight bars shall be bent to form a corrugated profile such that the pitch of the corrugation is 100 to 120mm and the depth of corrugation is 80 to 100mm. all the bent bars shall have uniform profile. Straight bar along with the adjoining bent bars on it both sides shall be held in position by passing the bars through holes in the links. Each link shall have three holes and the length of the links shall be such that the distance from the centre of the hole to the nearest edge of the flat is not less than the diameter of the hole. The corner of the links shall be rounded. All links shall be of uniform size and shape. The spacing of the links measured along the straight bar shall be the same as centre to centre distance between two consecutive crests/ troughts of the bars bent to the required profile. Each bar and link shall be continuous single piece without any joint.

Measurement & Rate

The measurement and rate shall be as specified in clause 2.02.01(g). In case of Rolling Shutter-cum-Grill, where the area of the grill portion is half or less than half the area of opening, it shall be measured and paid as rolling shutter and where the area of grill portion is more than half the area of opening, it shall be measured and paid as rolling grill.

2.06.00 **Shop Coat**

Shutters shall be painted with one coat of red lead or zinc chromate primer. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat. Wherever galvanized door not specified, the door shall be painted with synthetic enamel paint with two coats

2.07.00 **Erection**

Door shall be installed by the manufacturer or his authorised representative and all work shall be as per manufacturer's instructions. Any drilling or cutting to concrete, masonry etc. shall be made good after erection of shutters and all abrasion to shop coat shall be touched up. All electrical work shall be in strict accordance with the latest Indian Electricity Rules.

2.08.00 **Collapsible Gate / Door**

2.08.01 These shall be of approved manufacture and shall be fabricated from the mild steel sections.

2.08.02 The gates shall consist of double or single collapsible gate depending on the size of the opening. These shall consist of vertical double channels each 20 x 10 x 2 mm. at 10 cm. centre to centre braced with flat iron diagonals 20 x 5 mm and top and bottom rails of T- iron 40 x 40 x 6 mm @ 3.5 kg/m with 40 mm dia. ball bearings in every fourth double channel, unless otherwise specified. Wherever collapsible gate is not provided within the opening and fixed along the outer wall surface, T- iron at the top may be replaced by flat iron 40 x 10 mm.

The collapsible gate shall be provided with necessary bolts and nuts, locking arrangement, stoppers and handles. Any special fittings like spring, catches and locks, shall be so specified in the description of item where so required. The gate shall open and close smoothly and easily.

2.08.03 **Fixing**

T- iron rails shall be fixed to the floor and to the Lintel at top by means of anchor bolts embedded in cement concrete of floor and lintel. The anchor bolts shall be placed approximately at 45 cm centers alternatively in the two flanges of the T- iron. The bottom runner (T- iron) shall be embedded in the floor and proper groove shall be formed along the runner for the purpose. The collapsible shutter shall be fixed at sides by fixing the end double channel with T-iron rails and also by hold- fasts bolted to the end double channel and fixed in masonry of the side walls on the other side. In case the collapsible shutter is not required to reach the lintel, beam or slab level, a Tee-section suitably designed may be fixed at the top, embedded in masonry and provided with necessary clamps and roller arrangement at the top. All the adjoining work damaged in fixing of gate shall be made good to match the existing work, without any extra cost.

2.08.04 **Painting**

All the members of the collapsible gate including T-iron shall be thoroughly cleaned off rust, scales, dust etc. and given a priming coat of approved steel primer conforming to IS 2074 before fixing them in position.

2.08.05 **Measurements**

The height and breadth shall be measured correct to a cm. The height of the gate shall be measured as the length of the double channels and breadth from outside to outside of the end fixed double channels in open position, of the gate. The area shall be calculated in square metres, correct to two places of decimal.

2.08.06 **Rate**

The rate shall include the cost of materials and labour involved in all the operations described above.

3.00.00 **ACCEPTANCE CRITERIA**

3.01.00 **Shop Inspection**

After completing the manufacture of the different components of the rolling shutter, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

3.02.00 **Field Inspection**

After installing the shutters, the Contractor shall test the performance of the shutter in the presence of the Engineer. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault-free performance.

3.03.00 **Guarantee**

The Contractor shall give one year's guarantee for the successful operation of the shutters. This shall be supported by a separate and unilateral guarantee from the manufacturer of the shutters.

4.00.00 **RATES**

Rates shall be unit rates for complete items for supply and/or erection of rolling shutters, including all drives, accessories, hardware etc. No extra payment shall be made for cutting, drilling, welding, grouting etc. to structure for installation of the shutters.

The rates shall include the mounting of controls, wire and wiring from the nearest junction box, conduit and other electrical connections.

5.00.00 **METHOD OF MEASUREMENT**

a) Rolling shutters or grills shall be measured for area of opening in which they shall be installed. Alternatively, shutters shall be measured for actual number of different sizes used.

b) Cylinder locks shall be for actual numbers used. Pad locks shall be supplied by others.

6.00.00 **I.S. CODE**

IS : 6248 - Metal rolling shutters and rolling grills.

IS : 10521 - Collapsible Gate

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SECTION-XXII

TECHNICAL SPECIFICATION FOR GLASS AND GLAZING

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SECTION-XXII

TECHNICAL SPECIFICATION FOR GLASS AND GLAZING

1.00.00 SCOPE

The work in general shall consist of supplying and fixing all glass and glazing including all clips, putty, mastic cement etc wherever required as shown on drawings and specifications, supply of metal glazing beads and neoprene gaskets shall not be included in this scope.

2.00.00 INSTALLATION

2.01.00 General

The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions from approved manufacturer, shall have uniform refractive index and free from flaws, specks and bubbles. The glass shall be brought to site in the original packing from the manufacturer and cut to size at site.

Materials

a) Clear glass shall be float glass and should be approved by the Engineer-in-Charge and shall be at least 4 mm thick for windows and for doors & glazed partitions shall be minimum 8mm thick or as indicated in doors' and windows schedule. It shall be clear, float transparent and free from cracks subject to allowable defects. The float glass shall conform to the IS 14900. The thickness of float glass shall be measured with micrometers or a calliper which is graduated to 0.01 mm or with a measuring instrument having an equivalent capacity.

b) Obscure glass shall have a cast surface in one side.

c) 24mm thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with 12mm air gap & hermetically sealed shall be mounted on 15 micron coloured anodised aluminium frame suitable for structural glazing system.

d) In general, the putty shall conform to IS: 400 and be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing. Quick setting putty glass is used where it shall be non-setting type.

e) The EPDM Gaskets shall be of size and profile as shown in drawings and as called for, to render the glazing, doors, windows, ventilators etc. air and water tight. Samples of gaskets shall be submitted for approval and the EPDM gasket approved by Engineer-in-Charge shall only be used. The contractor shall submit documentary proof of using the above material in the work to the entire satisfaction of Engineer-in-Charge.

The EPDM gasket shall meet the requirements as given in Table below :

SL. No.	Description	Standard Follow	Specification
1	Tensile strength kg.f/cm^2	ASTM-D 412	70 Min.
2	Elongation at break %	ASTM-D 412	250 Min.
3	Modulus 100% Kgf/cm^2	ASTM-D 412	22 Min.
4	Compression set % at 0º CC 22 Hrs.	ASTM-D 395	50 Max.
5	Ozone resistance	ASTM-D 1149	No visible cracks

Quality of glass

a) All glass shall comply with ECBC 2007 requirements.

b) Single glass panels shall have properties like –
VLT = 35 to 50%, external reflection=6 to 15%, internal reflection=8 to 15%, solar factor=0.36 to 0.43, U value=2.8 to 3.0 W/sqm K to be provided.

c) Double glazed panels with glass having properties like-
VLT = 30 to 45%, external reflection=8 to 20%, internal reflection=15 to 30%, solar factor=0.26 to 0.29, U value=1.8 to 1.9 W/sqm K. shall be provided.

2.02.00 **Reflective Glass**

Definitions

i) **Shading Coefficient** : The shading coefficient is the ratio of total solar transmittance to the transmittance through 3.2 mm (1/8") clear glass. Windows with low shading coefficient values improve comfort for building, lower the total cooling load of the building and help smooth out of the difference in cooling loads between perimeter & core zones.

ii) **Luminous Efficiency Constant (Ke)** indicates a windows relative performance in rejection solar heat-while transmitting day light. It is the ratio of the visible transmittance to the shading coefficient; clear glass which lets in roughly equal amounts of visible light and solar near-infrared energy has a Ke close to 1.0. The solar radiation contains about 50% invisible near-infrared & ultra violet light. Therefore, a perfectly selective glazing, which would all allow visible light pass through while blocking all of the invisible near-infrared & ultraviolet light, would have Ke of about 2.0.

iii) **Resistance to Heat Conduction (R-valve) :** It is a measure of resistance to heat flow that occurs because of temperature difference between the two sides of the windows. The inverse of R-value is termed as U-value.

Reflective Glass

This is an ordinary float glass with a metallic coat to reduce solar heat. Clear glass transmits most of the sunlight that shines upon it, and most of the solar heat as well; the metallic coated glass i.e. reflective glass has better shading coefficients because they reflect rather than absorb infrared energy. However, most of reflective glazing blocks day light more than solar heat.

Types of Coatings : There are two types of reflective glass, Pyroltic (Hard) coated and vacuum (soft) coated.

i) **Pyroltic :** It is a coating applied during glass manufacture. The coating is fused in to the glass at 1200ºC.

ii) **Vacuum Coated Glass :** It involves the deposition of metal particles on the glass surface by a chain reaction in a vacuum vessel. It is often called a soft coat; because the coating is more susceptible to damage than hard coat glass. Where toughening of product is required, the product must be toughened first & then vacuum coated. Vacuum coated products have better shading coefficient values than Pyroltic products.

Performance of Reflective Glass : The performance of reflective glass 6 mm of nominal thickness is given below:

Sl. No.	Parameter	Threshold Ratio in %age
1.	Visible Light - Transmittance (%) - Reflectance (%)	 15-46 12-24
2.	Total Solar Energy: - Transmittance (%) - Reflectance (%)	 16-24 8-12
3.	Ultra Violet Rays: - Transmittance (%)	 2-10
4.	U-Value - Summer - Winter	 0.58 0.45
5.	Shading Coefficient	0.25-0.35

Testing : The reflective glass shall be tested for the followings :

i) Physical/Field Test: In a true reflective glass, when a pointed pencil is placed, then tip of pencil (physical) & image should coincide.

ii) Laboratory Test: In the laboratory, the reflective glass shall be tested for the parameter specified in the table above.

2.03.00 **Glazing, Setting and Finish**

All glazing clips, bolts, nuts, putty, mastic cement etc. as required shall be supplied by the Contractor.

All glass shall be thoroughly cleaned before putting in position. Each glass pane shall be held in place by special glazing clips of approved type. As specified in relevant I.S. Codes, four glazing clips shall be provided per glass pan, except for large panes where six or more clips shall be used as per Engineer's instructions. All holes that may be necessary for holding the clips glazing heads and all other attachments shall be drilled by the Contractor.

Glass panes shall be set without springing, and shall be bedded in putty and back puttied, except where moulding or gasket are specified, putty, mastic cement etc. shall be smoothly finished to the even line and figured glass shall be set with smooth side out.

Necessary glazing clips, putty, mastic cement etc. shall be supplied by the Contractor. The Contractor shall be responsible for damage of glass supplied by the Owner, during handling, transportation, fixing etc maximum wastage allowance shall be 5%.

After completion of glazing work, the Contractor shall remove all dirt stains, excess putty etc. clean the glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at the Contractor's own cost.

3.00.00 ACCEPTANCE CRITERIA

a) All installation shall be free from cracked, broken or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked or underground edges.

b) Glazing shall be carefully done to avoid direct contact with metal frames.

c) All glass shall be embedded in mastic or fixed by EPDM gaskets to give a leak proof installation.

d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer.

4.00.00 RATES

a) Rates shall be unit rates for supply and / or installation of different kinds of glass mentioned in the Schedule of Items.

b) No separate payment shall be made for glazing clips, mastic cement, putty, nails etc. for drilling holes in frames for inserting glazing clips.

c) No separate payment shall be made for cutting of glass to require size, edge finishing etc.

d) No separate payment shall be made for cleaning the glass after installation.

5.00.00 METHOD OF MEASUREMENT

All supply and / or installation of glass shall be measured for actual area of work done.

6.00.00 **IS CODES**

Following are some of the important I.S.Codes relevant to this Section;

IS : 3548 - Code of practice for glazing in building.

IS : 1083 - Code of practice for fixing and glazing metal doors, windows and ventilators.

IS : 14900 - Transparent Float glass- Specifications.

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SECTION-XXIII

TECHNICAL SPECIFICATION
FOR
FLOOR FINISHES AND ALLIED WORKS

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SECTION-XXIII

TECHNICAL SPECIFICATION FOR FLOOR FINISHES AND ALLIED WORKS

1.00.00 SCOPE

This specification covers furnishing, installation, finishing, curing, testing, protection, maintenance till handing over various types of floor finishes and allied items of work as listed below:

a) **In Situ Finishes**

i) Integral finish to concrete base

ii) Red Oxide of Iron finish

iii) Terrazzo finish

iv) Granolithic finish

v) Patent Stone

vi) Metallic Hardener like “Ironite” or equivalent finish

vii) Mastic Asphalt finish

viii) Chemical Resistant finish

b) **Tiled Finishes**

a) Terrazzo tile

b) Chequered tile

c) Glazed tile

d) Tesserae (Mosaic etc.)

e) Chemical Resistant

f) Rubber, Vinyl etc.

g) Stone slab

h) Steelcrete tile

i) Vitrified tiles

1.01.00 **Base**

The base to receive the finish is covered under other relevant specifications.

1.02.00 **Sequence**

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer in view the activities of other agencies working in that area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damages whatsoever till handing over.

2.00.00 **INSTALLATION**

2.00.01 **Special Materials**

Basic materials are covered under Specification “Properties Storage and Handling of Common Building Materials”. Special materials required for individual finishing items are specified under respective items. In general, all such materials shall be as per relevant I.S. Codes where available. In all cases these materials shall be of the best quality available indigenously, unless specified otherwise.

The materials for finishing items must be procured from well-reputed specialised manufacturers and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintain in the construction schedule.

2.00.02 **Workmanship**

Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Engineer’s permission, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Engineer so desires that the Contractor shall get the finishing items installed by the manufacturer.

2.00.03 **Preparation of the Base Surface**

The surface to be treated shall be thoroughly examined by the Contractor. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work.

For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking out joints and cleaning thoroughly all dirts, grease etc. with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification under individual item.

To prevent of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up.

The surface shall be done dry where adhesives are used for fixing the finishes.

Prior to commencement of actual finishing work the approval of the Engineer shall be taken as per the acceptability of the surface.

2.01.00 **In Situ Finishes**

2.01.01 **Integral Finish to Concrete Base**

Flooring shall be laid on base concrete where so provided. The base concrete shall be provided with the slopes required for the flooring. Flooring in verandah, courtyard, kitchens & baths shall have slope ranging from 1:48 to 1:60 depending upon location and decided by the Engineer-in-Charge. Floors in water closet portion shall have slope of 1:30 or as decided by the Engineer-in-Charge to drain off washing water. Further, necessary drop in flooring in bath, WC, kitchen near floor traps ranging from 6mm to 10mm will also be provided to avoid spread of water. Necessary margin to accommodate this drop shall be made in base concrete. Plinth masonry off set shall be depressed so as to allow the base concrete to rest on it. While the surface of the concrete laid as per specification for 'Cement Concrete has been fully compacted and levelled but the concrete is still green thick slurry made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark or undulations. This finish shall be as thin a possible by using 2.2 kg. of cement per sq.m. of area. in verandah, courtyard.

Laying

Panels : Flooring of specified thickness shall be laid in the pattern including the borders given in the drawings or as directed by the Engineer-in-Charge. The border panels shall not exceed 450mm in width and the joints in the boarder shall be in line with panel joints. The panels shall be of uniform size and no dimension of a panel shall exceed 2 m and the area of a panel shall not be more than 2 sqm. The joints of borders at corners shall be mitred for provision of strips.

Laying of Flooring with Strips : Normally cement concrete flooring shall be laid in one operation using glass/aluminium/PVC/brass strips/stainless steel strips or any other strips as required as per drawing or instructions of the Engineer-in-Charge, at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels. 4mm thick glass strips or 2mm PVC strips or 2mm aluminium or brass strips shall be fixed with their tops at proper level, giving required slopes. Use of glass and metallic strips shall be avoided in areas exposed to sun. Cost of providing and fixing strips shall be paid separately.

Concreting : Cement concrete shall be placed in the panels and be levelled with the help of straight edge and trowel and beaten with thapy or mason's trowel. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given. Beating shall cease as soon as the surface is found covered with a thin layer of cream of mortar. The evenness of the surface shall be tested with straight edge. Surface of flooring be true to required slopes. While laying concrete, care shall be taken to see that the strips are not damaged/disturbed by the labourers. The tops of strips shall be visible clearly after finishing with cement slurry.

Laying of Flooring without strips : Laying of cement concreting flooring in alternate panels may be allowed by the Engineer-in-Charge in case strips are not to be provided.

Shuttering : The panels shall be bounded by angles iron or flats. The angle iron/flat shall have the same depth as the concrete flooring. These shall be fixed in position, with their top at proper level giving required slopes. The surface of the angle iron or flats, to come in contact with concrete shall be smeared with soap solution or non-sticking oil (Form oil or raw linseed oil) before concreting. The flooring shall butt against the unplastered masonry wall.

Concreting : The concreting shall be done in the manner described earlier. The angle iron/flats used for shuttering, shall be removed on the next day of the laying of cement concrete. The ends thus exposed shall be repaired, if damaged with cement mortar 1:2 (1 cement: 2 coarse sand) and allowed to set for minimum period of 24 hours. The alternate panels shall then be cleaned of dust, mortar, droppings etc. and concrete laid. While laying concrete, care shall be taken to see that the edges of the previously laid

panels are not damaged and fresh mortar is not splashed over them. The joints between the panels should come out as fine straight lines.

Finishing

The finishing of the surface follow immediately after the cessation of beating. The surface shall be left for some time till moisture disappears from it or surplus water can be mopped up. Use of dry cement or cement and sand mixture stiffening the concrete to absorb excessive moisture shall not be permitted. Excessive trowelling shall be avoided.

Fresh cement shall be mixed with water to form a thick slurry and spreaded @ 2 to 2.2 kg of cement over an area of one sqm of flooring while the flooring concrete is still green. The cement slurry shall then be properly processed and finished smooth.

The edge of the sunk floors shall be finished & rounded with cement mortar 1:2 (1 cement: 2 coarse sand) and finished with a floating coat of neat cement.

The junction of floor with wall plaster, dado or skirting shall be rounded off where so specified.

The men engaged on finishing operations shall be provided with raised wooden platform to sit on so as to prevent damage to new work.

Curing

The curing shall be done for a minimum period of ten days. The surface shall be kept in shade for 24 hours and then cured for at least 10 days continuously by flooding with water. The surface shall not be subjected to any load or abrasion till 21 days after laying. Curing shall not be commenced until the top layer has hardened. Covering with empty gunnies bag shall be avoided as the colour of the flooring is likely to be bleached due to the remnants of cement dust from the bags.

As desired by the Engineer the surface, while still ‘green’ shall be indented by pressing strings. The marking shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

Precautions

Flooring in lavatories and bath room shall be laid only after fixing of water closet and squatting pans and floor traps. Traps shall be plugged while laying the floors and opened after the floors are cured and cleaned. Any damage done to W.C.’s squatting pans and floor traps during the execution of work shall be made good.

During cold weather, concreting shall not be done when the temperature falls below 4ºC. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone. During hot whether, precautions shall be taken to see that the temperature of wet concrete does not exceed 38ºC. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge. To facilitate rounding of junction of skirting, dado and floor, the skirting/dado shall be laid along with the border or adjacent panels of floor.

Measurement

Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

2.01.02 **Red Oxide of iron finish**

It shall consist of an underbed and a topping over already laid and matured concrete base.

a) **Thickness**

Unless otherwise specified the total thickness of the finish shall be minimum 50 mm or as per schedule of item for horizontal and 20 mm or as per schedule of item for vertical surface of which the topping shall (not less than 10 mm) while the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finishes. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontal shall be rounded neatly to uniform radius off 25 mm.

b) **Mix**

i) **Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 2 parts coarse sand and 4 parts 10 mm down graded stone chips by volume. For vertical and similar surfaces the mix shall consist of 1 part cement to 3 parts coarse sand by volume.

ii) **Topping**

For the topping cement, screened through a fine mesh and red oxide of iron pigment powder similarly screened shall be dry mixed thoroughly in right proportions to produce the desired colour when laid. The mix shall then be prepared with 1 part cement (mixed with pigment) and 3 parts coarse sand by volume. The whole quantity required for each visible area shall be prepared in one batch to ensure uniform colour.

c) **Laying**

The underbed shall be laid in panels of mixing area 5 Sq.M. each and no side shall be more than 2.5 along. For outdoor locations the maximum area shall be 2.0 Sq.M. The forms for the panels shall have perfectly aligned edges to the full depth of the total thickness of finish. If specified aluminium or glass dividing strips shall be used.

The panels shall be laid in alternate bays or in chequered board pattern. No panel shall be cast in contact with another already laid until the contraction of the latter has taken place. The underbed shall be laid, compacted, levelled and brought to proper grade with a screed or float. The topping shall be placed after about 24 hours while the underbed is still somewhat 'green' but firm enough to receive the topping. The surface of the underbed shall be roughened for better bonding. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water to achieve a compact dense mass fully bonded with the underbed. The topping shall then be levelled up by trowelling and finished smooth with slurry made with already prepared cement and pigment mixture. About 2.0 kg of the mixture shall be consumed/per sq.m for horizontal surface, and 1.0 kg for vertical surface. The surface shall be cured for seven days by keeping it moist.

d) **Polishing**

About 36 hours after laying when the surface has hardened sufficiently it shall be polished with polishing stone till a smooth shiny surface to the satisfaction of the Engineer, is achieved. The finish shall be washed and cleaned just before handing over.

2.01.03 **Terrazzo Finish: In Situ**

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

a) **Thickness**

Unless otherwise specified the total thickness of the finish shall be minimum 50 mm for horizontal and 20 mm or as per schedule of items for vertical surface of which the topping shall be not less than 10 mm or as per schedule of items. While the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project cut 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

b) **Mix**

i) **Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 1 1/2 parts sand and 3 parts stone chips by volume. For vertical surfaces the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips shall be 10 mm down well graded. Only sufficient water is to be added to give a workable consistency. The panels shall be of uniform size, not exceeding 2 sqm in area or 2 m in length for inside situations. In exposed situations, the length of any side of the panel shall not be more than 1.25 metre. Cement slurry @ 2.00kg per sqm shall be applied before laying of under layer over the base cement concrete/RCC base.

ii) **Fixing of Strips**

4 mm thick glass strips or 2mm thick PVC strips/aluminium strips/brass strips/stainless steel strips/copper strips unless otherwise specified shall be fixed with their top at proper level to required slope. Strips of stone or marble or any other material of specified thickness can also be used if specifically required. Use of glass and metallic strips shall be avoided in areas exposed to sun. The fixing and laying shall be as specified earlier.

iii) **Topping**

The mix for the topping shall be composed of cement, with or without colour pigment, marble dust, marble chips and water. Proportions of the ingredients shall be such as to produce the terrazzo of colour texture and pattern approved by the Engineer. The cement shall be white or grey or a mixture of

the two to which pigment shall be added to achieve the desired colour. 3 parts of this mixture 1 part marble powder by volume or weight shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1½ parts of marble chips by volume shall be added and thoroughly mixed dry again.

The marble chips shall be white or pink Makrana, black Bhainslana, Chittor black, Jaisalmer Yellow, Baroda green, Dehradun white, Chittor pink, yellow Patam cherala (Madras), Grey Gadu (Surat), Chitoor green and yellow and Alwar black or as specified. It shall be uniform in colour and free from stains, cracks, decay and weathering. The maximum thickness of the top layer for various sizes of marble aggregates (marble chips) shall be as shown in Table below.

Grade No.	Size of Aggregates in (mm)	Proportion of Aggregates to Binder Mix	Minimum Thickness of Top Layer(mm)
00	1 – 2	1.75:1	6
0	2 – 4	1.75:1	6
1	4 – 7	1.75:1	9
2	7 - 10	1.5:1	12

Where aggregate of size larger than 10 mm are used, the minimum thickness of topping shall not be less than one and one third times the maximum size of the chips. Where larger size chips such as 20mm or 25mm are used, it shall be used only with a flat shape and bedded on the flat face so as to keep the minimum thickness of wearing layer.

Before starting the work, the contractor shall get the sample of marble chips approved from the Engineer-in-Charge. This shall be done in advance by mixing different colour marble chips and panel samples of minimum 1 m x 1 m size shall be prepared and got approved from the Engineer-in-Charge before laying of flooring. The cement to be used shall be ordinary grey cement, white cement, cement with admixture of colouring matter of approved quality in the ratio specified in the description of the item in the ratio to get the required shade as ordered by the Engineer-in-Charge. Colouring materials where specified shall be mixed dry thoroughly with the cement and marble powder and then marble chips added and mixed as specified above. The full quantity of dry mixture of mortar required for a room shall be prepared in a lot in order to ensure a uniform colour. This mixture shall be stored in a dry place and well covered and protected from moisture. The dry mortar shall be mixed with water in the usual way as and when required. The mixed mortar shall be homogeneous and stiff and contain just sufficient water to make it workable.

The pigment must be stable and non-fading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than IS Sieve No. 30. The size of marble chips may be between 1 mm to 10 mm.

Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

c) **Laying**

The underbed shall be laid in panels. The panels shall not be more than 2 sq.m. in area of which no side shall be more than 2.0 M long. The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips as stated earlier shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping.

After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat “green” but firm enough to receive the topping. Slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be trowelled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in a even pattern of distribution.

d) **Curing**

The surface shall be left for curing for about 12 to 18 hours depending on atmospheric temperature conditions and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

e) **Grinding and Polishing**

The grinding and polishing may be commenced not before 2 days from the time of completion of laying for manual grinding and not before 7 days for machine grinding. When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no. 60) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping it moist and then ground with fine grit blocks (no. 120). It shall again be cleaned with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no. 320) to get smooth surface without any pinhole. The grinding shall be done by a suitable machine. Where grinding machine can not be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no. 60), second rubbing with medium grade (no. 80) and final rubbing and polishing with fine grade (no. 120).

Where use of machine for polishing is not feasible or possible, rubbing and polishing shall be done by hand, in the same manner as specified for machine polishing except that carborundum stone of coarse grade (No. 60) shall be used for the 1st rubbing, stone of medium grade (No. 80) for second rubbing and stone of final rubbing polishing.

The surface shall be cleaned with water, dried and covered with soil free, clean sawdust if directed by the Engineer. The final polishing shall be postponed till before handing over if desired by the Engineer. Just before handing over the surface shall be dusted with oxalic acid at the rate of 33 gm. per. sq.m sprinkled with water on to it and rubbed hard with a nemdah block (Pad of Wooden rags). The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped off and the surface to be left glossy but not slippery.

Curing shall be done by suitable means such as laying moist sawdust or ponding water.

Precautions

Flooring in lavatories and bathrooms shall be laid after fixing of water closet and squatting pans and floor traps. Traps shall be plugged, while laying the floors and opened after the floors are cured and cleaned. Any damage done to WC's squatting pans and floor traps during the execution of work shall be made good.

During cold weather, concreting shall not be done when the temperature falls below 4ºC. The concrete placed shall be protected

against frost by suitable coverings. Concrete damaged by frost shall be removed and work redone. During hot weather, precautions shall be taken to see the temperature of wet concrete does not exceed 38ºC. No concreting shall be laid within half an hour of the closing time of the day, unless permitted by the Engineer-in-Charge.

2.01.04 **Wax Polishing**

Application, Polishing and Precautions

Wax polish shall be of approved brand and manufacture and in sealed containers. It shall be applied in uniform layer to the dry surface of the flooring/skirting.

When the layer of the wax is shifted and surface of the floor is saturated with the polish, polishing shall be restored with machine fitted with bobs (pad of rags) and shall be done until shades of all chips have appeared and glossy surface is obtained.

The fresh polished wall surface shall be spreaded with dry saw dust to a thickness of about 12 mm uniformly. After the surplus wax has been soaked from the floor surface the saw dust shall be removed.

2.01.05 **Crazy Marble Flooring**

Base Concrete

Crazy marble stone flooring shall be laid on cement concrete base. The base concrete shall be provided with slope required for the flooring in verandahs and courtyards to drain off washing and rain water. The surface of base shall be roughened with steel wire brushes, without disturbing the concrete, wetted and smeared with a floating coat of cement slurry at 23 kg of cement spread over an area of one sqm so as to get a good bond between base and flooring.

Before laying the flooring on RCC slabs, the laitance shall be removed, the surface of slab hacked and a coat of cement slurry at rate of 2 kg of cement spread over an area of one sqm shall be applied so as to get a good bond between RCC slab and floor.

Under layer

The under layer of crazy marble flooring shall be of cement concrete of thickness 25mm or as specified. The mix shall normally be 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 mm nominal size) by volume unless otherwise specified.

Top layer

The mix of crazy marble stone flooring shall consists of white cement with or without pigment, marble powder, marble chips of 00 Nos. and marble stone

pieces and water. The marble stone pieces shall be hard, sound, dense and homogeneous in texture with crystalline and concrete grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. Before starting the work the contractor shall get the sample of marble stone approved by the Engineer-in-Charge. The marble stone pieces shall be of sizes as approved by the Engineer-in-Charge but the thickness shall be according to the overall thickness specified which could be achieved when laid over the under layer as specified. Thus for 50mm thick floor, the thickness of marble pieces will be 25mm while for 40mm thick floor, the thickness will be 15mm.

The white cement and marble powder shall be mixed in proportion of three parts of cement and one part of marble powder by weight, and the proportion of marble chips to binder mix by volume shall be 7 parts of marble chips to 4 parts of binder mix. The marble chips shall be as specified. It shall be hard, sound, dense and homogeneous in texture. It shall be uniform in colour and free from stains, cracks decay and weathering.

Laying

A coat of cement slurry at the rate of 2 kg of cement per sqm of area shall be spread and then the marble stone pieces shall be set by hand in such a manner that the top surface of all the set marble stones shall be true to the required level and slopes. After fixing the stones, the cement marble chips mixture shall be filled in between the gaps of laid marble stone pieces. The filled surface then shall be trowelled over, pressed and brought to the level of the laid marble stone pieces.

Polishing

Curing and Finishing shall be as described earlier.

Precautions

Flooring in lavatories and bathrooms shall be laid after fixing of water closet and squatting pans and floor traps. Traps shall be plugged, while laying the floors and opened after the floors are cured and cleaned.

Measurements

Length and breadth shall be measured correct to a cm before skirting, dado or wall plaster and it shall be calculated in sqm correct to two decimal places. No deduction shall be made nor extra paid for voids not exceeding 0.20 square metres. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metres. Nothing extra shall be paid for laying floor at different levels in the same room or courtyards.

2.01.06 **Granolithic Finish**

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

a) **Thickness**

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

b) **Mix**

The mix shall consist of 1 part cement: 1 part coarse sand: 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well graded between 6 mm and 12 mm. Minimum quantity of water to get workability shall be added.

c) **Laying of Monolithic Topping**

The concrete base shall be laid as per specification “Cement Concrete” and levelled up to the required grade. The form shall remain sufficiently protruding to take the finish.

Within about 3 hours of laying the base while it is still fully “green” the topping shall be laid evenly to proper thickness and grade. If it is considered necessary the surface of the base shall roughened by wire brushing. Unless manual operation is permitted by the Engineer, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly to secure full bond with concrete base.

The laitance brought to the surface during compression shall be removed carefully without disturbing the stone chips. The surface shall then be lightly trowelled to remove all marks. When sufficiently set, hand trowelling shall be done to secure a smooth surface without disturbing the stone-chips.

For large areas the laying shall be in panels of maximum 25 Sq.M area. The panels shall be laid in chequered board pattern.

d) **Laying of Topping Separately on Hardened Base.**

The base concrete shall be prepared as stated in clause 7.1.2.0.3 and a slurry of neat cement applied just prior to laying the granolithic concrete mix (1:1:2). The method of compaction etc. shall be same as for monolithic topping.

e) **Curing**

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface had hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pounding of water on the surface. The floor shall not be exposed to heavy traffic during this period.

f) **Grinding**

If grinding is specified, it shall start only after the finish has fully set. Clause 2.01.03 (e) shall be followed. However, the ultimate polish required shall be decided upon by the Engineer.

g) **Finishing**

Where specified, sodium silicate or magnesium or zinc silico fluoride treatment shall be done. The number of coats to be applied shall be as specified in the Schedule of Items. The concentration and method of application of the solutions shall be as specified in IS: 5491.

2.01.07 **Patent Stone**

It shall consist of an underbed and a topping laid on an already laid and matured concrete base.

a) **Thickness**

The patent stone finish shall have thickness as stipulated under clause 2.01.03(a) except that the topping shall be 6 mm thick.

b) **Mix**

i) **Underbed**

The mix shall be as stipulated under clause 2.01.03 (b).

ii) **Topping**

The mix for the topping shall consist of 1 part cement and 1 part fine sand by volume.

c) **Laying**

The Patent Stone finish, including the underbed shall be laid in alternate bays or in chequered board pattern. No panel shall be as in contact with another already laid till the contraction of the latter has already taken place.

The maximum area of each panel shall be 3 Sq.M. of which no side shall be more than 2 M long.

A cement grout shall be applied and worked into the surface to receive the finish; the underbed then laid, compacted and levelled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set but firm enough and rolled and pressed to get full bond. The topping shall be trowelled to a dense finish to the satisfaction of the Engineer. All trowel marks shall be mopped out with a soft cloth to give a clean smooth surface.

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing. If desired the finish shall be polished as directed by the Engineer.

2.01.08 **Cement Concrete Flooring with Metallic Hardener Topping**

Wherever floors are required to withstand heavy wear and tear, use of floor hardener shall be avoided as far as possible by using richer mixes of concrete, unless the use of a metallic hardener is justified on the basis of cost.

This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is “Green”.

a) **Thickness**

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth.

b) **Material**

The hardening compound shall be of approved quality consisting of uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand soluble alkaline compounds or other injurious materials. When desired by the engineer, actual samples shall be tested.

c) **Mix**

The top layer shall consist of 12mm thick layer of mix 1: 2 (1 cement: 2 stone aggregate 6mm nominal size) by volume or as otherwise specified with which metallic hardening compound is mixed in the ratio of 1:4 (1 metallic concrete hardener: 4 cement) by weight or as per manufacturer's specification relevant to medium/heavy duty floor. Metallic hardener shall be dry mixed thoroughly with cement on a clean dry pacca platform. This dry mixture shall be mixed with stone aggregate 6mm nominal size or as otherwise specified in the ratio of 1:2 (1 cement :2 stone aggregate) and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete.

d) **Laying**

The concrete floor shall be laid as per specification "Cement Concrete" and levelled upto the required grade. The forms, if any shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible.

The mixture so obtained shall be laid in 12mm thickness, on cement concrete floor while the concrete under bed is still very "green" within 2 to 4 hours of it's laying. The topping shall be laid true to provide a uniform and even surface without trowel marks, pin holes etc. It shall be firmly pressed into the bottom concrete so as to have good bond with it. Just when the initial set starts the surface shall be finished smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

2.01.09 **Mastic Asphalt Finish**

This is a one-layer treatment on concrete or brick base.

a) **Thickness**

The thickness shall be as specified in the drawing or schedule of items.

b) **Materials**

Bitumen shall be industrial bitumen of the grades 90/15 and 75/15 conforming to IS: 702.

Mineral filler shall be dry stone dust passing through 75-micron IS Sieve.

Fine aggregate shall be crushed and graded natural limestone or other hard work.

Coarse aggregate shall be crushed siliceous stone or other approved aggregate 6 mm stone chips shall be used for finish upto 20 mm thick and 10 mm chips for thicker finish.

c) **Composition**

Bitumen mastic shall conform to IS: 1195 and shall be either brought to site in blocks weighing about 25 Kg. or prepared at site. If brought in blocks, these shall be re-melted in mechanically agitated mastic cookers and coarse aggregate, preferably preheated fed in successive portions until the complete change is thoroughly incorporated. At no stage during the re-melting and mixing process, shall the temperature exceed 205^{o} C.

d) **Laying**

The hot mastic shall be laid on dry base surface cleaned thoroughly by wire brushing and sweeping. The mastic shall be levelled and when cooled to some extent shall be finished with a wooden float with addition of small quantity of fine sand if required. No load shall be allowed till the finish has cooled to normal temperature.

The mastic shall be laid in suitable panels of about 15 Sq.M. in area each formed by formers. Succeeding panels shall be laid overlapping the finish panel so as to melt its edges and form a continuous finish without joint.

2.01.10 **Acid or Alkali Resistant Tiles**

Manufacture and Finish

The tiles shall be of vitreous ware and free from deleterious substances. The iron oxide content allowable in the raw material shall not exceed two percent. The tiles shall be vitrified at the temperature of 1100ºC and above and shall be kept unglazed. The finished, tile, when fractured shall appear fine grained in texture, dense and homogeneous. The tiles shall be sound, true to shape, flat and free from flows and manufacturing defects affecting their utility.

The tiles shall be conforming to IS 4457. The tiles to be tested for water absorption, compressive strength, acid resistance as per IS 4457. Sampling procedure for acceptance tests and criteria for conformity to be as per IS 4457. The tiles shall be of required colour.

Dimensions and Tolerances

Ceramic unglazed vitreous acid-resistant tiles shall be made in three sizes namely 98.5 x 98.5 mm, 148.5 x 148.5mm and 198.5 x 198.5mm. They shall be available in the following thickness: 35, 30, 25, 20 and 15 mm. The depth of the grooves on the under side of the tile shall not exceed 3 mm. Tolerance on length, breadth and thickness of tiles shall be ± 2 percent.

Shape

The tiles shall be square shaped. Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles shall have dimensions which shall be such as to make two half tiles, when joined together, match with the dimension of full tile. The shape of tiles other than square shall be as agreed to between the purchaser and the manufacturer. Tiles shall be checked for square ness and warp as per IS 4457.

Performance Requirements

The tiles when tested in accordance with method given in IS 4457, shall conform to be requirement specified in the code (IS 4457).

Loss in Abrasion

The maximum percentage of loss in abrasion of the ceramic unglazed vitreous acid resistant tiles determined in accordance with the procedure laid down in IS 1237, shall be as mentioned in IS 4457.

Marking

Tiles shall be legibly marked on the back with the name of the manufacturer or his trade mark. Manufacturer’s batch number and year of manufacture.

Each tile may also be marked with the ISI certification mark.

Preparation of Surface and Laying

Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The average thickness of the bedding shall be 10mm or as specified while the thickness for dado/skirting to be 12mm or specified on item.

Alkali resistant mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

Over the mortar bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of acid alkali resistant cement per square metre over an area up to one square metre. Tiles shall be socked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope. In bath, toilet W.C. kitchen and balcony/verandah flooring, suitable tile drop or as shown in drawing will be given in addition to required slope to avoid spread of water. Further tile drop will also be provided near floor trap.

Where full size tiles cannot be fixed these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints.

Tiles which are fixed in the floor adjoining the wall shall enter not less than 10mm under the plaster, skirting or dado.

After tile has been laid surplus cement slurry shall be cleaned off.

Pointing and finishing

The joints shall be cleaned off the grey cement slurry with wire/coir brush or trowel to a depth of 2 mm to 3mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of tiles. Where spacer lug tiles are provided, the half the depth of joint shall be filled with polysulphide or as specified on top with under filling with cement grout the lugs remaining exposed. The floor shall then be kept wet for 7 days. After surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

Measurements

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where covers are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metres. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10squre metre.

Areas, where glazed tiles or different types of decorative tiles are used will be measured separately.

Rate

The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. For tiles of sizes up to 0.16 sqm, unless otherwise specified in the description of the item. Nothing extra shall be paid for the use of cost (Swan) tiles in the work.

2.02.00 **Tiled Finish**

These shall include finish tiles, stone slabs and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

2.02.01 **Terrazzo Tile Finish**

The finish will consist of manufacture terrazzo tile and an underbed.

a) **Thickness**

The total thickness including the underbed shall be minimum 40 mm for floors 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the tiled finish, to accommodate the specified thickness shall be done.

b) **Tiles: Terrazzo**

Terrazzo tiles shall generally conform to IS 1237-Edition 2.3. The tiles shall, unless specifically permitted in special cases be machine made under quality control in a shop. The tile shall be manufactured in a factory under pressure process subject to pressed hydraulically to a minimum of 140 Kg. per sq.cm and shall be given the initial grinding with machine and grouting of the wearing layer before delivery to site. The wearing layer shall be free from projections, depressions, cracks, holes, cavities and other blemishes. The edges of wearing layer may be rounded. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be carefully stored to prevent staining by damp, rust, oil, and grease or other chemicals. Tiles made in each batch shall be kept and used separately so that colour of each area of the floor may remain uniform. The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers for the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

Each tile shall bear on its back permanent and legible trademark of the manufacturer. All angles of the tiles shall be right angles all arises

sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance allowance length and breadth shall be ± 1 mm and the thickness +5 mm. The variation of dimensions in any one delivery of tiles shall not exceed 1 mm on length and breadth and 3mm on thickness. Face of the tile shall be plane, free from pinholes and other blemishes.

The proportion of cement to aggregate in the backing of tiles shall be not leaner than 1:3 by weight. Where colouring material is used in the wearing layer, it shall not exceed 10 percent by weight of cement used in the mix.

The finished thickness of the upper layer shall not be less than 5 mm for size of marble chips ranging from the smallest up to 6mm and also, not less than 5 mm for size of marble chips ranging from the smallest up to 12mm, and not less than 6mm for size of marble chips varying from the smallest up to 20mm.

The topping shall be as specified under clause 2.01.03 (b) (iii).

c) **Mix : Underbed**

Base concrete or RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with cement mortar of specified proportion and in conformity with provisions in relevant para of chapter on 'Mortar'

Cement mortar 1:4 (1 cement: 4 coarse sand) bedding shall be used. Average thickness of the bedding mortar shall be 20mm and the thickness at any place shall not be less than 10 mm.

d) **Laying**

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The surface shall be roughened for better bond. Before the underbed had time to set and while it is still fairly moist but firm, neat cement slurry of honey like consistency shall be spread at the rate of 4.4 kg of cement per square metre over such an area as would accommodate about twenty tiles. The tiles shall immediately be placed upon and firmly pressed by wooden mallet on to the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match the dimensions these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Engineer taken.

At the junction of horizontal surface with vertical surface the tiles on the former shall enter at least 12 mm under the latter.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall not be allowed.

If desired dividing strips as specified under Clause 2.01.03 (b ii) may be used for dividing the work into suitable panels.

e) **Grinding and Polishing**

The day after the tiles are laid all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shape of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be grounded evenly with machine fitted with coarse grade grit block (No.60). Water shall be used profusely during grinding. After grinding the surface shall be thoroughly washed to remove all grinding mud, cleaned and mopped. It shall then be covered with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit block (No. 120)

The final grinding with machine fitted with the finest grade grit blocks (No. 320) shall be carried out the day after the second grinding described in the preceding para or before handing over the floor, as ordered by the Engineer-in-Charge.

For small areas or where circumstances so require, hand grinding/polishing with hand grinder may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:

1st grinding	-	coarse grade stone (No. 60)
Second grinding	-	medium grade (No. 80)

Final grinding - fine grade (No. 120)

In all other respects, the process shall be similar as for machine polishing.

After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per sqm sprinkled with water and rubbed hard with a 'namdah' block (pad of woollen rags). The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

If any tile is distributed or damaged, it shall be refitted or replaced, properly jointed and polished.

The finished floor shall not sound hollow when tapped with a wooden mallet.

2.02.02 **Chequered Tile Finish**

The finish shall consist of manufactured grey or coloured cement tiles or terrazzo tiles with chequered face and an underbed laid over concrete or brick surface.

a) **Thickness**

Thickness shall be same as in clause 2.02.01

b) **Tiles: Chequered**

The tiles shall be of nominal sizes such as 20 x 20 cm, 25 x 25 cm and 30 x 30 cm or standard sizes with equal sides. The size of tiles to be used shall be as shown in drawings or as required by the Engineer-in-Charge. The tiles shall have chequers not less than 2.5 cm. c/c and not more than 5 cm c/c, Depth of grooves shall be not less than 5 mm. The grooves shall be uniform and straight.

The tiles shall conform to clause 2.2.1 (b) except that these may have the topping in terrazzo or plain grey cement or colour pigment added to cement as specified.

c) **Underbed**

As per clause 2.02.01 (c).

d) **Laying**

As per clause 2.02.01 (d)

e) **Grinding and Polishing**

As per clause 2.01.03 (e) except that the tiles shall be ground and polished by hand after laying taking special care in polishing the grooves properly and uniformly.

2.02.03 **Pressed Ceramic Tile Flooring**

The tiles shall be of approved make and shall generally conform to IS 15622. They shall be flat, and true to shape and free from blisters crazing, chips, welts, crawling or other imperfections detracting from their appearance. The tile shall be tested as per IS 13630.

Classification and Characteristics of pressed ceramic tiles shall be as per IS 13712.

The tiles shall be square or rectangular of nominal size. Table 1, 3, 5 and 7 of IS 15622 give the modular preferred sizes and table 2, 4, 6 and 8 give the most common non modular sizes. Thickness shall be specified by the manufacturer. It includes the profiles on the visible face and the rear side. Manufacturer/supplier and party shall choose the work size of tiles in order to allow a nominal joint width up to 2 mm for uncertified floor tiles and up to 2mm for uncertified floor tiles and up to 1mm for rectified floor tiles. The joint in case of spacer lug tile shall be as per spacer. The tile shall conform to table 10 of IS 15622 with water absorption to 3% to 6% (Group BII)

The tiles surface of the tiles shall be glazed. Glazed shall be either glossy or matt as specified. The underside of the tiles shall not have glaze on more than 5% of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be preferably free from glaze. However, any glaze if unavoidable, shall be permissible on only up to 50% of the surface area of the edges.

Coloured Tiles

Only the glaze shall be coloured as specified. The sizes and specifications shall be the same as for the white glazed tiles.

Decorative Tiles

The type and size of the decorative tiles shall be as follows :

i) **Decorated white back ground tiles**

The size of these tiles shall be as per IS 15622

ii) **Decorative and having coloured back-ground**

The sizes of the tiles shall be as per IS 15622.

Preparation of Surface and Laying

Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with cement mortar 1:4 (1 cement: 4 coarse sand) or as specified. The average thickness of the bedding shall be 20mm or as specified while the thickness under any portion of the tiles not to be less than 10mm.

Mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

Over the mortar bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of cement per squre metre. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope. In bath, toilet W.C. kitchen and balcony/verandah flooring, suitable tile drop or as shown in drawing will be given in addition to required slope to avoid spread of water. Further tile drop will also be provided near floor trap.

Where full size tiles cannot be fixed these shall be cut (sawn) to the required size and their edge rubbed smooth to ensure straight and true joints.

Tiles which are fixed in the floor adjoining the wall shall enter not less than 10mm under the plaster, skirting or dado.

After tiles have been laid surplus cement slurry shall be cleaned off.

This finish shall be composed of glazed earthenware tiles with an underbed laid over a concrete or masonry base.

Pointing and Finishing

The joints shall be cleaned off the grey cement slurry with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of tiles. Where spacer lug tiles are provided, the half the depth of joint shall be filled with polysulphide or as specified on top with under filling with cement grout without the lugs remaining exposed. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

Measurements

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where covers are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

Areas, where glazed tiles or different types of decorative tiles are used will be measured separately.

Rate

The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. For tiles of size up to 0.16 sqm. Unless otherwise specified in the description of the item. Nothing extra shall be paid for the use of cut (swan) tiles in the work.

Extra over and above the normal rate for white tiles shall be paid where coloured or any other type of decorative tiles have been used.

2.02.04 **Pressed Ceramic Tile Flooring (Vitrified Tile Flooring)**

Tiles shall conform to Table 12 of IS and the joint thickness in flooring shall not be more than 1mm.

a) **Materials : Vitrified Tiles**

The tiles shall be of approved make and shall generally conform to the approved standards. They shall be flat and true to shape, free from cracks, crazing spots, chipped edges and corners. Unless otherwise specified, the nominal sizes of tiles shall be as under:

The tiles shall be square or rectangular of nominal sizes such as: 600 x 600 mm; 900 x 900 mm or as per tender schedule / drawings or as directed by the Engineer-in-Charge. Thickness shall be as per recommendations of the approved manufacturers. However the floor tile thickness shall not be less than 10mm.

Technical specifications of the tiles shall be generally conforming to the following standards:

Technical Specifications For Vitrified Tiles

No.	Property	Expected Standards
1	Deviation in length	(+/-) 0.6%
2	Straightness of sides	(+/-) 0.5%
3	Rectangularity	(+/-) 0.6%
4	Surface flatness	(+/-) 0.5%
5	Water absorption	< 0.50%
6	Mohs. Hardness	> 6
7	Flexural strength	> 27 N / mm2
8	Abrasion resistance	< 204 mm2
9	Skid resistance (friction coefficient)	> 0.4
10	Glossiness Min.	85% reflection

The tiles shall conform to the relevant standards in all respects. Samples of tiles shall be got approved from the Engineer-in-charge before bulk procurement for incorporation in the work.

b) **Preparation of Surface for Flooring**

Following procedure shall be followed :

- **Sub grade**

  Concrete or RCC slab or side brick wall / or plastered surfaces on which tiles are to be laid shall be cleaned, wetted and mopped as specified for terrazzo tile flooring.

- **Mortar and bedding**

Cement mortar for bedding shall be prepared of mix 1:4 or as specified in the schedule of items, to a consistent paste and shall conform to the specification for materials; preparations etc. as specified under cement mortar. The amount of water added while preparing mortar shall be the minimum necessary to give sufficient plasticity for laying. Care shall be taken in preparation of the mortar to ensure that there are no hard lumps that would interfere with even bedding of the tiles. Before spreading the mortar bed the base shall be cleaned off all dirt, scum or laitance and loose materials and well wetted without forming any pools of water on the surface. The mortar of specified proportion and thickness shall then be evenly and smoothly spread over the base by use of screed battens to proper level or slope.

Once the mix is prepared, no further water be added and the same shall be used within one hour of adding water.

Apply on an average 20 mm thick bedding of mortar over an area of 1 sqm at a time over surface of the area for laying tiles, in proper level and allowed to harden sufficiently to offer a fairly good cushion for the tiles to set.

c) **Laying Of Tiles for Flooring**

The tiling work shall be done as per the pattern shown in the drawing or as directed by the Engineer-in-Charge. As a general practice laying of tiles shall be commenced from the centre of the area and advanced towards the walls. Cut tiles, if any, shall be laid along wall with necessary border pattern as shown / directed by the Engineer-in-Charge. Tiling work shall be completed by pressing tiles firmly into place along the wall /floor. White cement slurry to the back of the tile to be applied to ensure proper and full bedding. The tiles shall be laid on the bedding mortar when it is still plastic but has become sufficiently stiff to offer a fairly firm cushion for the tiles. Tiles, which are fixed on the flooring adjoining the wall, shall be so arranged that the surface on the round edge tiles shall correspond to the skirting or dado. Press gently the tile with wooden mallet for even adherence at the back of the tile. Do not use an iron hammer or some heavy material to press the tile. The edges of the tiles shall be smeared with neat white cement slurry and fixed in this grout one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. There shall be no hollows in bed or joints. The joints shall be kept as close as possible and in straight line. Unless otherwise specified, joint-less tiling shall be done butting the tiles with each other. If joint is specified, the same shall not exceed 1.00 mm. in width. The joint shall be grouted with white / matching colour cement slurry. After fixing the

tiles, finally in an even plane or slope, the flooring shall be covered with wet sand and allowed undisturbed for 14 days.

d) **Fixing Tiles For Dado & Skirting / Facia**

The fixing of tiles on wall surfaces shall be done only after completing fixing of the tiles on the floor. Following procedure shall be followed:

DAE / DCSEM: 102: SPN-CVL

The back of tiles shall be cleaned off and covered with layer of approved adhesive like BAL-ENDURA or equivalent with proper trowelling as per manufacturers recommendations.

The edges of the tiles shall be smeared with the adhesive and fixed on the wall one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly fixed in level with the adjoining tiles. There shall be no hollows on the back or in joints. Unless otherwise specified, joint-less tiling shall be done butting the tiles with each other. If joint is specified, the same shall not exceed 1.00 mm. in width. The joint shall be grouted with approved adhesive. The joints shall be kept in straight line or as per the approved pattern.

While fixing tiles in dado / skirting work, care shall be taken to break the joints vertically. The top line shall be touched up neatly with the rest of the plaster above. If doors, windows or other openings are located within the dado area, the corners, sills, jambs etc. shall be provided with true right angles without any specials. The contractor will not be entitled to any extra claims on this account for cutting of tiles if required.

The fixing shall be done from bottom of wall to upward without any hollows in the bed of joints. Each tile shall be as close as possible to one adjoining. All tiles faces shall be in one vertical plane.

e) **Grouting Of Joints In Floor / Skirting / Dado**

The joints, if specified, shall be cleaned off and all dust and loose particles removed. Joints shall then be filled with approved adhesive like BAL-ENDURA or equivalent grouts.

After finishing the grouting process, after 15 minute, wipe off excess grout with a damp sponge and polish the tiles with a soft & dry cloth for a clean surface. The Finished work shall not sound hollow when tapped with a wooden mallet.

f) **Cleaning**

As directed by the Engineer-in-Charge, the tiles shall be cleaned by mild acid (However, Hydrofluoric acid and its derivatives should not be used). After the tiles have been laid in a room or the days fixing work is completed, the surplus cement grout / adhesive that may have come out of the joints shall be cleaned off before it sets. The dado / skirting shall be thoroughly cleaned. In the case of flooring, once the floor has set, the floor shall be carefully washed clean and dried. When drying, the floor shall be covered with oil free dry sawdust. It shall be removed only after completion of the construction work and just before the floor is used.

g) **Mode of Measurement and Rate**

Dado / flooring / skirting shall be measured in sqm correct to two places of decimal. Length and breadth shall be measured correct to 1 cm. between the exposed surfaces of skirting or dado. No deductions shall be made nor extra paid for any opening of area upto 0.1 sqm. The rate shall include all the cost of labour and materials involved.

h) **Cleaning Agents for Vitrified Tiles**

Vitrified tiles are resistant to all chemicals (except hydrofluoric acid and its derivatives), hence commercially available detergents and cleaning agents can also be used for regular maintenance. Any spills and stains must be removed immediately. If left dry they may leave stains, which may be difficult to remove completely.

Cleaning Agents for Vitrified Tiles

Stains	**Cleaning Agent**
Robin Blue	Household detergent / Warm water
Marker ink	Turpentine / Acetone / Trichloroethylene
Pen ink	Acetone / Isopropyl alcohol
Methylene blue	Isopropyl alcohol / Acetone
Sauce	Ammonia solution
Cement	Turpentine / Acetone / Trichloroethylene / Conc. HCL
Tea	Hydrochloric acid / Bleaching powder
Coffee	Sodium hydroxide / Potassium hydroxide
Beer	Sodium hydroxide / Potassium hydroxide
Diesel	Acetone / Petrol
Lab indicator	Acetone / Isopropyl alcohol
Cement and grouting	Hydrochloric acid
Pencil mark	Benzene or Toluene or Xylene
Plaster of Paris (POP)	Ammonium sulphate solution

Stains	Cleaning Agent
Iodine (Tincture iodine)	Sodium hydroxide / Potassium hydroxide
Hair dye	Per chloric acid
Paan	Lemon juice or citric acid
Marker pen	Acetone

Rate

The rate for flooring shall include the cost of all materials and labour involved in all the operations described above. Nothing extra shall be paid for the use of cut (sawn) tiles in the work.

2.02.05 **Pressed Ceramic Tiles In Skirting And Dado**

The tiles shall be approved make and shall generally conform to IS 15622. The tiles shall be pressed ceramic covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility.

The top surface of the tiles shall be glazed. The underside of the tiles shall not have glaze or more than 5% of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be free from glaze; however, any glaze if unavoidable shall be permissible on only up to 50% of the surface area of edges.

The glaze shall be free from welts, chips, craze specks, crawling or other imperfections detracting from the appearance when viewed from a distance of one metre. The glaze shall be either glossy or matt as specified. The glaze shall be white in colour except in the case of coloured tiles when colours shall be specified by the Engineer-in-Charge. There may be more than one colour on a tile.

Dimensions and Tolerances

Glazed pressed ceramic tiles shall be made square or rectangular in sizes Table 1, 3, 5, & 7 of IS 15622 give the modular sizes and table 2, 4, 6 & 8 of IS 15622 gives the sizes of non modular tiles. The tiles shall conform to IS 15622 for dimensional tolerance, physical and chemical properties.

Half tiles for use as full tiles shall have dimensions which shall be such as to make the half tiles when joined together (with 1mm joint) match with dimensions of full tiles. Tiles may be manufactured in sizes other than those specified above.

The thickness of the tiles shall be 5 mm or 6 mm or as specified.

The dimensions of fittings associated with the glazed tiles namely cover base, round edge tile, angles corner cups, ridge and legs and capping beds shall be of the shape and dimensions as required and thickness of fittings shall be the same as the thickness of tiles given above.

Preparation of Surface

The joints shall be raked out to a depth of at least 15mm in masonry walls. In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

Laying

12mm thick plaster of cement mortar 1:3 (1 cement: 3 coarse sand) mix of as specified shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at closed intervals.

The tiles should be soaked in water, washed clean and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper plane and lines. The tiles shall be set in the required pattern and joined. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Odd size/cut size of tile shall be adjusted at bottom to take care of slope of the flooring. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed these shall be cut (swan) to the required size and their edges rubbed smooth. Skirting/ dado shall not project from the finished “surface of wall” by more than the thickness, undulations if any shall be adjusted in wall.

Curing and Finishing

The joints shall be cleaned off the grey cement grout with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work shall then be kept wet for 7 days.

After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

2.02.06 **Tesserae Finish (Mosaic etc.)**

This finish consists of manufactured vitreous, glass, ceramic or similar hard small pieces set in an underbed over a concrete or masonry surface, already laid.

a) **Thickness**

The total thickness including the underbed shall be between 20 mm and 40 mm.

b) **Tesserae Finish**

These shall usually be 6 mm thick small piece of ceramic vitreous china, tinted glass or similar hard wearing, strong and durable material in desired shapes and sizes and patterns. Mosaic tiles shall be of grey/white base as per the requirement and as per directives of Engineer-in–charge.

The supply shall come in the desired pattern in full or sections conveniently for handling, stuck to pieces of strong thick paper on the surface to be exposed. The gum used for this purpose must be water soluble and non-staining. The sections shall be properly marked to avoid mistakes and master drawing shall be available at the site for guidance.

c) **Mix : Underbed**

Same as clause 2.02.01(c)

d) **Laying**

The specification for laying if given by the manufacturer of the item shall be followed provided it is approved by the Engineer. Otherwise clause 2.02.01(d) shall generally be followed. However, instead of grey cement the slurry shall be made with white cement to fix the panels. The paper-mounted patterns in sections shall be carefully placed and pressed in position true to lines and levels. Earliest possible the paper shall be peeled off and surface examined and cleaned, joints flush pointed with white cement and cured for 7 days by keeping it wet.

2.02.07 **Chemical Resistant Tiled Finish**

This shall include all verities of special tiles used for specific chemical resistance function and an underbed over already laid concrete or masonry.

a) **Tiles**

The chemical resistant tiles as detailed in the Schedule of items shall be of the best indigenous manufacture unless otherwise specified and shall be resistant to the chemical described in the Schedule of Items. The tiles shall have straight edges, uniform thickness, plain surface, uniform non-fading colour and textures.

Glazed tiles if permitted to act as chemical resistant finish shall be considered under clause 2.02.03.

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/Cm2. The surface shall be abrasion resistant and durable.

b) **Laying**

The mortar used for setting or for underbed the tiles shall be durable and strong. The grout which shall be to the full depth of tile shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Engineer.

2.02.08 **Rubber, Vinyl or Vinyl Asbestos Tiles Finish**

This shall include various types of tiles manufactured from rubber, vinyl, etc. set with an adhesive on concrete or masonry base. An underbed may be required to secure desirable surface and grade.

a) **Thickness**

The thickness of the tiles shall be mentioned in the Schedule or in drawing.

b) **Tiles**

Unless otherwise desired the tiles shall be squares of approved dimensions. The tolerance in dimensions shall be $\pm$ 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be non-fading and uniform in appearance, insoluble in water and resistant to alkalise, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trademark, the thickness, sizes, batch number and date of manufacture.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) **Mix: Underbed**

The underbed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty: 1 part cement: 4 parts coarse sand mixed with just sufficient water to make it workable.

d) **Laying**

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air-conditioned space, the air-conditioning shall be completed before tiling is taken up.

The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

e) **Finishing**

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried and polished with an approved type of polish just before handing over.

2.02.09 **Stone Slab Finish: Marble, Stone and Similar Fine Grained Stone**

a) **Dressing of slabs**

Every stone shall be cut to the required size and shape, fine chisel dressed on all sides to the full depth so that a straight edge laid along the side of the stone shall be fully in contact with it. The top surface shall also be fine chisel dressed to remove all waive ness. In case machine cut slabs are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid any where along the machine cut surface is in contact with every point on it. The sides and top surface of slabs shall be machined rubbed or table rubbed with coarse sand before paving. All angles and edges of the marble slabs shall be true, square and free from chippings and the surface shall be true and plane.

b) **Thickness**

The underbed shall be average 20 mm thick. The thickness of the slabs shall be 18, 30, or 40mm as specified in the description of the item. Tolerance of ± 3% shall be allowed for the thickness. In respect of length and breadth of slabs a tolerance of ± 2% shall be allowed.

c) **Stone Slab**

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the full depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

d) **Mix: Underbed**

Same as clause 2.01.03 (c).

e) **Laying**

Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 cement: 4 coarse sand) or as given in the description of the item.

The average thickness of the bedding mortar under the slab shall be 20mm and the thickness at any place under the slab shall be not less than 12mm.

The slabs shall be laid in the following manner :

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg of cement per sqm. The edges of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the marble slabs as given in the description of the item.

The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels and slopes as instructed by the Engineer-in-Charge. Joint thickness shall not be more than 1 mm.

Due care shall be taken to match the grains of slabs which shall be selected judiciously having uniform pattern of veins/streaks or as directed by the Engineer-in-Charge.

The slabs shall be matched as shown in drawings or as instructed by the Engineer-in-Charge.

Slabs which are fixed in the floor adjoining the wall shall enter not less than 12mm under the plaster skirting or dado. The junction between wall plaster and floor shall be finished neatly and without waviness.

Marble slabs flooring shall also be laid in combination with other stones and/or in simple regular pattern/design as described in item of work and/or drawing.

f) **Polishing, Finishing**

Fine chiselling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified under clause 2.01.03 (e). However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for. Cement slurry with or without pigment shall not be applied on the surface before each polishing.

2.02.10 **Stone Slab Finish: Sand Stone and Similar Coarse Grained Stone Finish**

Generally clause 2.02.10 shall be followed except that the workmanship and finish shall not be fine as which are explained hereunder.

The slabs shall be rough chiselled or fine chiselled as specified. Tolerance may be allowed up to ± 3 mm for rough finish, but no sharp unevenness and shall be allowed. For fine chiselling the unevenness shall be limited to ± 2 mm. The sides shall be chisel dressed at least to half slab depth so that the maximum deviation from straight line shall be within 25 mm. Beyond this depth the edge may be slightly splayed.

The joint thickness shall be kept limited to 5 mm in case of rough finish and 3 mm in case of fine finish unless wider joints are specified. The joints shall be grouted with white or coloured cement.

2.02.11 **Marble Stone In Risers Of Steps And Skirting**

Marble Stone Slabs and Dressing of slabs shall be as specified in Clause no. 2.02.09 except that the thickness of the slabs shall be 18mm. A tolerance of ± 3% shall be allowed, unless otherwise specified in the description of the item.

Preparation of Surface

It shall be as specified in 2.02.05 where necessary; the wall surface shall be cut uniformly to the requisite depth so that the skirting face shall have the projection from the finished face of wall as shown in drawings or as required by the Engineer-in-Charge. In no case the skirting should project by more than thickness of stone.

Laying

The riser of steps and skirting shall be in grey or white cement admixed with or without pigment to match the shade of the stone, as specified in the description of the item, with the line of the slab at such a distance from the wall that the average width of the gap shall be 12mm and at no place the width shall be less than 10mm, if necessary, the slabs shall be held in position by temporary M.S. hooks fixed in to the wall at suitable intervals. The skirting or riser face shall be checked for plane and plumb and corrected. The joints shall thus be left to harden then the rear of the skirting or riser slab shall be packed with cement mortar 1:3 (1cement: 3 coarse sand) or other mix as specified in the description of the item. The fixing hooks shall be removed after the mortar filling the gap has acquired sufficient strength.

The joints shall be as fine as possible but nor more than 1 mm. The top line of skirting and risers shall be truly horizontal and joints truly vertical, except where otherwise indicated.

The risers and skirting slab shall be matched as shown in drawings or as instructed by the Engineer-in-Charge.

Curing, Polishing and Finishing

It shall be as specified in 2.02.01(e) as far as possible, except that cement slurry with or without pigment shall not be applied on the surface and polishing shall be done only with hand. The face and top of skirting shall be polished.

2.02.12 **Kota Stone Flooring**

Kota Stone Slabs

The slabs shall be selected quality, hard, sound, dense and homogeneous in texture free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness. They shall be of the colour indicated in the drawings or as instructed by the Engineer-in-Charge.

The slabs shall have the top (exposed) face polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required. Before starting the work the contractor shall get the samples of slabs approved by the Engineer-in-Charge.

Dressing

Every slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the sides of the stone shall be in full contact with it. The sides (edges) shall be table rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane.

The thickness of the slab after it is dressed shall be 20, 25, 30, or 40 mm as specified in the description of the item. Tolerance of ± 2 mm shall be allowed for the thickness. In respect of length and breadth of slabs Tolerance of ± 5 mm for hand cut slabs and ± 2 mm for machine cut slabs shall be allowed.

Preparation of Surface and Laying

The specification as described in 2.02.10 except that the edges of the slabs to be joined shall be buttered with grey cement, with admixture of pigment to match the shade of the slab. The thickness of the joints should be minimum as possible. In any location, it shall not exceed 1 mm.

Polishing and Finishing

The specifications shall be as described in 2.02.10 except that (a) first polishing with coarse grade carborundum stone shall not be done, (b) cement slurry with or without pigment shall not be applied on the surface before polishing.

2.02.13 **Kota Stone In Risers of Steps, Skirting and Dado**

Kota Stone Slabs and Dressing shall be as specified in 2.02.12 except that the thickness of the slabs shall be 25mm or as specified in the description of the item. The slabs may be of uniform size if required.

Preparation of surface shall be as specified in 2.02.11.

Laying shall be as specified in 2.02.11 except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs.

Curing, Polishing and Finishing shall be as specified in 2.02.11 except that first polishing with coarse grade carborundum stone shall not be done.

2.02.14 **Wooden Flooring**

Seasoning and Preservation

All timber used for timber floors shall be thoroughly seasoned in accordance with IS 1141. After seasoning the timber shall be treated with preservative in accordance with IS 401. Seasoning and preservative treatment shall be paid for separately unless otherwise specifically included in the description of the item of flooring.

Supporting Joists

Main beams and joists of the class of wood sections specified in the description of the item for beams and joists, or as instructed by the Engineer-in-Charge shall be fixed in position to dead levels. The width of the joists shall not be less than 50mm. The arrangement and spacing of beams joists etc. shall be as per design furnished.

Boards

It shall be the class of timber and thickness specified in the description of the item. Only selected boards of uniform width shall be used. Unless otherwise specified or shown in the drawings, the width of boards selected shall not be less than 100 mm nor more than 150 mm. The same width of boards shall not be maintained throughout except where the width of the room is not an exact multiple of the boards. In the latter case, the difference shall be equally adjusted between the two end boards (adjacent to walls). The length of the boards shall not exceed 3 metre anywhere. Ordinarily, the minimum length of

boards shall be such that the boards shall rest at least on three supports, except where otherwise required by the pattern specified in the drawings or as directed by the Engineer-in-Charge.

The boards shall be planed true on the top face only unless otherwise specified in the description of the item. Where the bottom face is exposed and it is also required to be planed, then such planing shall be paid for extra.

Unless otherwise described in the item, the longitudinal joints of planks shall be tongued and grooved to a minimum depth of 12 mm while the heading joints shall be of the squire butt type and shall occur over the centre line of the supporting joists. Heading joists in adjacent boards shall be placed over the same joists.

Iron screws

Iron Screws shall be of the slotted counter sunk head type, of length not less than the thickness of planks plus 25 mm, subject to a minimum of 40 mm, and of designation No. 9 confirming to IS 451.

Fixing

The joints on which the planks shall be fixed shall be checked and corrected to levels. The end boards shall be accurately fixed with the sides parallel and closed to the walls. Each adjoining board shall be carefully jointed and shall be tightened in position and screwed. For fixing the boards to the joists, two screws shall be used at each end of the boards and one screw at each of the intermediate joists in a zig zag manner. The screws shall be countersunk and screw holes filled with approved stopping.

The junction between timber flooring and adjacent flooring shall be formed by inserting a metal strip (brass or aluminium) at the junction. The metal strip shall be fixed to the end of the planks by screws. The strips shall be paid for extra.

The flooring shall be truly level and plane. The joints shall be truly parallel and or perpendicular to the walls, unless otherwise specified.

The floor shall be planed in both directions and made perfectly even, true and smooth.

Note : No wood of any kind shall be placed within 60 cm of any fire place or flue. Provision shall be made for ventilation in the space below the floor in case of ground floor and between floor and top of ceiling in the case of upper floors. Such arrangements shall be paid for separately.

Finishing

The surface of the floor shall be bees waxed or finished otherwise as directed by the Engineer-in-Charge. The lower face shall be painted or treated with wood preservative as directed. The finishing shall be paid for separately unless specifically included in description of the flooring item.

2.02.15 **Anti Static PVC Flooring**

PVC flooring of 2mm thick should be of approved make & brand with scratch proof, flexible & impregnated polyurethane reinforced (PUR) permanently static conductive Vinyl sheet, consists of impregnated polyurethane homogeneous mixture of PVC, plasticizers, urethane, colour pigments and filler calendared of approved colours and pattern detail. The material should be fixed with synthetic acrylic adhesive after preparing the floor, leveling & smoothening when necessary with suitable putty, as per the design & instruction of the Engineer-in-charge. Electrical resistance should be min $R10^8$ ohm as per ESD approval, SP-method 2472. Anti-static sheets should be confirming clean Room Test Class A as per ASTMF 51/100.

2.02.16 **Heavy Duty Cement Concrete Tiles (Steelcrete or equivalent)**

1. **Materials**

Cement - Cement used in the manufacture of tiles shall be ordinary Portland cement conforming to IS: 269-1976t or rapid hardening Portland cement conforming to IS: 8041-1978 or white Portland cement conforming to IS: 8042-1978t or Portland Puzzolana cement conforming to IS: 1489-1976.

Aggregates - Aggregates used in the backing layer of tiles shall conform to the requirements of IS: 383-1970s. For the wearing layer, unless otherwise specified aggregates shall consist of natural stone chips, like carborundum.

Pigments - Pigments, synthetic or otherwise, used for colouring tiles shall have durable colour. It shall not contain matters detrimental to concrete and shall according to the colour required be one of the following or their combination:

Pigments	**Relevant Indian Standard**
a) Black or red or brown pigment	IS: 44-196911
b) Green pigments	IS: 54-19757
c) Blue pigments	IS: 55-1970 or IS: 56-1975 or IS : 3574 (Part II)-1966
d) White pigments	IS: 411-196845
e) Yellow pigments	IS: 50-19791111 or IS : 3574 (Part I)-1965

Colours other than mentioned above may also be used. The pigments shall not contain zinc compounds or organic dyes. Lead pigments shall not be used unless otherwise specified by the purchaser.

2. **Manufacture**

2.1 Cement concrete flooring tiles shall be manufactured from a mixture of cement, natural aggregates, and colouring material where required, by pressure process. During manufacture the tiles shall be subjected to a pressure of not less than 14 N/mm” (140 kg/cm”).

2.2 The proportion of cement to aggregate in the backing of the tiles shall be not leaner than 1: 3 by mass.

2.3 Where colouring material is used in the wearing layer, it shall not exceed 10 percent by mass of cement used in the mix.

2.4 On removal from the mould, the tiles shall be kept in moist condition continuously for such a period that would ensure their conformity to the requirements of this standard. Tiles shall be stored under cover.

3. **Dimensions**

The size of cement concrete flooring tiles shall be as follows :

Length (mm)	Breadth (mm)	Thickness (mm)
200	200	20
250	250	22
300	300	25

Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles in the floor shall have dimensions which shall be such as to make two half tiles when joined together, match with the dimensions of the one full tile.

4. **Tolerances**

4.1 Tolerances on length or breath of tiles shall be ± 1mm. In addition the difference in length of side between the longest side and shorter side in the sample shall not exceed 1mm.

4.2 Tolerance on thickness shall be +5 mm. In addition the difference in thickness between the thickest and the thinnest tile in the sample shall not exceed 3 mm.

4.3 Thickness of Wearing Layer - The minimum thickness of wearing layer for the various classes of cement concrete flooring tiles shall be as specified in Table 1.

4.3.1 The thickness of the wearing layer shall be measured at several points along the fracture line of the tile that was tested for wet transverse strength in accordance with 11.5. The arithmetic mean of the two measurements which yielded the lowest value shall be the minimum thick- ness of the wearing layer.

TABLE 1 THICKNESS OF WEARING LAYER

SL. NO.	CLASSIC OF TITLE	MINIMUM THICKNESS OR WEARING LAYER (mm)
(1)	(2)	(3)
i)	Plain cement and plain coloured tiles for general purpose	5
ii)	Terrazo tiles with chips of riie varying from the smallest up to 6 mm, for general purpose	5
iii)	Terrazo tiles with chips of size varying from the smallest up to 12 mm, for general purpose	5
iv)	Terrazo tiles with chips of size varying from the smallest up to 20 mm, for general purpose	6
		6
v)	Plain cement and plain coloured tiles, for heavy duty	

5. **General Quality**

5.1 Unless otherwise specified, the tiles shall be supplied with initial grinding and grouting of the wearing layer. The wearing layer of the tiles shall be free from projections, depressions, cracks (hair cracks not included), holes, cavities and other blemishes layer may be rounded.

6. **Finish**

6.1 The colour and texture of the wearing layer shall be uniform through-out its thickness. No appreciable difference in the appearance of the tiles, from the point of view of colour of aggregate, its type and its distribution on the surface of the wearing layer shall be present.

6.2 When indenting for terrazzo tile, the purchaser shall state the size of chips to be used in the wearing layer of size 2B.

7. **Physical Requirements**

7.0 The tests on tile shall not be carried out earlier than 28 days from the date of manufacture.

7.1 Flsitness of the Tile Surface - The tiles when tested, the amount of concavity and convexity shall not exceed 1 mm.

7.2 Perpendicularity - When tested the longest gap between the arm of the ‘square’ and the edge of the tile shall not exceed 2 percent of the length of the edge.

7.3 Straightness - When tested the gap between the thread and the plane of the tile shall not exceed 1 percent of the length of the edge.

7.4 Water Absorption - When tested according to the procedure laid down by the method for determination of water absorption that is given below, the average percentage of water absorption shall not exceed 10.

8. **Method For Determination Of Water Absorption**

1. Six full size tiles selected in accordance with 14 shall be used for the test. They shall be immersed in water for 24 hours, then taken out and wiped dry.

2. Each tile shall be weighed immediately after saturation and wiping as in D-l. The tile shall then be oven-dried at a temperature of 65 f (±) 1°C for a period of 24 hours cooled to room temperature and reweighed.

3. The water absorption for each tile shall be determined as follows: Water absorption, percent by mass =(M_1 - M_2) / M_2x 100 where MI = mass in g of the saturated specimen, and MB = mass in g of the oven-dried specimen.

4. The average value shall be reported.

3.00.00 ACCEPTANCE CRITERIA

The finish shall be checked specially for :

a) Level, Slope, Plumb as the case may be

b) Pattern and Symmetry

c) Alignment of joints, dividing strip etc.

d) Colour, texture

e) Surface finish

f) Thickness of joints

g) Details at edges, junctions etc.

h) Performance

i) Precautions specified for durability

4.00.00 RATES

Rates shall be for the complete finishing work including necessary forms, underbed, sticker and preparation of the surface including cutting and chipping to receive the finish but exclusive of the base unless specially included in Contract.

The dividing strips in case of in situ terrazzo finish shall be included in the rates. Similarly, indentations, laying in desired patterns and in panels shall be inclusive in the rates.

All necessary cutting tiles, slabs, etc. cost of specials if any shall be included in the rates. No extra shall be paid for rounding corners and edges. Unless specifically mentioned otherwise, same rates will apply to floor, skirting, dado, treads, nosing, etc.

5.00.00 METHOD OF MEASUREMENT

The finished surface shall be measured for area. Any opening less than 0.1 Sq.M. (and 0.05 Sq.M. in case of marble finish only) shall not be taken into account neither any extra shall be paid for it.

For terrazzo finish, either in situ or tiled shall be paid at the same rate unless mentioned separately in the schedule of items.

Except in case of in situ terrazzo finish and unless mentioned in the Schedule dividing strips shall be measured in length.

6.00.00 I.S. CODES

Important relevant codes for this section:

IS: 777	:	Glazed earthenware tiles
IS: 1196	:	Code of practice for laying bitumen mastic flooring.
IS: 1197	:	Code of practice for laying of rubber floors
IS: 1237	:	Cement concrete flooring tiles
IS: 1443	:	Code of practice for laying and finishing of cement concrete flooring tiles.
IS: 2114	:	Code of practice for laying in situ terrazzo floor.
IS: 3461	:	PVC asbestos floor tiles
IS: 4860	:	Specification for acid resistant bricks
IS: 5518	:	Code of practice for laying of flexible PVC sheet and tile flooring.
IS: 5491	:	Code of practice for laying in situ granolithic floor topping.
IS: 4457	:	Specification for ceramic unglazed vitreous acid resisting tiles
IS: 4441	:	Code of practice for use of silicate type chemical resistant mortars.
IS: 4443	:	Code of practice for use of resin type chemical resistant mortars.
IS: 4832 (part I)		Specification for chemical resistant mortar: silicon type.

IS: 4832 (part II)		Specification for chemical resistant mortar: resin type.
IS: 4832 (part III)		Specification for chemical resistant mortar: sulphur type.
IS: 13753	:	Specification for dust pressed ceramic tiles with water absorption of E>10%
IS: 13755	:	Specification for dust pressed ceramic tiles with water absorption of 3%, E6% (Group B11a)

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SECTION-XXIV

TECHNICAL SPECIFICATION FOR FALSE FLOORING

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SECTION-XXIV

TECHNICAL SPECIFICATION FOR FALSE FLOORING

1.00.00 SCOPE

This specification covers supplying, installation, repairing, finishing, testing, protection and maintenance till handing over of removable free access false flooring systems consisting of an assembly of panels mounted on adjustable pedestal and supporting steel grid system to provide an under floor space.

2.00.00 FALSE FLOORING SYSTEM

2.01.01 Base

The system shall be placed over a base of R.C.C. floor slab and with necessary grouting etc. to fix the supporting structure.

2.01.02 Supporting Structure

The supporting structure shall comprise of fabricated jacks made out of 25 mm. dia. MS rounds having 150 mm. threads at top. This jack shall be welded to 100 mm x 100 mm x 6 mm thick MS base plate pedestal. Pedestals shall be vertically true and located at 600 mm. centre to centre to conform to the size of the floor panels and shall be fixed to the RCC floor slab with ARALDITE. The jack shall be equipped with locking device to prevent loss of finished elevation. Adjustment shall be provided by the threaded rod member and elevating nut. The capital shall be of aluminium alloy die cast and shall receive cold rolled MS floor supporting channels of size 40 mm x 40 mm x 3.15 mm thickness as per drawings, both for main and cross runners. The pedestal shall be equipped with conducting grounding pad. All MS members shall be treated with steel protective paint as per drawing.

2.01.03 Floor Panel

The floor panels shall be made of phenol formaldehyde bonded particleboard treated with fire resistant paint as per schedule items. Size of each panel shall be 600 mm. x 600 mm. with all panel edges finished to a tolerance of $\pm$ 0.25 mm. on the diagonals. The edges of the floor panels shall be covered by 4 mm. thick rigid PVC edging. The underside of the panel shall have 0.05-mm. thick Aluminium foils, which shall be fixed to the particleboard with resin-based adhesive.

3.00.00 **STRENGTH**

Each 600 mm x 600 mm floor panel must be capable of supporting an uniform minimum live load of 1220 Kg/Sq. or a concentrated minimum load of 450 Kg. applied through a phenolic caster 75 mm in diameter and 45 mm wide, or a rolling minimum load of 450 Kg. at any point with a maximum deflection of 2 mm. The ultimate strength shall be capable of carrying a 2300 Kg. axial load without deformation of any part.

4.00.00 **SURFACE FINISH**

All removable panels shall have the top surface finished with 2 mm thick Antistatic Vinyl Flooring bonded to the surface with adhesive as per manufacturer's specification.

5.00.00 **SKIRTING**

Skirting shall be of the same Antistatic Vinyl tiles, 150 mm. high and 2 mm. thick, completely matching with the false flooring surface and shall be fixed with the plastered wall surface as per manufacturer's specification.

6.00.00 **INSTALLATION**

All steel surfaces are to be protected by pointing over a primer, as per schedule of items and any damage to the paint during installation shall be made good. Finished floor surface, when specified by the Engineer-in-Charge shall be protected by the Contractor with Kraft paper taped and sealed at edges to prevent tearing.

Any damage to the sub floor during installation of the false flooring system shall be made good by the Contractor without any extra cost to the owner.

7.00.00 **METALLIC FALSE FLOORING**

7.01.00 **Laminated Panel**

Floor panel of size 600x600 mm shall be all steel welded construction, with an enclosed bottom pan of **49 hemispherical and 36 reverse cones** and top plain sheet which are fuse welded at 129 locations to form a panel of an overall depth of 37 mm. The panel after cleaning, degreasing, phosphating by 11 tank process is coated with 40-60 micron epoxy coat and is heated to achieve maximum adhesion to the panel surface and corrosion resistance. The inner empty core of the panel is injected with a light weight fire retardant, non combustible cementitious compound at high pressure to fill in all the

crevices of the panel and ensures support of not less than 90% of the top surface area of the panel.

The panel is then laminated with 1.5/2.00 mm thick fire retardant floor grade Antistatic Laminate / ESD Laminate – PVC / Conductive PVC on a semi - automated lamination line to ensure maximum bonding to the steel surface. The edges of the laminated are protected with black **Conductive PVC edge trim** 5mm wide on all sides. This edge trim is mechanically locked and sealed in place to avoid detachment

7.02.00 **Sub Structure-Pedestal Assembly**

Sub structure installed to support the panel shall be suitable to achieve a minimum finished floor height of **65 mm to a maximum of 600 mm** from the existing floor level. Pedestal design shall confirm speedy assembly and removal for relocation and maintenance. The assembly shall provide easy adjustment of leveling and accurately align panels for a maximum of ± 25 mm in the vertical direction. Pedestals shall support an axial load without permanent deflection and an ultimate load as laid out in System Performance requirement.

The Pedestal head assembly shall consist of a 75 x 75 mm x 3.5 mm embossed head mechanically riveted to a 100mm long 19 mm Dia rolled formed stud and 2 check nuts for level adjustment and arresting vertical movement. The pedestal head shall consist of an anti-irrational PVC cap, for Panel and stringer location.

The Pedestal Base assembly shall consist of 22.20 mm OD pipe of thickness 1.6mm mechanically locked on a press for perpendicularity and then welded to a base plate of 100 x 100 x 2mm thick with stiffening folds.

The sub structure assembly shall be suitably anchored to the floor with suitable adhesive or fastener as recommended by the manufacturer. All steel components shall be zinc electro plated.

7.03.00 **Stringers**

The stringer is hot dipped galvanized steel cold rolled construction specially designed with ribs embossed on 3 sides for strength, lateral stability, rolling loads and to support the panels on all four sides for alignment. The stringer to have a counter sunk holes at both ends to accommodate bolting of M6 machine screws to the pedestal head assembly. The stringers shall be 21 x 32 x .8mm x 570 mm length.

PERFORMANCE CONFORMING TO MASTER SPECS 10270 / 096900 (USA)

A. **Structural Performance : CISCA A/F, 'Recommended Test Procedures for Access Floors'**

- **Concentrated Loads**

  540 Kgs (1200 lbf) with a top-surface deflection under load and a permanent set not to exceed , respectively, 2.54 & 0.25 mm (0.10 & 0.010 inch) according to CISCA A/F, Section I '' Concentrated Loads''

- **Ultimate Concentrated Load**

  1350 Kgs (3000 lbf) without failing according to CISCA A/F, Section II '' Ultimate Loading''

- **Rolling Loads**

  270 kgs (600 lbf) of the following magnitude, with a combination of local and overall deformation not to exceed 1.02 mm (0.040 inch) according to CISCA A/F, Section III '' Rolling Loads''

  CISCA AF Rolling Load: 10000 Passes

- **Stringer Load Testing**

  204 Kgs (450 lbf) at the centre of the span with a permanent set not to exceed 0.25mm (0.010 inch) as determined by CISCA A/F, Section IV, '' Stringer Load Testing''

- **Pedestal Axial Load Test**

  22 Kn axial Load per pedestal, according to CISCA A/F, Section V, ''Pedestal Axial Load Test ''

- **Pedestal Over Turning Moment Test**

  113 N x meters, according to CISCA A/F, Section VI, ''Pedestal Overturning Moment Test''

B. **Other Optional Structural Parameters**

- **Floor Panel Impact – Load Performance**

  100 lbf when dropped from 36 inches (914 mm) on to 1-Sq.Inch (6.5 sq.cm) area located anywhere on Panel without failing.

- **Uniformly Distributed Load (UDL)**

  1620 kg/m^2 with a maximum permissible deflection of not more than 1.52 mm as per definition of “Uniform load” of CISCA tested over an area of 300x300 mm square for 100kgs load

Note : The uniform load rating of an access floor panel as specified here in should not be confused with the “uniform live load” as specified in seismic zone application.

C. **Other Non structural Parameters**

- **Fire Rating**

  The Panels shall confirm to Class O & Class 1 Fire Ratings tested as per BS 476 Part 6 (Fire Propagation) & 7 (Surface spread of flame) as also ASTM E84 1998 (Flammability) and ASTM E136 (Combustibility)

- **Electrical Resistivity**

  As per ASTM F150/ NFPA 99 / ANSI S7.1 but modified for surface to ground to place one electrode on the floor surface and to attach the other electrode on the pedestal. Resistance to be tested at 500 volts

  1. Conductive range : $2.5x10^4$ – $1x\ 10^6$ Ohms (surface to ground)
  2. Static dissipative range : $1x10^6$- $1x10^9$ Ohms (surface to ground)
  3. Anti static range : $1x10^9$ – $2x10^{10}$ Ohms (surface to surface)

- **Fabrication Tolerance**

A.	Floor panel flatness	:	± 0.76 mm in any direction
B.	Floor panel width or length from specified size	:	± 0.25 mm
C.	Floor panel squareness	:	± 0.38 mm

7.04.00 **Acceptance Criteria**

The false flooring system shall be checked specially for :

a) Level

b) Alignment of joints

c) Thickness of joints

d) Surface finish

e) Colour and texture

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SECTION-XXV

TECHNICAL SPECIFICATION
FOR
PAINTING, WHITE WASHING AND POLISHING ETC.

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SECTION-XXV

TECHNICAL SPECIFICATION FOR PAINTING, WHITE WASHING AND POLISHING ETC.

1.00.00 SCOPE

This specification covers painting, white washing, varnishing, polishing etc. of both interior and exterior surfaces on wood work, masonry, masonry surface with lime punning or white cement putty, concrete plastering, plaster of Paris punning, false ceiling, structural and other miscellaneous steel items, rain water down comer, floor and roof drains, soil, waste and service water pipes, and other ferrous and non-ferrous metal items as shown on drawings, schedule or as directed by the Engineer.

Copper, bronze, chromium plate, nickel, stainless steel, aluminium and monel metal shall generally not be painted or finished except if otherwise specified.

The painting Contractor shall inspect the work of others prior to the application of paint. If surface to be finished cannot be put in suitable condition for painting by customary preparatory methods, the painting contractor shall notify the Engineer in writing or assume responsibility for and rectify unsatisfactory finishing those results.

Before commencing painting, the painting contractor shall obtain the approval of the Engineer in writing regarding the schedule of work to minimize damage, disfiguration or staining by other trades. He shall also undertake normal precautions to prevent damage, disfiguration or staining to work of other trades or other installations. Contractor shall keep record of number of coats of painting. Before applying second coat, the contractor shall obtain prior approval of Engineer in Charge

2.00.00 INSTALLATION

2.01.00 Materials

Materials shall be Grade-1 quality from well-known approved manufacture and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection, analysis and approved by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint or one shade is obtained from the same

manufacturing batch. All paint shall be subject to analysis from random samples taken at site from painter's bucket, if so desired by the Engineer.

All prime coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

All unspecified materials such as shellac, turpentine or linseed oil shall be of the highest quality available and shall conform to the latest IS standards. All such materials shall be made by reputable recognised manufacturers and shall be approved by the Engineer.

All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

a) **White Washing**

Preparation of Surface : Before new work is white washed, the surface shall be thoroughly brushed free from mortar droppings an foreign matters.

Preparation of Lime wash : The lime wash be prepared from fresh stone white lime (Natural or Dehradun quality) or fat lime, or a mixture of both as instructed by the Engineer, and shall conform to IS: 712 latest editions and shall be submitted to the Engineer for approval and approved sample shall be brought to site in unslaked condition. The lime shall be thoroughly slaked on the spot, mixed and stirred with sufficient water to make a thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 40 gm of gum dissolved in hot water, shall be added to each 10 cubic decimeter of the cream. The approximate quantity of water to be added in making the cream will be 5 liters of water to one kg of lime.

Indigo (Neel) up to 3 gm per kg of lime dissolved in water, shall then be added and stirred well. Water shall then be added at the rate of about 5 liters per kg. of lime to produce a milky solution.

Application: The white wash shall be applied with moonj brushes to the specified number of coats. The operation for each coat shall consist of a stroke of the brush given from the top downwards, another from the bottom upwards over the first stroke, and similarly one stroke horizontally from the right and another from the left before it dries.

Each coat shall be allowed to dry before the next coat is applied. Further each coat shall be inspected and approved by the Engineer-in-Charge before the subsequent coat is applied. No portion of the surface shall be left out initially to be patched up later on.

For new work, three or more coats shall be applied till the surface presents a smooth and uniform finish through which the plaster does not show. The finished dry surface shall not show any signs of cracking and peeling nor shall it come off readily on the hand when rubbed.

Protective Measures : Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed, shall be protected from being splashed upon. Splashing and droppings, if any shall be removed by the contractor at his own cost and the surfaces cleaned. Damages if any to furniture or fittings and fixtures shall be recoverable from the contractor.

Measurements : Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals.

Measurements for Jambs, Soffits and Fills etc. for openings shall be as described earlier.

Corrugated surfaces shall be measured flat as fixed and the area so measured shall be increased by the following percentages to allow for the girthed area.

Corrugated non-asbestos cement sheet 20%

Semi corrugated non-asbestos cement sheet 10%

Cornices and other such wall or ceiling features shall be measured along the girth and included in the measurements.

The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc exceeding 50 sq. cm. each with material similar in composition to the surface to be prepared.

The rate shall include all material and labour involved in all the operations described above.

b) **Colour Washing**

The mineral colours, not affected by lime, shall be added to white wash. Indigo (Neel) shall however, not be added. No colour wash shall be done until a sample of the colour wash of the required tint or shade has been got approved from the Engineer-in-Charge. The colour shall be of even tint or shade over the whole surface. If it is blotchy or otherwise badly applied, it shall be redone by the contractor.

For new work, the priming coat shall be of white wash with lime or with whiting as specified in the description of the item. Two or more coats, shall then be applied on the entire surface till it represents a smooth and uniform finish.

For old work, after the surface has been prepared (as described above) a coat of colour wash shall be applied over the patches and repairs. Then a single coat, or two or more coats of colour wash, as stipulated in the description of the item shall be applied over the entire surface. The colour washed surface shall present a uniform finish.

The finished dry surface shall not be powdery and shall not readily come off on the hand when rubbed.

Other specifications as described eallier.

c) **Dry Distemper**

Materials : Dry distemper of required colour (IS 427) and of approved brand and manufacture shall be used. The shade shall be got approved from the Engineer-in-Charge before application of the distemper. The dry distemper colour as required shall be stirred slowly in clean water using6 decilitres (0.6 litre) of water per kg of distemper or as specified by the makers. Warm water shall preferably be used. It shall be allowed to stand for at least 30 minutes (or if practicable over night) before use. The mixture shall be well stirred before and during use to maintain an even consistency.

Distemper shall not be mixed in larger quantity than is actually required for one day's work.

Preparation of Surface : Before new work is distempered, the surface shall be thoroughly brushed free from mortar droppings and other foreign matter and sand papered smooth.

New plastered surfaces shall be allowed to dry completely, before applying, distemper.

In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt, etc.

Pitting in plaster shall be made good with plaster of paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the resular coat of distemper is applied.

Priming Coat : A priming coat of whiting shall be applied over the prepared surface in case of new work, if so stipulated in the description of the item. No white washing coat shall be used as a priming coat for distemper.

The treated surface be allowed to dry before distemper coat is given.

Application : In the case of new work, the treatment shall consist of a priming coat of whiting followed by the application of two or more coats of distemper till the surface shows an even colour.

For old work, the surface prepared (as described before) shall be applied one or more coats of distemper till the surface attains an even colour.

The application of each coat shall be as follows :

The entire surface shall be coated with the mixture uniformly, with proper distemper brushes (ordinary white wash brushed shall not be allowed) in horizontal strokes followed immediately by vertical ones which together shall constitute one coat.

The subsequent coats shall be applied only after the previous coat has dried.

The finished surface shall be even and uniform and shall show no brush marks.

Enough distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day.

After each day's work, the brushes shall be washed in hot water and hang down to dry. Old brushes which are dirty or caked with distemper shall not be used.

The specifications in respect of scaffolding and protective measures shall be as described before.

d) **Oil Emulsion (Oil Bound) Washable Distemper**

Materials

Oil emulsion (Oil Bound) washable distemper (IS 428) of approved brand and manufactures shall be used. The primers where used as on new work shall be cement primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's work shall be prepared.

The distemper and primer shall be brought by the contractor in sealed tins in sufficient quantities at a time to suffice for a fortnight's work, and the same shall be kept in the joint custody of the contractor and the Engineer-in-Charge. The empty tins shall not be removed from the site of the work, till this item of work has been completed and passed by the Engineer-in-Charge.

Preparation of the Surface

For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing & scrubbing. The surface shall then be allowed to dry for that at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc.

Pitting in plaster shall be made good with plaster of paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

Application

Priming Coat : The priming coat shall be with distemper primer or cement primer, as required in the description of the item. The application of the distemper primer shall be as described before.

Note: If the wall surface plastered has not dried completely, cement primer shall be applied before distempering the walls. But if distempering is done after the wall surface is dried completely, distemper primer shall be applied.

Oil bound distemper is not recommended to be applied, within six months of the completion of wall plaster. However, newly plastered surface if required to be distempered before a period of six months shall be given a coat of alkali resistant priming Paint confirming to IS 109 and allowed to dry for atleast 48 hours before distempering is commenced.

For old work no primer coat is necessary.

Distemper Coat : For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated as stipulated by the manufacturer) shall be applied with brushes in horizontal strokes followed immediately by vertical ones which together constitutes one coat.

The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.

A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.

For old work the distemper shall be applied over the prepared surface in the same manner as in new work. One or more coats of distemper as are found necessary shall be applied to obtain an even and uniform shade.

15 cm double bristled distemper brushes shall be used. After each days work, brushes shall be thoroughly washed in hot water with soap solution and hang down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

The specifications in respect of scaffolding, protective measures shall be as described before.

e) **Cement Primer Coat**

Cement primer coat is used as a base coat on wall finish of cement, lime or lime cement plaster or on non-asbestos cement surfaces before oil emulsion distemper Paints are applied on them. The cement primer is composed of a medium and pigment which are resistant to the alkalies present in the cement, lime or lime cement in wall finish and provides a barrier for the protection of subsequent coats of oil emulsion distemper Paints.

Primer coat shall be preferably applied by brushing and not by spraying. Hurried priming shall be avoided particularly on absorbent surfaces. New plaster patches in old work should also be treated with cement primer before applying oil emulsion Paints etc.

Preparation of the Surface : The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any uneveness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

Application : The cement primer shall be applied with a brush on the clean dry 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. It shall be allowed to dry for at least 48 hours, before oil emulsion Paint is applied.

The specifications in respect of scaffolding, protective measures shall be as described before.

f) **Cement Paint**

Material : The cement Paint shall be (confirming to IS 5410) of approved brand and manufacturer.

The cement Paint shall be brought to the site of work by the contractor in its original containers is 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 the work has been completed and permission obtained from the Engineer-in-Charge.

Preparation of the Surface : For new work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement Paint shall be applied over patches after wetting them thoroughly.

Preparation of Mix : Cement Paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement Paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement Paint and one part of water stirred thoroughly and allowed to stand for 5 minutes. Care shall be taken to add the cement Paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency. In all cases the manufacturer's instructions shall be followed meticulously.

The lids of cement Paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement Paint rapidly becomes air set due to its hygroscopic qualities.

In case of cement Paint brought to in gunny bags, once the bag is opened, the contents should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

Application : The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The salutation shall be kept well stirred during the period of application. It shall be applied on the surface which is on the shady side of the building so that the direct heat of the sun of the sun on the surface is avoided. The method of application of cement Paint shall be as per manufacturer's specification. The completed surface shall be watered after the days work.

The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted.

For new work, the surface shall be treated with three or more coats of water proof cement Paint as found necessary to get a uniform shade.

For old work, the treatment shall be with one or more coats as found necessary to get a uniform shade.

Precaution : Water proof cement Paint shall not be applied on surfaces already treated with white wash, colour wash, distemper dry or oil bound, varnishes, Paints etc. It shall not be applied on gypsums, wood and metal surfaces.

If water proofing cement is required to be applied on existing surface, previously treated with white wash, colour wash etc., the surface shall be thoroughly cleaned by scrapping off all the white wash, colour wash etc. completely. Thereafter, a coat of cement primer shall be applied followed by two or more coat of water proof cement.

The specifications in respect of scaffolding and protective measures shall be as described before. The coefficient for cement paint on RCC Jalli shall be 2 x (for painting all over).

g) **Exterior Painting on Wall**

Material : The paint shall be (Textured exterior paint / Acrylic smooth exterior paint / premium acrylic smooth exterior paint) 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 material 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 form 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.

Application :

Base coat of water proofing cement paint – All specifications in respect of base coat of water proofing cement paint shall be as described before.

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 portable 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.

The specifications in respect of scaffolding and protective measures shall be as describe before.

3.00.00 **PAINTING**

Materials

Paints, oils, varnishes etc. of approved brand and manufacture shall be used. Only ready mixed Paint (Exterior grade) as received from the manufacturer without any admixture shall be used.

If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer-in-Charge shall be used.

Approved paints, oil or varnishes shall be brought to the site of work by the contractor in their 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 empties shall not be removed from the site of the work, till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge.

Commencing Work

Painting shall not be started until the Engineer-in-Charge has inspect the items of work to be painted, satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface should not be done in adverse weather condition like hail storm and dust storm.

Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work.

The rooms should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the Paint work being started.

Preparation of Surface

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commenced.

Application

Before pouring into smaller containers for use, the Paint shall be stirred thoroughly in its containers, when applying also, the Paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grains of wood. The crossing and laying off consists of covering the area over the Paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, to or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying should be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by through ventilation. Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is laid.

No left over Paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

No hair marks from the brush or clogging of Paint puddles in the corners of panels, angles of moulding etc. shall be left on the work.

In painting doors and windows, the putty round the glass panes must also be painted but care must be taken to see that no Paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting. However, bottom edge of the shutters where the painting is not practically possible, need to be done nor any deduction on this account will be done but two coats of primer of approved make shall be done on the bottom edge before fixing the shutters.

On painting steel work, special care shall be taken while painting over bolts, nuts, rivets overlaps etc.

The additional specifications for primer and other coats of Paints shall be as according to the detailed specifications under the respective headings.

Brushes and Containers

After work, the brushes shall be completely cleaned of Paint and linseed oil by rinsing with turpentine. A brush in which Paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that Paint dose not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

Measurements

The length and breadth shall be measured correct to a cm. The area shall be calculated in the sqm. (correct to two places of decimal), except otherwise stated.

Small articles not exceeding 10 sq. decimeter (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Note: Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sqm. irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The coefficients as indicated in following tables shall be used to obtain the area payable. The coefficients shall be applied to the areas measured flat and not girthed.

Table 1
Equivalent Plain Areas of Uneven surface

Sl. No.	Description of Work	How measured	Multiplying Coefficients
I.	**Wood Work Doors, Windows etc.**		
1.	Panelled or framed and braced doors, windows etc.	Measured flat (not girthed including)	1.30 (for each side)
2.	Ledged and battened or ledged, battened and braced doors, windows etc.	Chowkhat or frame, Edges, chocks, cleats, etc. shall be deemed to be included in the item.	1.30 (for each side)
3.	Flush doors etc.	. --- do ---	1.20 (for each side)
4.	Part paneled and part glazed or gauzed doors, window etc. (Excluding painting of wire gauze portion)	. --- do ---	1.00 (for each side)
5.	Fully glazed or gauzed doors, windows etc. (Excluding painting of wire gauze portion)	. --- do ---	0.80 (for each side)
6.	Fully venetioned or louvered doors, windows etc.	. --- do ---	1.80 (for each side)
7.	Trellis (or Jaffri) work one way or two way	Measured flat overall, no deduction shall be made for open spaces, supporting members shall not be measured separately	2.00 (for painting all over)
8.	Carved or enriched work	Measured flat	2.00 (for each side)
9.	Weather boarding	Measured flat (not girthed supporting frame work) shall not be measured separately	1.20 (for each side)
10.	Wood single roofing	Measured flat (not girthed)	1.10 (for each side)
11.	Boarding with cover fillets and match boarding	Measured flat (not girthed)	1.05 (for each side)
12.	Tile and slate battening	Measured flat overall no deductions shall be made for open spaces	0.08 (for painting all over)

Sl. No.	Description of Work	How measured	Multiplying Coefficients
II.	**Steel Work Doors, Windows etc.**		
13.	Plane sheeted steel doors or windows	Measured flat (not girthed) including frame edges etc.	1.10 (for each side)
14.	Fully glazed or gauzed steel doors and windows (Excluding painting of wire gauze portion)	. --- do ---	0.50 (for each side)
15.	Part paneled and partly glazed or gauzed doors and windows etc. (Excluding painting of wire gauze portion)	. --- do ---	0.80 (for each side)
16.	Corrugated sheeted steel doors or windows	. --- do ---	1.25 (for each side)
17.	Collapsible gates	. --- do ---	1.50 (for painting all over)
18.	Rolling shutters of interlocked laths	Measured flat	1.10 (for each side)

Sl. No.	Description of Work	How measured	Multiplying Coefficients
III.	**General**		
19.	Expanded metal, hard drawn steel wire fabric of approved quality, grill works and gratings in guard bars, balustrades, railing partitions and MS Bars in windows frames.	Measured flat overall; no deduction shall be made for open spaces; supporting members shall not be measured separately	1.00 (for Paint all over)
20.	Open palisade fencing and gates including standards, braces, rails stays etc. in timber or steel	. --- do --- (See note no. 12)	1.00 (for Paint all over)
21.	Corrugated iron sheeting in roofs, side cladding etc.	. --- do --- Measured flat (not girthed)	1.14 (for each side)
22.	AC corrugated sheeting in roofs, side cladding etc.	. --- do ---	1.20 (for each side)
23.	AC semi corrugated sheeting in roofs, side cladding etc. or Nainital pattern using plane sheets	. --- do ---	1.10 (for each side)
24.	Wire gauze shutters including painting of wire gauze	. --- do ---	1.00 (for each side)

Explanatory Notes for Table 1

1. Measurement for doors windows etc., shall be taken flat (and not girthed) over all including chowkhuts or frames, where provided. Where Chowkhuts or frames are not provided, the shutter measurements shall be taken.

2. Where doors, windows etc., are of composite types, different portion shall be measured separately with their appropriate coefficients, the centre line of the common rail being taken as the dividing line between the two portions.

3. The coefficients for doors and windows shall apply irrespective of the size of frames and shutter members.

4. In case steel frames are used the area of doors, windows shutters shall be measured flat excluding frames.

5. When the two faces of a door, window etc. are to be treated with different specified finishes, measurable under separate items, the edges of frames and shutters shall be treated with the one or the other type of finish as ordered by the Engineer-in-Charge and measurement of this will be deemed to be included in the measurement of the face treated with that finish.

6. In the case where shutters are fixed on both faces of the frames, the measurement for he door frame and shutter on one face shall be taken in the manner already described, while the additional shutter on the other face will be measured for the shutter only excluding the frame.

7. Where shutters are provided with clearance at top or / and bottom each exceeding 15 cm height, such openings shall be deducted from the overall measurements and relevant coefficient shall be applied to obtain the area payable.

8. Collapsible gates shall be measured for width from outside to outside of gate in its expanded position and for height from bottom to top of channel vertical. No separate measurements shall be taken for the top and bottom guide rails rollers, fittings etc.

9. Coefficients for sliding doors shall be the same as for normal types of doors in the table. Measurements shall be taken outside to outside of shutters, and no separate measurements shall be taken for the painting guide rails, rollers, fittings etc.

10. Measurements of painting as above shall be deemed to include painting all iron fittings in the same or different shade for which no extra will be paid.

11. The measurements of guard bars, expanded metal, hard drawn steel wire fabric of approved quality, grill work and gratings, when fixed in frame work, painting of which is once measured else where shall be taken exclusive of the frames. In other cases the measurements shall be taken inclusive of the frames.

12. For painting open palisade fencing and gates etc., the height shall be measured from the bottom of the lowest rail, if the palisade do not go below it, (or from the lower end of the palisades, if they project below the lowest rail), upto the top of rails or palisades whichever are higher, but not up to the top standards when the letter are higher than the top rails or the palisades.

Width of moulded work of all other kinds, as in hand rails, cornices, architraves shall be measured by girth.

For trusses, compound girders, stanchions, lattice girders, and similar work, actual areas will be measured in sqm. and no extra shall be paid for painting on bolt heads, nuts, washers etc. even when they are picked out in a different tint to the adjacent work.

Painting of rain water, soil, waste, vent and water pipes etc. shall be measured in running metres of the particular diameter of the pipe concerned. Painting of specials such as bends, heads, branches, junctions, shoes, etc. shall be included in the length and no separate measurements shall be taken for these or for painting brackets, clamps etc.

Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actual.

Flag staffs, steel chimneys, aerial masts, spires and other such objects requiring special scaffolding shall be measured separately.

Precautions

All furnitures, fixtures, glazing, floors etc. shall be protected by covering and stains, smears, splashing, if any shall be removed and any damages done shall be made good by the contractor at his cost.

Rate
Rates shall include cost of all labour and materials involved in all the operations described above and in the particular specifications given under the several items

4.00.00 **PAINTING PRIMING COAT ON WOOD, IRON OR PLASTERED SURFACES**

Primer

The primer for wood work, iron work or plastered surface shall be as specified in the description of item.

Primer for plaster / wood work / Iron & Steel / Aluminium surfaces shall be as specified below.

Table-2

Sl. No	Surfaces	Primer to be used
1.	Wood work (hard and soft wood)	Pink conforming to IS 3536
2.	Resinour wood and plywood	Aluminium primer confirming to IS 3585
3.	(A) Aluminium and light alloys	Zinc chromate primer confirming to IS 104
	(B) Iron, Steel and Galvanized steel	Red Oxide Zinc chromate Primer confirming IS 2074
4.	Cement/Concrete/RCC/brickwork, Plastered surfaces, non-asbestos surfaces to receive Oil bound distemper or Paint finish.	Cement primer confirming to IS 109

The primer shall be ready mixed primer of approved brand and manufacture.

Where primer for wood work is specified to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of 0.7 kg : 0.7 kg : 1 litre.

Where primer for steel work is specified to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg :1 litre : 1 litre.

The specifications for the base vehicle and thinner for mixed on site primer shall be as follows:

i) **White Lead :** The white lead shall be pure and free from adulterants like barium sulphate and whiting. It shall confirm to IS 103.

ii) **Red Lead:** This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall confirm to IS 102.

iii) **Raw Linseed Oil:** Raw linseed oil shall be lightly viscous bit clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30 degree C shall be between 0.923 and 0.928.

Note: The oil shall be mellow and sweet to the taste with very little small. The oil shall be of sufficiently matured quality. Oil turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall confirm in all respects to IS 75. The oil shall be of approved brand and manufacture.

iv) **Double Boiled Linseed Oil:** This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0.931 and 0.945 at a temperature of 30 degree C. It shall dry with a glossy surface. It shall confirm in all respects to IS 77. The oil shall be of approved brand and manufacture.

Turpentine : Mineral turpentine i.e. petroleum distillate which has the same rate of evaporation as vegetable turpentine (distillate product of oleoresin of conifers) shall be used. It shall have no grease or other residue when allowed to evaporate. It shall confirm to IS 533.

All the above materials shall be approved manufacture and brought to site in their original packing in sealed condition.

4.01.00 **Preparation of Surface**

4.01.01. **Wooden Surface :** The wood work to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with strong glue sized and used hot. Appropriate filler material confirming to IS 345 with same shade as Paint shall be used where specified. The surface treated for knotting shall be dry before paint is applied. After obtaining approval of Engineer-in-Charge for wood work, the priming coat shall be applied before the woo work is fixed in position. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier's putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in stopping and the latter is therefore liable to crack.

4.01.02. **Iron and Steel Surface :** All rust and scales shall be removed by scrapping or by brushing with wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.

All dust and dirt shall be thoroughly wiped away from the surface.

If the surface is wet, it shall be dried before priming coat is undertaken.

4.01.03. **Plastered Surface :** The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations shall be filled up with plaster of paris and rubbed smooth.

Application

The primer shall be applied with brushes, worked well into the surface and spread even and smooth. The painting shall be done by crossing and laying off as described before.

Treatment on Steel for Aggressive Environment

A second coat of ready mixed red oxide zinc chromate primer may be applied where considered necessary in aggressive environment such as near Industrial Establishment and Coastal regions where the steel members are prone to corrosion. The second coat (which shall be paid for separately) is to be applied after placing the member in position and just before applying Paint. The second coat of primer is not necessary in case of painting with synthetic enamel Paint as it is applied over and under coat of ordinary Paint.

Painting Priming Coat On Wood, Iron Or Plastered Surfaces

Synthetic Enamel

Paint, suitable for painting over G.S. sheets, of approved brand and manufacture and of the required shade shall be used. New or weathered G.S sheets shall be painted with a priming coat of one coat of redoxide zinc chromate Paint. Primer shall be applied before fixing sheets in place.

Preparation of Surface

Painting New Surface : The painting of new G.S. sheets shall not usually be done till the sheets have weathered for about a year. When new sheets are to be painted before they have weathered they shall be treated with a mordant solution prepared by mixing 38 gm of copper acetate in a litre of soft water or 13 gm hydrochloric acid in a solution of 13 gm each of copper chloride, copper nitrate and ammonium chloride dissolved in a litre of soft water. This quantity of solution is sufficient for about 235 sqm. to 280 sqm. of area and is applied for ensuring proper adhesion of Paint. The painting with the mordant solution will be paid for separately.

Before painting on new or weathered G.S. sheets, rust patches shall be completely cleaned with coarse emery paper and brush. All grease marks shall also be removed and surface washed and dried and rusted surface shall be touched with synthetic enamel paint of approved brand, manufacturer and shade.

Painting Old Surface : If the old Paint is firm and sound, it shall be cleaned and grease, smoke etc. The surface shall then be rubbed down with sand paper and dusted. Rusty patches shall be cleaned up and touched with synthetic enamel paint.

If the old Paint is blistered and flaked, it shall be completely removed as described before. Such removal shall be paid for separately and painting shall be treated as on new work.

Application

The number of coats to be applied shall be as in the description of item. In the case of C.G.S. sheets, the crowns of the corrugations shall be painted first and when these get dried the general coat shall be given to ensure uniform finish over the entire surface without the crowns showing signs of thinning.

The second or additional coats shall be applied when the previous coat has dried.

5.00.00 **PAINTING CAST IRON RAIN WATER, SOIL, WASTE AND VENT PIPES AND FITTINGS**

The primer shall be prepared on site or shall be of approved brand and manufacture as specified in the item.

Paint shall be anti-corrosive bitumastic Paint, aluminium Paint or other type of Paint as specified in the description of the item.

Painting New Surface

Preparation of Surface : The surface shall be prepared for priming coat as described earlier.

Application : The number of coat of painting over the priming coat shall be as stipulate in the description of the item. The application of Paint over priming coat shall be carried out as specified above.

Measurements : Measurements will be taken over the finished line of pipe including specials etc. in running metres, correct to a cm.

Pipes of different diameters of bore shall be measured and paid for separately.

Specials and fittings such as holder bat clamps, plugs etc. will not be measured separately.

Rate : The rate shall include the cost of all materials and labour involved in all the operations described above, including painting of all specials and fittings.

Painting on Old Surface

Preparation of Surface : If the old Paint is firm and sound, it shall be cleaned and grease, smoke etc. The surface shall then be rubbed down with sand paper and dusted. Rusty patches shall be cleaned up and touched with synthetic enamel paint.

If the old Paint is blistered and flaked, it shall be completely removed as described before. Such removal shall be paid for separately and painting shall be treated as on new work.

Application : The specifications for application shall be as described earlier.

Measurements : Measurements will be taken over the finished line of pipe including specials etc. in running metres, correct to a cm.

Pipes of different diameters of bore shall be measured and paid for separately.

Specials and fittings such as holder bat clamps, plugs etc. will not be measured separately.

Rate : The rate shall include the cost of all materials and labour involved in all the operations described above, including painting of all specials and fittings.

6.00.00 **PAINTING WITH WOOD PRESERVATIVE**

Oil type wood preservative of specified quality and approved make, confirming to IS 218 shall be used. Generally, it shall be creosote oil type-I or anthracene oil.

Painting on New Surface

Preparation of Surface : Painting shall be done only when the surface is perfectly dry to permit of good absorption. All dirt, dust or other foreign matter shall be removed from the surface to be painted. All roughness shall be sand papered and cleaned.

Application : The preservative shall be applied liberally with a stout brush and not daubed with rags or cotton waste. It shall be applied with a pencil brush at the joints of the wood work. The first coat shall be allowed at least 24 hours to soak in before the second (the final) coat is applied. The second coat shall be applied in the same manner as the first coat. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

Painting on Old Surface

The work shall be done in the same manner as on new surface except that only one coat shall be done.

7.00.00 COAL TARRING

Coal tar of approved manufacture confirming to IS 290 shall be used. The tar, to every litre of which 200 gm of unslaked lime has been added, shall be heated till it begins to boil. It must then be taken off the fire and kerosene oil added to it slowly at the rate of one part of kerosene oil to six or more parts by volume and stirred thoroughly. The addition of lime is for preventing the tar from running.

Coal Tarring on New Surface

Preparation of Surface : This shall be done as specified in 4.01.00 except that sand papering is not necessary. Where iron work is to be painted it shall be free from scales and rust before painting.

Application : The mixture shall be applied as hot as possible with a brush. The second coat shall be applied only after the first coat has thoroughly dried up. Where possible, the article to be tarred, shall be dipped in the hot mixture for better results. The quantity of tar to be used for the first or second coat shall be not less than 0.16 and 0.12 litre per sqm respectively. Thinning with kerosene oil shall be suitable done to ensure this.

Coal Tarring on Old Surface

The work shall be done in the same manner as specified above (Coal Tarring on New Surface) except that only one coat using 0.12 litre per sqm. area shall be done.

8.00.00 **SPRAY PAINTING WITH FLAT WALL PAINT ON NEW SURFACE**

The work shall include a priming coat of 'Distempering Primer' or 'Cement Primer' as specified in the description of the item. Flat wall Paint shall normally be applied on walls 12 months after their completions, in which case Distemper primer will suffice. If the walls are to be painted earlier, the primer coat shall consist of cement primer.

The primer and the flat wall Paint shall be of approved brand and manufacture and of the required shade.

Preparation of the Surface : The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any uneveness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

Application

Priming Coat : The specified primer shall be painted or sprayed over the surface in an even and uniform layer.

Painting Coats : When the surface is dry, the spray painting with the wall Paint in uniform and even layers will be done to the required number of coats. Each coat shall be allowed to dry overnight and lightly rubbed with every fine grade of sand paper and loose particles brushed off before the next coat is sprayed.

Spraying should be done only when dry condition prevails. During spraying the spray gun shall be held perpendicular to the surface to be coated and shall be passed over the surface in a uniform sweeping motion. Different air pressures and fan adjustment shall be tried so as to obtain the best application. The air pressure shall not be kept too high as otherwise the Paint will fog up and will be wasted.

At the end of the job, the spray gun shall be cleaned thoroughly so as to be free from dirt. Incorrect adjustments shall be set right, as otherwise they will result in variable spray patterns, runs, sags and uneven coats.

If after the final coat of wall Paints, the surface obtained is not upto the mark, further one or more coats as required shall be given after rubbing down the surface and dusting off all loose particles to obtain a smooth and even finish.

If the primer or wall Paint gets thickened during the application, it shall be thinned suitably with the thinner recommended by the manufacture.

Adequate ventilation shall be provided to disperse spray fumes. Fitments and floor shall be protected from the spray.

9.00.00 SPRAY PAINTING WITH FLAT WALL PAINT ON OLD SURFACE

Where the old Paint is in sound condition, renewal shall be carried out as described below, otherwise the old Paint shall be completely stripped and spray painting shall be carried out as over new work. Such removal shall be paid for separately.

The flat wall Paint shall be of approved brand and manufacture and of required shade.

Preparation of Surface

The surface shall be washed to remove dust and dirt. A mild detergent solution like soap water shall be used for washing and surface shall also be rubbed down lightly with abrasive paper when dry. Any patches appearing on the surface shall first be touched up with a coat of Paint. These shall be allowed to dry and then rubbed down tightly.

Application

The paint shall then be applied with spraying machine in uniform and even layer. A second coat shall be applied if considered necessary by the Engineer-in-Charge but only after the first coat is complete dry and hard.

Spraying should be done only when dry condition prevails. During spraying the spray gun shall be held perpendicular to the surface to be coated and shall be passed over the surface in uniform sweeping motion. Different air pressures and fan adjustment shall be tried so as to obtain the best application. The air pressure shall not be kept too high as otherwise the Paint will fog up and will be wasted. At the end of the job, the spray gun shall be cleaned thoroughly so as to be free from dirt. Incorrect adjustments shall be set right, as otherwise they result in variable spray patterns, runs, sags and uneven coats.

10.00.00 WALL PAINTING WITH PLASTIC EMULSION PAINT

The plastic emulsion Paint is not suitable for application on external, wood and iron surface and surfaces which are liable to heavy condensation. These Paints are to be used on internal surfaces except wooden and steel.

Plastic emulsion Paint as per IS 5411 of approved brand and manufacture and of the required shade shall be used.

Painting on New Surface

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, morter droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commended.

Application : The number of coats shall be as stipulated in the item. The Paint will be applied in the usual manner with brush, spray or roller. The Paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surface to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer's instructions.

The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

Precautions

a) Old brushes if they are to be used with emulsion Paints, should be completely dried of turpentine or oil Paints by washing in warm soap water.

   Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the Paint from hardening on the brush.

b) In the preparation of wall for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.

c) Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.

d) Washing of surfaces treated with emulsion Paints shall not be done within 3 to 4 weeks of application.

Painting on Old Surface

Preparation of Surface *:* This shall be done, generally as specified in 4.01.01 except that the surface before application of Paint shall be flattened well to get the proper flat velvety finish after painting.

Application : The number of coats to be applied shall be as in description of item. The number of coats shall be as stipulated in the item. The Paint will be applied in the usual manner with brush, spray or roller. The Paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surface to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer's instructions.

The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

Except the above the thinning with water shall not normally be required.

11.00.00 PAINTING WITH SYNTHETIC ENAMEL PAINT

Synthetic Enamel Paint (confirming to IS 2933) of approved brand and manufacture and of the required colour shall be used for the top coat and an under coat of ordinary Paint of shade to match the top coat as recommended by the same manufacture as far the top coat shall be used.

Painting on New Surface

Preparation of Surface *:* Preparation of surface shall be as specified in 4.01.00 as the case may be.

Application : The number of coats including the undercoat shall be as stipulated in the item.

a) **Under Coat :** One coat of he specified ordinary Paint of shade suited to the shade of the top coat, shall be applied and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

b) **Top Coat:** Top coat of synthetic enamel Paint of desired shade shall be applied after the under coat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

Other details shall be as specified in 'EXTERIOR PAINTING ON WALL' as far as they applicable.

Painting on Old Surface

Preparation of Surface : Where the existing Paint is firm and sound it shall be cleaned of grease, smoke etc. and rubbed with sand paper to remove all loose particles dusted off. All patches and cracks shall then be treated with stopping and filler prepared with the specified Paint. The surface shall again be rubbed and made smooth and uniform.

If the old Paint is blistered and flaked it will be necessary to completely remove. Such removal shall be paid for separately and the painting shall be treated as on new surface.

Painting : The number of coats as stipulated in the item shall be applied with synthetic enamel Paint. Each coat shall be allowed to dry and rubbed down smooth with very fine wet abrasive paper, to get an even glossy surface. If however, the surface is not satisfactory additional coats as required shall be applied to get correct finish.

12.00.00 PAINTING WITH ALUMINIUM PAINT

Aluminium Paint shall be (confirming to IS 2339) of approved brand and manufacture. The Paint comes in compact dual container with the paste and the medium separately.

The two shall be mixed together to proper consistency before use.

Preparation of Surface

Steel Work (New Surfaces) : All rust and scales shall be removed by scraping or brushing with steel wire brushes and then smoothened with sand paper. The surface shall be thoroughly cleaned of dust.

C.G.S. Sheets (New Surfaces) : The preparation of surface shall be as specified in 'PAINTING SYNTHETIC ENAMEL PAINT OVER G.S. SHEETS on Painting New Surface'.

Steel Work or C.G.S. Sheets (Old Surfaces) : The specifications shall be as described in 'PAINTING SYNTHETIC ENAMEL PAINT OVER G.S. SHEETS on Painting Old Surface'.

Application

The number of coats to be applied shall be as given in the item. Each coat shall be allowed to dry for 24 hours and lightly rubbed down with fine grade sand paper and dusted off before the next coat is applied. The finished surface shall present an even and uniform appearance.

As aluminium paste is likely to settle in the container, care shall be taken to frequently stir the Paint during used. Also the Paint shall be applied and laid off quickly, as surface is otherwise not easily finished.

13.00.00 PAINTING WITH ACID PROOF PAINT

Acid proof Paint of approved brand and manufacture and of the required shade shall be used.

Preparation of surface and application shall be as specified under 11.00.00 for new/old surface as the case may be.

Other details shall be as specified in 3.00.00 as far as they applicable

14.00.00 PAINTING WITH ANTI-CORROSIVE BITUMASTIC PAINT

Ready mixed Paint (confirming to IS 158) shall be of approved brand and manufacture. It shall be black, lead free, acid-alkali-heat-water resistant.

Preparation of surface and application shall be as specified in 13.32 for Painting on new or old surfaces as the case may be.

The drying time between consecutive coats, however, shall be not less than 3 hours.

Other details shall be specified in 3.00.00 as far as applicable.

15.00.00 FLOOR PAINTING

Floor Paint of approved brand and manufacture and of the required colour shall be used.

Preparation of Surface

All dirt, grease shall be removed from the floor by wiping with rags, soaked in turpentine and scraping where necessary and then washing with warm water, containing caustic soda or washing soda in solution. The floor should then be rinsed thoroughly with water and dried. Cracks and holes shall then be filled with specified filler as recommended by the manufacture and rubbed smooth.

It should be noted that the painting with floor paints shall not be done over concrete surfaces less than two years old.

Old surface shall be prepared as specified in 'PAINTING WITH SYNTHETIC ENAMAL PAINT, Painting on Old Surface, Preparation of Surface'.

Application

The number of coats as in the description of the item shall be applied. Each coat shall be allowed to dry for not less than 24 hours before the next coat is applied. The flooring should not be brought into use for a week after final coat so that the painted surface can thoroughly harden.

16.00.00 **VARNISHING**

Ordinary copal varnish or superior quality spray varnish shall be used. The work includes sizing of transparent wood filler.

Varnish (confirming to IS 347 for the finishing and undercoats shall be of the approved manufacturer.

Varnishing on New Surfaces

Preparation of Surface : New wood work to be varnished shall have been finished smooth with a carpenter's plan. Knots shall be cut to a slight depth. Cracks and holes shall be cleaned of dust. The knots, cracks etc. shall then be filled in with wood putty made as follows:

On a piece of wood say 20 x 15 cm face and on the side where cross grains appear, a small quantity of glue size shall be poured and surface scraped with the edge of a fine carpenter's chisel. Very fine wood powder shall be mixed with the glue and the stiff paste thus formed shall be used for the filling.

The fillings when dry shall be rubbed down with a carpenter's file and then the entire surface shall be rubbed down perfectly smooth with medium grained and fine sand papers and wiped with dry clean cloth so that it presents uniform appearance. In no case shall sand papers be rubbed across the grains, as in this case even the finest marks will be visible when the varnishing is applied.

Sizing or Transparent Wood Filler Coat : The surface shall then be treated with either glue sizing or with transparent wood filler coat as stipulated in the description of item.

a) **Sizing :** When sizing is stipulated, an application of thin clean size shall be applied hot on the surface. When dry, the surface shall be rubbed down smooth with sand paper and cleaned. It shall then be given another application of glue size nearly cold. The sized wood work shall again be rubbed down smoothly with fine sand paper and cleaned. The surface shall be perfectly dry and all dust shall be removed not only from the surface but also from the edges and joints before varnishing is commenced. If the wood work is to be stained, the staining colour shall be mixed with the second coat of the size which must be applied evenly and quickly keeping the colour on the flow.

Any jointing up with work already dry will show badly. The object of application of the glue size is to seal the pores in wood to prevent absorption of the oil in the varnish.

Glue sizing is inadvisable on floors, table tops and other horizontal surfaces likely to carry wet household untensils which are likely to disturb the size coatings and thus expose bare wood.

Where glue sizing is omitted to be done the rate for the work shall be suitably reduced.

b) **Transparent Wood Filler Coat :** Where instead of glue sizing, transparent wood filler application is stipulated in the item, then the surface prepared as described earlier, shall be given as application of the application of the filler with brush or rag in such a way that the filler fills up all the pores and indentations and levels up the surface. It shall be allowed to dry for 24 hours. Then it shall be cut and rubbed with emery paper so that the surface of the wood is laid bare, with the filler only in the pores and crevices of the wood.

Application of Varnish : The number of coats to be applied shall be as stipulated in the description of the item.

The undercoat shall be with a flatting varnish. This dries hard and brittle and when cut and rubbed down to produce a smooth surface enhance the gloss of the finishing varnish. The top coat shall be given with stipulated brand of finishing varnish.

The varnish shall be applied liberally with a full brush and spread evenly with short light strokes to avoid frothing. If the work is vertical the varnish shall be crossed and recrossed and then laid off, letter being finished on the upstrokes so that varnish, as it sets, flows down and eliminates brush marks, the above process will constitute one coat. If the surface is horizontal, varnished shall be worked in every direction, with light quick strokes and finish in one definite direction so that it will set without showing brush marks, in handling and applying varnish care should be taken to avoid forming froth or air bubbles. Brushes and containers shall be kept scrupulously clean.

Rubbing down and flatting the surface shall be done after each coat except the final coat with fine sand paper.

The work shall be allowed to dry away from droughts and dump air. The finished surface shall then present a uniform appearance and fine glossy surface free from streaks, blister etc.

Any varnish left over in the small container shall not be poured back into the stock tin, as it will render the latter unfit for use.

Special fine haired varnishing brushes shall be used and not ordinary Paint brushes. Brushes shall be well worn and perfectly clean.

Other details shall be as specified in 3.00.00 as far as they are applicable.

Varnishing on Old Surface

Preparation of Old Surface : If the old varnished surface is firm and sound it shall be cleaned of grease and dirt with turpentine and then rubbed with wet sand paper until the surface is clean and smooth. It shall be dried and wiped clean with a soft cloth. Knots, holes and cracks shall be stopped as specified in ‘Varnishing on New Surfaces, Preparation of Surface’. The entire surface shall then be rubbed down smooth with sand paper and wiped clean.

If the old varnished surface is peeled or cracked then it will be necessary to remove the entire varnish and such removal shall be paid for separately outside the rate for varnishing. Future the varnishing itself will have to be done like new work and will be paid for as such.

Application : The specification shall be same as described in ‘Application of Varnish’ as far as applicable except that the coats to be applied will be with the stipulated quality of varnish for finishing coat.

Other details shall be as specified in 3.00.00 as far as they are applicable.

17.00.00 **FRENCH SPIRIT POLISHING**

Pure shellac confirming to IS 16 varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit at the rate of 140 gm of shellac to 1 litre of spirit. Suitable pigment shall be added to get the required shade. Ready made polish confirming to IS 348 can also be used.

Polishing New Surface

Preparation of Surface : The surface shall be cleaned. All unevenness shall be rubbed down smooth with sand paper and well dusted. Knots if visible shall be covered with a preparation of red lead and glue size laid on while hot. Holes and indentations on the surface shall be stopped with glazier's putty. The surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1.5 Kg of whiting per litre of spirit. The surface shall again be rubbed down perfectly smooth with glass paper and wiped clean.

Application : The number of coats of polish to be applied shall be as described in the item.

A pad of wooden cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the wood, in a series of overlapping circles applying the mixture sparingly but uniformly over the entire area to given an even level surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

Other details shall be as specified in 3.00.00 as far as they are applicable.

Polishing Old Surface

Preparation of Surface : If the old polished surface is not much solid it shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sand paper.

If the old polished surface is much soiled then it will be necessary to remove the entire polish and such removal shall be paid for separately outside the rate of polishing. Further the polishing itself will have to do done like new work and will be paid for as such.

Application : The specifications shall be same as described above and as far as applicable.

Other details shall be as specified in 3.00.00 as far as they are applicable.

18.00.00 EPOXY COATING/PAINTING

On the clean surface of concrete after properly drying of the following system is to be adopted as per manufacturers specification:

One coat of primer of following proportion to be applied over clean and dried concrete surface by brush application.

ARALDITE GY 250 - 100 Parts by weight

HARDENER HY 840 - 50 Parts by weight

Over the primer, the uneven surface of concrete should be filled with levelling putty as mentioned above. The cost of putty is included in the item rate without fixing prior limit to consumption of putty. Two top coats of the protective treatment to be applied over the prepared smooth surface in the following proportion.

ARALDITE GY 250 - 100 Parts by weight

HARDENER HY 830 - 45 Parts by weight

HARDENER BY 850 -15 Parts by weight

SILICA FLOUR - 20 Parts by weight

FLOW CONTROL - 2 Parts by weight
AGENT

Pigment may be added if desired by Engineer. The first top coat is applied over the primer and is left to reach a tack free state. At this stage, the final top coat is applied.

18.01.00 Protection

Furniture and other movable objects, equipments, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationary equipments shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as per instructions of the Engineer.

18.02.00 **Cleaning up**

In addition to provisions in general conditions the Contractor shall, upon completion of painting etc. remove all marks and make good surfaces, where paint has been spilled, splashed or splattered, including all equipment, fixtures, glass, furniture, fittings etc. to the satisfaction of the Engineer.

19.00.00 **ACCEPTANCE CRITERIA**

a) All painted surfaces shall be uniform and pleasing in appearance.

b) All varnished surfaces shall be of uniform texture and high glossy finish.

c) The colour, texture etc. shall match exactly with those of approved samples.

d) All stains, splashes and splatters of paints and varnishes shall be removed from surrounding surfaces.

20.00.00 **RATES**

Rates shall be unit rates for complete items described in the Schedule of Items. No extra payment will be made for preparation of surface before painting or for cleaning up after the work is complete.

21.00.00 **METHOD OF MEASUREMENT**

a) All structural steelwork whose any or all faces are to be painted shall be measured and paid according to Table-1.

b) Painting or whitewashing to concrete or masonry shall be measured and on the area painted. For measurement of openings whose jambs, sills, soffits etc. are to be painted the following procedure shall be followed:

i) For openings up to 0.5 sq.m. but not exceeding 3.0 sq.m. each deductions shall be made for half the area of openings and no additions shall be made for jambs, sills, etc.

ii) For openings exceeding 0.5 sq.m. but not exceeding 3.0 sq.m. each deductions shall be made for half the area of openings, and no additions shall be made for jambs, sills etc.

iii) For openings exceeding 3.0 sq.m. each, deductions shall be made for the whole area, and additions shall be made for the jambs, sills soffits, reveals etc.

c) For openings, pipes, sleeves etc. whose sides are not finished no deductions shall be made for openings etc. upto 0.1 sq.m. in area each and full deductions shall be made for all openings above 0.1 sq.m. in area each.

d) No extra shall be paid for painting etc. done around openings, sleeves, pipes, ducts, inserts, etc.

e) No extra payment shall be made for painting, etc. on wall features such as grooves, ducts, beads, projections, cornices, etc. unless give different finish or otherwise specified in the "Schedule of Items". The actual area of the features shall be girthed and included in the wall measurements.

f) For painting of uneven surfaces in doors, windows, ventilators, louvers, guard bars, balustrades, gratings, railings, gates, etc. equivalent plain areas shall be measured as given in Clause 17.2 (Table II) of IS:1200.

g) Corrugated surfaces shall be measured flat as fixed and not girthed. The quantities as measured shall be multiplied by the following factors to get equivalent plain area :

i) Corrugated steel sheets - shall be multiplied by 1.14.

ii) Corrugated asbestos sheets with large corrugations shall be multiplied by 1.20

iii) Semi-corrugated asbestos cement sheets shall be multiplied by 1.10.

iv) Any other non-standard corrugated surfaces shall be measured as decided by the Engineer.

h) For painting pipes for sanitary and plumbing work, measurement shall be made on actual work done in R.M. for different diameters. Measurements shall be along the central lines of pipes laid. No deductions or additions shall be made for valves, fittings, etc.

i) Unless specifically stated on the schedule of items, all painting, varnishing or polishing of wood shall be measured and paid on the area treated. For measurement of uneven surfaces, equivalent Main area shall be measured as per Clause 17.2 (Table II) of IS: 1200.

22.00.00 **I. S. CODE**

Important relevant IS Codes for this Sections are listed below :

IS: 348	:	Specification for French polish
IS: 427	:	Specification for Distemper, dry colour as required.
IS: 428	:	Specification for Distemper oil emulsion, colour as required.
IS: 1477 (I & II)	:	Code of Practice for painting of ferrous metal in buildings.
IS: 2338 (I & II)	:	Code of Practice for finishing of wood and wood based materials.
IS: 2339	:	Specification for Aluminium Paints for general purposes in dual containers.
IS: 2395	:	Code of Practice for painting concrete, masonry and plaster surface.
IS: 2932	:	Specification for enamel, synthetic, exterior, type-I.
IS: 5410	:	Specification for cement paint, colour as required.

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SECTION-XXVI

TECHNICAL SPECIFICATION FOR SUSPENDED CEILING

CONTENT

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2.00.00	INSTALLATION	VII-C/S-XXVI : 1
3.00.00	ACCEPTANCE CRITERIA	VII-C/S-XXVI : 5
4.00.00	RATES	VII-C/S-XXVI : 5
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SECTION-XXVI

TECHNICAL SPECIFICATION FOR SUSPENDED CEILING

1.00.00 SCOPE

The work under this Section shall include the supply and insulation of suspended ceiling using insulation / acoustic boards, plaster of paris boards. Perspex etc. together with the suspension system as shown on drawing or specified in Schedule with all materials labour and equipment. The work shall also include providing of openings in the ceiling for lighting, air conditioning diffusers etc. as shown on drawings or instructed by the Engineer.

2.00.00 INSTALLATION

2.01.00 Suspension System

2.01.01 General

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural walls, slabs and beams or trusses.

All members of the suspension system shall be of sufficient strength and rigidity to carry the ceiling boards or sheets in a true and level plane without exceeding a deflection of 1/360th of their span. All joints in ceiling panels shall run straight and cross joint shall be securely fixed to walls. All drillings of structural concrete or welding to steel for installation of the suspension system shall be included in the rate. All M S sections used for supports etc. shall be given one coat of synthetic enamel paint over a coat of red lead primer. All wood supports shall be painted with two coats of “Solignum” or other approved wood preservative before erection.

2.01.02 Metal Grid Suspension System

Aluminium grid ceiling system shall be “Bead lock” as manufactured by W A Beard shell and Co. Pvt. Ltd. or approved equal. Steel grid ceiling system shall be snap grid as manufactured by Anil Hardboards Ltd. or approved equal.

Angle cleats or other suitable fixing device shall be fixed to the structural beam or slab above for fixing of hangers. Main runners shall be hung by M S flats angles or 12 g or heavier galvanized tie wire hangers at maximum 1.2 centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be as shown on drawings.

The cross tees shall intersect main runners in pattern shown on drawing and positively looked together with intersection clips. All perimeter areas shall have angle mouldings fixed to vertical wall surfaces and end tees shall rest on the moulding, unless otherwise shown on drawings.

2.01.03 **Timber Grid Suspension System**

Unless otherwise shown on drawings, the suspension system shall consist of 50 mm x 50 mm pre-treated teakwood batten grid suspended in the same manner described for metal grid system. The spacing of timber battens shall be as shown on drawing. Extra battens shall be provided where necessary for openings for light fixtures A C grills etc.

2.02.00 **Ceiling Panels**

2.02.01 **Materials**

Ceiling panels shall be best quality material in thickness and properties call for in the “Schedule of Items”. The Contractor shall submit test certificates to the Engineer for approval before bulk supply. The ceiling panels may be of the following types :

a) Plaster of Paris boards

b) Expanded polystyrene insulation boards

c) Fibre insulation boards

d) Wood particle boards

e) Glass fibre reinforced polystyrene sheets

f) Glass Reinforced Gypsum Board / Gypsum Board or Tiles

g) Mineral Fibre Board

h) Aluminium Panel – Linear / square / plank type false ceiling

i) Calcium silicate Board or tiles

Acrylic plastic sheets translucent or figured glass sheets moulded plastic louvers etc. shall be from approved manufacturers and in thickness specified in schedule.

2.02.02 **Installation of Ceiling Panels**

Installation of ceiling panels shall be strictly as per manufacturer's instruction.

For exposed grid ceiling system, tile hold down clips shall be used at the rate of minimum one per 1.2 meter length of perimeter. These shall however be omitted in access panels which shall be located as per the instruction of the Engineer.

For concealed grid ceiling system, tiles shall be fixed to the supporting grid in manner shown on drawing or as specified by the manufacturer. Where V joints in tiles are called for in drawings, these shall begin true lines. Where flush surface is required, the joints shall be filled with approved filler material and finished to give a neat uniform surface. Where shown on drawings and schedule of items, 6 mm thick cement : lime : sand surface of ceiling boards and finished in a true and even surface without undulations suitable for subsequent painting. Special care shall be taken to neatly finish the ceiling at junctions with walls, light fixtures, diffusers etc.

2.03.00 **False ceiling systems with different materials**

2.03.01 **Glass Reinforced Gypsum (GRG) or Gypsum Moisture Resistant Tiles / Board**

1. Load bearing galvanized light gauge sections shall be used for supporting of (seamless) finished ceiling. G.I. channels of size 0.55 mm thickness having one flange of 300 mm. and a web of 27 mm. shall be fixed along with perimeter of ceiling, screw fixed to brick wall/ partition with the help of nylon sleeves & screws at 610 mm centres. Then suspending G.I. intermediate channels of size 45 mm. 0.9 mm. thick with two flanges of size 15 mm. each from the soffit at 1200 mm centres with ceiling angle of width 25 mm X 25 mm X 0.55 mm thick fixed to soffit with G.I. cleat and steel expansion fastner. Ceiling section of 0.55 mm thickness having knurled web of 51.5 mm and two flanges of 26 mm each with lips of 10.5 mm are then fixed to the intermediate channel with the help of connecting clips and in direction perpendicular to the intermediate channel at 457 mm centres. 12 mm thick GRG/Gyp MR Board is then screw fixed to ceiling sections with 25 mm dry wall screws at 230 mm centres. The board shall be joined and finished to have a flush look.

2. For profiled and curved surface, supporting structure from galvanized steel shall be made in required shape. Board shall be formed in to the curved shape while wet before fixing.

2.03.02 **Mineral Fibre Board**

For laying Mineral Fibre Board in tile of 600 mm X 600 mm the supporting grid system shall be formed by light gauged galvanized steel T- sections. Supporting grid system shall be rolled formed double web galvanized tees and shall meet the requirements of ASTM C-635. Nominal size of T-section shall be 24x38 mm for main runner. Exposed flange surface i.e. 24 mm wide shall be precoated or provided with a matching coloured cap. Main supporting section shall be suspended from RCC soffit / steel member with 4 mm dia galvanized rod & spring steel clip @ 1200 mm c/c. Suspensions from RCC shall be taken using expansion fasteners. The main supporting member shall be placed @ 1200 cross T-sections is inserted into the slots provided in main supporting member at 600 mm c/c so as to give a maximum size of 1200 mm x 600 mm.

Mineral Fibre Board Tiles shall be laid onto the grid 4 nos. of PVC holding clips shall be provided for each panel.

Aluminium Panels – Linear / Square tiles (lay-in or lay-on type) / planks

Aluminium panel ceiling, perforated or un-perforated as per requirement, of approved make, colour consisting of panel 150 mm wide x 15.5 mm deep x 0.5 mm thick with bevel edge, panel length up to 6 mtr, Coil Coated on a Continuous Paint Line, Double baked and roll formed from enamelled corrosion resistance Aluminium alloy AA 5050(Al.mg) for higher strength and good roll forming characteristics. The Panels about each other with a narrow V grove. Panel shall be clipped to a baked enamelled Aluminium Panel carrier of 32 mm wide x 39 mm deep x 0.95 mm thick in standard length of 5 mtr made of double baked enamelled Aluminium alloy AA 5050 (Al.mg) black with cut-outs to hold the panels in a module of 150 mm closed at a distance 1.00 mtr. Panel carrier shall be suspended by means of G.I. suspension rod 4-mm diameter and a Galvanised suspension spring clip at a distance of 1.7 mtr c/c. Paint Finish: Aluminium Panels shall be chromatised for maximum bond between metal and paint enamelled twice under high temperature, one side with a full primer and finish coat the other side (inner side) with a primer coating and Skin Coat on a Continuous Paint Line. Mode of Measurements: Measurements shall be wall to wall without any deductions for lights, diffusers, columns etc.

Or tile of 600mm wide and 600mm long manufactured out of 0.7mm thick Aluminium alloy AA 5050(Al.mg). Tile ends will be raised with pips and stops to ensure positive engagement into the spring to enable for de-mounting of individual panels. The Tile sides will be sufficiently high to ensure a minimum deflection across the length of Tile. All Tiles will be bevel edged. The Tile shall be Polyester based, powder coated in white colour. The Tile shall be clipped into clip in profile of 0.5mm thick G.I. The clip in profile shall be supported from slab by means of rigid suspension of 4mm G.I. Rod, Hold on Clamp with Clip. Mode of Measurements: Measurements shall be wall to wall without any deductions for lights, diffusers, columns etc.
Or Aluminium lineal ceiling system shall be “Luxalon 84C” or approved equal and the installation shall be strictly as per manufacturer’s instruction/ specification subject to approval of the Engineer. Aluminium lineal ceiling

shall comprise of plain panels, 84 mm wide and 12.5 mm deep with a 23.9 mm recessed flange, roll formed out of 0.5 mm thick aluminium alloy panels stove enamelled on both sides, fixed on roll-formed carriers made of enamelled 0.95 mm thick aluminium, 32 mm wide and 39 mm deep with prongs to hold panels in the module of 100mm, at maximum spacing 1.2 M centre to centre. The carriers shall be suspended from roof by 4 mm dia galvanised steel wire hangers with special height adjustment clips made out of spring steel at maximum spacing of 1.2 M c/c. Hangers shall be fixed to roof by 12mm dia 50mm long anchor bolts and nylon inserts. 25 mm thick resin bonded mineral wool (spintex 300 or equivalent) insulation bound in polythene shall be laid on top of panels. Lineal ceiling shall be fixed in pattern as per detailed drawings.

3.00.00 ACCEPTANCE CRITERIA

Finished ceiling shall be at the correct plane and present a pleasing and uniform appearance, free from sags, warps, figures or damaged boards, joints, exposed grids etc. shall be in true lines and symmetrically placed in manner shown on drawings. Cut-outs for light fixtures, diffusers etc. shall be of exact dimensions and in exact locations.

4.00.00 RATES

Shall be unit rates for complete items called for in the “Schedule of Items”. No extra payment will be made for arrangement for lighting fixtures air conditioning diffusers access panels, etc. The rate shall include all cutting and wastage from standard size sheets boards, runners, etc.

5.00.00 METHOD OF MEASUREMENT

a) Actual area of work done shall be measured.

b) No deduction will be made for opening upto 0.25 sq. metre in area each

c) Where a rigid steel framework is required to support the ceiling, it shall be measured and paid separately under relevant item in the Schedule.

6.00.00 I. S. CODES

IS: 2441 - Code of Practice for fixing ceiling coverings.

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SECTION-XXVII

TECHNICAL SPECIFICATION
FOR
SHEET WORK IN ROOF AND SIDE WALL

CONTENT

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2.00.00	INSTALLATION	VII-C/S-XXVII : 1
3.00.00	ACCEPTANCE CRITERIA	VII-C/S-XXVII : 8
4.00.00	RATES	VII-C/S-XXVII : 8
5.00.00	METHOD OF MEASUREMENT	VII-C/S-XXVII : 8
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SECTION-XXVII

TECHNICAL SPECIFICATION FOR SHEET WORK IN ROOF AND SIDE WALL

1.00.00 SCOPE

This specification covers the erection of asbestos, C.G.I., aluminium or other sheet plain /corrugated/trough covering to roof and side walls at various elevations and the fabrication and/or installation of asbestos, C.G.I or aluminium gutters, flashings etc., as shown on drawings and schedule of items.

2.00.00 INSTALLATION

2.01.00 Storage of Materials

All materials shall be stored by the Contractor in proper way to prevent all damage. If the materials are issued at site by the Owner, the Contractor shall at the time of issue, satisfy himself about the condition of issued sheets, gutters, etc. and no complaints shall be entertained later.

2.02.00 Workmanship

The workmanship shall be according to best construction practice to give a water tight finish to the satisfaction of the Engineer fixing of gutters and down pipes shall be according to IS:2527.

2.02.01 Asbestos Sheeting

Asbestos sheets of profiles as stated in the Schedule of Items, shall be fixed with minimum 150 mm end lap and side laps as per manufacturer's specification Hook bolts or J-bolts shall be 8 mm dia. at 305 centres 6 mm dia galvanised iron seam bolt and nut with G.I. flat washers and bitumen washers shall be used for stiching ridge cappings, corner pieces, ventilators, north light curves etc.

2.02.02 C.G.I. Sheeting and Aluminium Sheeting

This shall be of the thickness specified in the description of the item and shall conform to IS 277. The sheets shall be of 275 grade of coating unless otherwise specified in the description of item.

The sheet shall be free from cracks, split edges, twists, surface flaws etc. They shall be clean, bright and smooth. The galvanizing shall be non-injured and in perfect condition. The sheets shall not show signs of rust or white powdery deposit on the surface. The corrugations shall be uniform in depth and pitch and parallel with the side.

Purlins : Purlins of the specified material or M.S. rolled sections of requisite size shall be fixed over the principal rafters and the spacing will be as specified in the drawing.

Slope : Roof shall not be pitched at a flatter slope than 1 vertical to 5 horizontal or as specified in the drawing. The normal pitch adopted shall usually be 1 vertical to 3 horizontal.

Laying and Fixing : The sheets shall be laid and fixed in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

The sheets shall be laid with a minimum lap of 15 cm at the ends and 2 ridges of corrugations at each side. The above minimum end lap of 15 cm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end lap shall be 20 cm. The minimum lap of sheets with ridge, hip and valley shall be 20 cm measured at right angles to the line of the ridges, hip and valley respectively. These sheets shall be cut to suit the dimensions or shapes of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge chisel to give a smooth and straight finish.

Lapping in C.G.I. sheets shall be painted with a coat of approved steel primer and two coats of painting with approved paint suitable for G.I. sheet, before the sheets are fixed in place.

Sheet shall not generally be fixed in to gables and parapets. They shall be bent up along their side edges close to the wall and junction shall be protected by suitable flashing or by a projecting drip course, the later to cover the junction by at least 7.5 cm.

The laying operation shall include all scaffolding work involved.

Sheets shall be fixed to the Purlins or other roof members such as hip or valley rafters etc. with galvanized J or L hook bolts and nuts, 8 mm diameter, with bitumen and G.I. limpet washers or with a limpet washers filled with white lead as directed by the Engineer-in-Charge. While J hooks are used for fixing sheets on angle iron Purlins, and L hooks are used for fixing the sheet to R.S. joists, timber or precast concrete Purlins. The length of the hook bolt shall be varied to suit the particular requirements.

The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm. There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 30 cm. Coach screws shall not be used for fixing sheets to purlins.

The galvanized coating on J or L hooks, and bolts shall be continuous and free from defects such as blisters, flux stains, drops, excessive projections or other imperfections which would impair serviceability.

The galvanized coating should conform to IS 1367 9pt. XIII). The mass of coating per square meter of the surface shall be as under:

Mass and Equivalent Thickness of coating

Minimum Mass (g/m^2	Average Thickness(µm)	Minimum Mass (g/m^2)	Individual Thickness(µm)
375	54	300	43

Where slopes of roofs are less than 21.5 degrees (1 vertical to 2.5 horizontal) sheets shall be joined together at the side laps by galvanized iron bolts and nuts 25 x 6 mm size, each bolt provided with bitumen and a G.I. limpet washers or a G.I. limpet washers filled with white lead. As the overlap at the sides extends to two corrugations, these bolts shall be placed zigzag over the two overlapping corrugations, so that the ends of the overlapping sheets shall be drawn tightly to each other. The spacing of these seam bolts shall not exceed 60 cm along each of the staggered rows. Holes for all bolts shall be drilled and not punched in the ridges of the corrugations from the underside, while the sheets are on the ground.

Finish : The roof when completed shall be true to lines, and slopes and shall be leak proof.

Measurements : The length and breadth shall be measured correct to cm. Area shall be worked out in sq.m. correct to two places of decimal.

The specified area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc. shall be included in the measurements of the roof.

Roof with curved sheets shall be measured and paid separately. Measurements shall be taken on the flat and not girthed.

No deduction in measurement shall be made for opening up to 0.4sqm and nothing extra shall be allowed for forming such openings. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed. No additions shall be made for laps cut through.

Rate : The rate shall include the cost of all the materials and labour involved in all the operations described above including a coat of approved steel primer and two coats of approved steel paint on overlapping of C.G.I. sheets. This includes the cost the cost of roof sheets, galvanized iron J or L hooks, bolts and nuts, galvanized iron seam bolts and nuts, bituminous and galvanized iron limpet washers etc.

Ridges and Hips of Plain Galvanised Steel Sheets

Ridges and Hips : Ridges and hips of C.G.I. roof shall be covered with ridge and hip sections of plain G.S. sheet with a minimum lap of 20 cm on either side over the C.G.I. sheets. The end laps of the ridges and hips and between ridges and hips shall also be not less than 20 cm. The ridges and hips shall be of 60 cm overall width plain G.I. sheet, 0.6mm or 0.8 mm thick as given in the description of the item and shall be properly bent in shape.`

Fixing : Ridges shall be fixed to the purlins below with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to the purlins.

Similarly, hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips on either side. If this is not possible extra hook bolts shall be provided.

The end laps of ridges and hips shall be joined together with C.G.S sheet by galvanized iron seam bolts 25 x 6 mm size each with a bitumen and G.I. washer or white lead as directed by the Engineer-in-Charge. There shall be at least two such bolts in each end lap.

Surface of C.G.I. sheets of ridge and hip sections and roofing sheets which overlap each other shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.I. sheets before they are fixed in place.

Finish : The edges of the ridges and hips shall be straight from end to end and their surfaces should be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

Measurement : The measurements shall be taken for the finished work in length along the centre line of ridge or hip, as the case may be, correct to a cm. The laps in ridges and hips and between ridges and hips shall not be measured.

Rate : The rate shall include the cost of all labour and materials specified above, including painting, cost of seam bolts and any extra G.I. hook bolts, nuts and washers, required.

Valley and Flashing of Plain Galvanised Steel Sheets

Valley and Flashing : Valley shall be 90 cm wide overall plain G.I. sheet 1.6 mm thick or other size as specified in the item bent to shape and fixed. They shall lap with the C.G.I. sheets not less than 25 cm width on other side. The end laps of valley shall also be not less than 25 cm.

Valley sheets shall be laid over 25 mm thick wooden boarding if so required.

Flashing shall be of plain G.I. sheet of 40 cm overall width 1.25 mm thick or 1.00 mm thick as specified in the item bend to shape and fixed. They shall lap not less than 15 cm over the roofing sheets. The end laps between flashing pieces shall not less than 25 cm.

Laying and Fixing : Flashing and valley sheets shall be fixed to the roof members below, such as purlins and valley rafters with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members.

At least one of the fixing bolts shall pass through the end laps of the valley pieces on other side. If this is not possible extra hook bolts shall be provided. The free end of flashing shall be fixed at least 5 cm inside masonry with the mortar of mix 1:3 (1cement: 3 coarse sand).

Surface of G.I. sheets under overlaps shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.I. sheets.

Finish : The edges of valley and flushing should be straight from end to end. The surface should be true and without bulges and depressions.

Measurements : The length of the valleys and flashing shall be measured for the finished work correct to a cm. The laps along the length of the valley or flashing pieces, including the portion embedded in masonry, shall not be measured.

Rates : The rate for valleys, shall be for all the labour and materials specified above, including painting, cost of seam bolts and the cost of requisite G.I. hook bolts, nuts and washers required over and above those needed for connecting the roof sheets to the roof members. The rate for valleys shall exclude the cost of boarding underneath which shall be paid for separately.

The rate for flashing shall be for all the labour and materials specified above, and shall include the cost of painting and mortar for fixing in wall.

Gutters Made of Plain Galvanised Steel Sheets

Gutters : Gutter shall be fabricated from plain G.I. sheets of thickness as specified in the item

Eaves gutters shall be of the shape and section specified in the description in the item. The overall width of the sheet referred to their in shall mean the peripheral width of the gutter including the rounded edges. The longitudinal edges shall be turned back to the extent of 12 mm and beaten to form rounded edges. The ends of the sheets at junction of pieces shall be hooked in to each other and beaten flush to avoid leakage.

Slope : Gutters shall be laid with a minimum slope of 1 in 120.

Laying and fixing : Gutters shall be supported on and fixed to M.S. flat iron brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1.20 metres.

Where these brackets are to be fixed to the sides of rafters, they shall be of 40 x 3 mm section bend to shape and fixed rigidly to the sides of rafters with 3 nos. 10 mm dia bolts, nuts and washers. The brackets shall overlap rafter not less than 30 cm and the connecting bolts shall be at 12 cm centers.

Where the brackets are to be fixed to the purlins, the bracket shall consist of 50 x 3 mm M.S. flat iron bent to shape with one end turned at right angle and fixed to the purlin face with 2 nos. of 10 mm diameter bolts, nuts and washers. The bracket will be stiffened by provision of 50 x 3 mm M.S. flat whose over hung portion bent to right angle shape with its longer leg connected to the bracket with 2 nos. 6 mm dia M.S. bolts, nuts and washers and its shorter leg fixed to face of purlin with 1 no. 10 mm dia bolt, nut and washer. The overhang of the vertical portion of the bracket from the face of the purlin shall not exceed 22.5 cm with this arrangement. The spacing of the brackets shall not exceed 1.20 metres.

The gutter shall be fixed to the brackets with 2 nos. G.I. bolts and nuts 6 mm dia, each fitted with a pair of G.I. and bitumen washers. The connecting bolts shall be above the water line of the gutters.

For connection to down take pipes, a proper drop end or funnel shaped connecting piece shall be made out of G.I. sheet of the same thickness as the gutter and reverted to the gutter, the other end tailing in to the socket of the rain-water pipe. Wherever stop ends, angles etc., should be provided.

Finish : The gutters when fixed shall be true to line and slope and shall be leak proof.

Measurements : Measurements shall be taken for the finished work along the centre line of the top width of the gutter connection to a cm. The hooked lap portion in the junctions and gutter lengths shall not be measured. The number of brackets which are fixed to purlins with stiffener flats should be measured.

Rate : The rate shall include the cost of all labour and materials specified above, including all specials such as angles, junctions, drop ends or funnel shaped connecting pieces, stop ends etc., flat iron brackets and bolts and nuts required for fixing latter to the roof members. Brackets of 50 x 3 mm flats fixed to purlins with stiffener flats will be paid extra.

2.02.03 **Fiber Glass Reinforced Plastic Sheeting**

This shall be of thickness and profile as mentioned in the Schedule of Item. Colour and light transmittance shall be as mentioned in drawings and or schedules. Where used in conjunction with C.G.I. or asbestos sheeting the end and side laps and fixing device shall be same as used for general sheeting. Where used in lieu of glass, the fixing shall be by means of timber or metal glazing beads as mentioned in schedule of items. In all cases, the installation shall be completely watertight and able to withstand the designed wind-pressure as mentioned in Schedule.

2.02.04 **Precoated metal sheet**

Precoated metal sheeting for roof shall be of precoated cold rolled sheet of total coated thickness (TCT) 0.58 to 0.68 mm of approved manufacturer. The sheet shall be metallic hot deep coated with an alloy of 55% aluminium, 43% zinc and 1.55 silicon coating mass shall be 150 gms/sq.m. sheet shall be fixed with fastening clip and self tapping fastener. Ridge for slope roof shall be of similar material and shall be fixed with necessary self tapping screws as per manufacturer details.

Thermally insulated sandwiched metal cladding for external facade shall be of approved manufacturer. Sheeting shall Hi Rib 0.5 mm troughed sheeting manufactured from aluminium alloy high tensile steel (550Mpa) coated with fluro polymer (PV F2 or equivalent) and shall have life span sustenance against aggressive weathering action. Inner profiled sheet shall be with profile sheet of .6 mm thick (total coated thickness) permanently coated galvanised sheet.

Galvanised coating shall be not less than 120 gm/sq.m. and sandwiched insulation of 25 mm thick or as per design requirement shall be bonded mineral wool blanket or equivalent conforming to IS: 8183 (minimum density of 32/kg/cum for glass wool and 48/kg/cum for rock wool) having minimum coefficient of thermal conductivity of 0.49 m W/cm deg C (at 50 degree C) Cladding shall be fixed to supports/rails by nuts, bolts, hooks, washers self tapping screws of stainless steel Austentic grade) conforming to IS:1367 (part

14) including sealants, gaskets, PVC tape 0.25 mm thick, flashing, black synthetic rubber external trough filler and 25X3 mm aluminium earthling.

2.02.04 **Polycarbonate Sheeting Work**

Solid Polycarbonate sheet of minimum 4mm thick should be of UV resistant and high temperature resistant. Sheet should be of approved brand and quality, colour and transparency for ceiling/ roofing on plain, sloped, curved surfaces to any pitch or height including fixing purlins with polymer quoted galvanized self drilling, self tampering metal screws and fasteners and EPDM washers, rubber gasket with closing caps, adequate adhesive and sealants as per manufacturer's specification etc. complete but excluding the cost of purlins, rafters, trusses etc.(if any). Polycarbonate sheets shall be uniform pigmentation and thickness with out air pockets and shall conform to IS: 14443: 1997 and including cutting to required length and size including profile machine bending of sheets to achieve the desired profile by conforming minimum joints and laps as per drawing.

3.00.00 **ACCEPTANCE CRITERIA**

The installations shall present a neat appearance and shall be checked for water tightness. The following shall be checked:

a) Side and end laps

b) Absence of cracks, holes or damages in sheet

c) Spacing of bolts

d) Provision of double washers (G.I. and asbestos or bituminous washers)

e) Proper installation of flashing

4.00.00 **RATES**

Rates shall be for unit rate for complete item described in the Schedule and shall include all wastages as mentioned earlier.

5.00.00 **METHOD OF MEASUREMENT**

a) No allowance shall be made for laps.

b) Roofing and side sheeting shall be measured for net area of work done. Corrugated sheeting shall be measured flat and not girthed. Openings less than 0.4 Sq.m shall not be deducted. Detailed stated earlier.

c) Special features like flashings, ridge pieces, caves, corner pieces, north-light curves etc. shall be measured for length of installation.

d) Gutter and down comers shall be measured for length along their centre lines and bends, junctions, shoes ends, etc. shall not be paid properly.

e) S-type asbestos louvers shall be measured for area of opening in which it is installed.

f) Curved asbestos roofing sheets shall be measured for area of curve.

g) Asbestos ventilators, roof lights shall be measured and paid under relevant items.

6.00.00 **IS CODES**

The following are some of the important IS Codes relevant to these sections:

IS : 3007	:	Code of practice for laying of asbestos cement sheets
IS : 2527	:	Code of practice for fixing rain water gutters and down pipes for roof drainage
IS : 1626	:	Specification for asbestos cement building pipes gutters and fittings
IS : 277	:	Specification for galvanised steel sheets (plain and corrugated)
IS : 1200 (PT.IX)	:	Method of measurements of building and civil engineering works: Part – 9 Roof covering (including cladding)
IS : 2633	:	Method of testing uniformity of coating on zinc coated articles.
IS : 3144	:	Method of test for mineral wool thermal insulation materials.
IS : 3346	:	Method of the determination of thermal conductivity of thermal insulation materials.
IS : 8183	:	Bonded mineral wool

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SECTION-XXVIII

TECHNICAL SPECIFICATION FOR ROOF WATER PROOFING, INSULATION AND ALLIED WORKS

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SECTION-XXVIII

TECHNICAL SPECIFICATION FOR ROOF WATER PROOFING, INSULATION AND ALLIED WORKS

1.00.00 SCOPE

This specification covers providing, furnishing, installation, repairing, finishing, curing, testing,, protection, maintenance till handing over of roof water-proofing, insulation and allied work for buildings and at locations covered under the scope of the Contract.

2.00.00 INSTALLATION

2.01.00 Before taking up the water proofing work the construction of parapet walls, including finishing should be completed. Similarly, the ancillary items like haunches, khurras, grooves to take the fiber cloth layer, fixing up of all down take pipes, water pipes and electric conduits etc. should be completed and no such work should be allowed on the area to be treated during the progress of water proofing treatment or even later.

2.01.01 There is no necessity of hacking the surface to be treated shall be cleaned including removing the mortar dropping from the surface.

2.01.02 **Grading Underbed**

The surface to receive the underbed shall be roughened and thoroughly cleaned with wire brush and water. Oil patches if any shall be removed with detergent. The surface shall be soaked with water and all excess water removed just before laying of the underbed.

The underbed shall not be laid under direct hot sun and shall be kept in shade immediately after laying so as to avoid quick loss of water from the mix and separation from the roof surface. The underbed shall be cured under water for at least 7 days.

The underbed shall be laid to provide an ultimate run off gradient not less than 1 in 120 and as directed by the Engineer. Upto an average thickness of 25 mm the underbed shall usually be composed of cement and sand plaster. For higher thickness the underbed shall be made with cement concrete.

The underbed shall be finished to receive the waterproofing treatment direct or insulation as the case may be.

2.01.03 The grading plaster shall be average 25mm thick maximum. It shall consist of cement and coarse sand in the ratio 1:4 nominal by volume. The same and cement shall be thoroughly mixed dry and them water added. Each batch of mix shall be consumed before the initial set starts.

The plaster shall be fully compacted to the desired grade in continuous operation. The surface shall be even and reasonably smooth.

2.02.00 **Concrete**

The concrete shall be used where the sub-grade is more than average 25mm thick. It shall consist of cement concrete 1:2:4 nominal mix by volume with 12mm down stone chips and coarse sand. The aggregate shall be mixed dry and minimum quantity of water shall be added to make the mix workable.
The mix shall be laid to proper grade, fully consolidated and surface shall be smooth and even.

2.03.00 **Insulation**

The Tenderer shall along with the tender send specification of insulating materials he proposes to use and the proposed method of laying. Before bulk supply, the contractor shall send samples of insulating material to the Engineer, and after approval of the samples, the Contractor shall procure and transport the bulk material to the site. Whenever asked by the Engineer, the Contractor shall furnish test certificates from testing laboratory on the insulating and other properties of the materials.

After laying the insulation the surface shall be made ready as required to receive the waterproofing treatment. If any plastering is used it shall be not leaner than 1:4 cement sand by volume and not thinner than 12mm and it shall be cured for seven days.

2.03.01 **Foam Concrete**

This shall be of light weight foam concrete of average 50 mm thickness or as specified or as shown on drawings. This may be laid in situ in suitable panels or in precast blocks. The insulating properties shall be such that the thermal conductivity shall not exceed 0.125 Kcl m/m degree C. The weight of the insulating material shall be from 0.3 to 0.5 gm/cm.

Before starting the laying of foam concrete samples shall be prepared at site and got tested for approval of the Engineer.

The foam concrete laid shall be sufficiently strong to make the usual work load and standard loads expected on the roof. Any damaged portion shall be removed and replaced forthwith. Approval of the Engineer shall be taken before laying the waterproofing over the insulation.

While laying the foam concrete, samples from each batch of the mix shall be kept for test if so desired by the Engineer.

2.03.02 **Expanded Polystyrene Blocks**

The expanded polystyrene block insulation shall be fire retardant quality and shall have a maximum thermal conductivity of 0.026 KCl m/m degree C. It must be strong enough to withstand without deformation the workload and standard loads expected on the roof.

The Contractor shall lay the expanded polystyrene block as per manufacturer's approved specification. Only specifically experienced workers shall be used for this work. If the Engineer is not satisfied about the efficiency of the workers the Contractor shall have to secure manufacturer's supervision.

Material: Expanded polystyrene shall conform to IS 4671. It is of two types given below :

Type N-Normal

Type SE – It shall be of self extinguishing type when tested in accordance with IS 4671.

Dimensions : The size of the finished boards shall be 1.0 x 0.5 m or as specified and having a thickness of 15, 20, 25, 40, 50, 60, 75 or 100mm.

Tolerance : The tolerances on the length, width and thickness of the finished board shall be ± mm.

Requirements for Expanded Polystyrene for General Use :

Sl. No.	Characteristics	Requirements at various nominal apparent densities in kg/cum					Test Reference
		15	20	25	30	35	
1.	Thermal conductivity (k. value) (a) at 0ºC (b) at 10ºC	 0.34 0.37	 0.32 0.35	 0.30 0.33	 0.29 0.32	 0.28 0.30	 IS 3346
2.	Compressive strength at 10% deformation in kg/sq.cm Minimum.	0.7	0.9	1.1	1.4	1.7	IS 4671

Sl. No.	Characteristics	Requirements at various nominal apparent densities in kg/cum					Test Reference
		15	20	25	30	35	
3.	Cross breaking strength in kg/sq.cm Minimum.	1.4	1.6	1.8	2.2		IS 4671
4.	Water vapour permeance in g/sqm 24 hrs. Max.	50	40	30	20		IS 4671
5.	Thermal stability Percent Max.	1	1	1	1		IS 4671
6.	Water absorption	Less than 0.5% by volume (after 24 hrs. immersion)					IS 4671

Sampling : In a single consignment all the items of the same type, shape and dimensions belonging to the same batch of manufacture shall be grouped together to constitute a lot. For the purpose of judgment conformity to the requirements each lot shall be considered separately. The number of sample items for this purpose shall depend on the size of the lot and shall be in accordance with col. 1 & 2 of Table given below. The sample shall be taken at random from the lot.

No. of items in the lot	No. of sample items	Permissible number of defective sample items
1	2	3
Up to 25	3	0
26 to 100	5	0
101 to 300	8	0
301 to 1000	13	0
1001 to 3000	20	1
3001 and above	32	2

All the sample items selected from the lot shall be tested for all requirements of the specifications. Any item failing in one or more of the requirements shall be regarded as defective.

General : Expanded polystyrene can either be fixed with suitable adhesive to the false ceiling board or else it can simply be rolled ober the suspended false ceiling.

Measurements : Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of area up to 40 square decimeter. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimeter in area deduction for the full opening will be made, but nothing extra will be paid for any extra material/labour involved in forming such openings.

Rate : The rate shall include the cost of material and labour in providing and fixing the polystyrene boards.

2.03.03 **With Resin Bonded Fiber Glass Wool (Bonded Mineral Wool)**

Material : The material shall be mineral wool made from sock slag or glass processed from a molten state in to fibrous form and shall be bonded with a suitable binder. Bonded mineral wool shall be 25, 40, 50, conform to specifications of group I of IS 8183.

Dimensions : The bonded mineral wool shall be supplied in width of 50, 60, 75 and 100 cms, and length of 100, 120 and 140 cms and the thickness of the bonded material wool shall be 25, 40, 50, 65 or 75 mm.

Tolerance : For width and length, the dimensional tolerance of the bonded material wool shall be -1/2 %. For nominal thickness in the range 25 to 75 mm the tolerance shall be -2 mm. An excess, in all dimensions is permitted.

Requirements for Fiber Glass Wool

Sl. No.	Characteristics	Group I	Test Reference
1.	Bulk density	12 to 15 kg/cum	IS 3144
2.	Recovery after compression	Not less than 90% of original thickness	Annexure. A of IS 3144
3.	Shot content max	500 micron-5% 250micron-15%	IS 8183
4.	Moisture content and absorption	Not more than 2%	IS 3144
5.	In combustibility	Incombustible	IS 3144
6.	Thermal conductivity deg. C at mean temperature 50 deg. C	0.49 mw/ cm^{o}C	IS 3346
7.	Sulphur content	Not more than 0.6%	IS 3144

General : Bonded mineral wool insulation can be either laid over false ceiling or alternatively it can be fixed to the ceiling when the space above false ceiling is being used for carrying return air. In the first case the bonded mineral wool can either be fixed with suitable adhesive to the false ceiling board or else it can simply be rolled over the suspended false ceiling.

Measurements : Length and breadth of roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas up to 40 square decimeter. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimeter in areas, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

Boarding fixed to curved surface in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately in running metres.

Rate : The rate shall include the cost of all materials and labour required in providing bonded mineral wool.

Either of above items (cl. No. 2.3.1 or 2.3.2 or 2.3.3) can be adopted subject to approval of engineer.

2.04.00 **Fillets**

Fillets at junction of roofs and vertical walls shall be provided with the same insulating material as provided for the main roof insulation. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

Where there is no insulation over roof slab, fillets shall be cast-in-situ cement concrete (1:2:4) nominal mix by volume.

2.05.00 **Water proofing by epoxy resin based application**

Exposed surfaces of cement concrete, lime concrete or brickwork to be treated for waterproofing by the resin based application shall be throughly cleaned and the epoxy resin based material to be applied as directed by the manufacturer. The material shall not have any adverse effect on the surface on which it is applied and must stick to it uniformly to make a strong durable bond. It shall not be affected by short duration from fire, sun, and light traffic. The application shall be resistant to growth of fungus and proof against saltpeter action. If desired by the Engineer, a sample shall be prepared in advance and tested for waterproofness for 48 hours under 300 mm depth of standing water. The Contractor shall arrange the demonstration by providing free the materials and labours for the application.

2.06.00 **Flashing**

Unless otherwise stated flashing shall be done in the same way as the waterproofing except that the last layer, instead of being finished with pea-sized gravel, shall be finished with two coats of bituminous primer. The flashing shall be extended up the vertical surfaces as shown on drawing. The flashing shall end in grooves in vertical walls. The grooves shall be at least 65 mm deep and caulked with waterproof mastic cement. The minimum overlap with horizontal roofing felt shall be 100 mm.

Where specified on drawings or directed by the Engineer, metal flashing shall be provided. The metal flashing shall be done as shown on the drawings. The materials shall be 18g or 22g G.I. sheets, as specified on the drawings and/or as directed by the Engineer.

2.07.00 **Elastomeric Membrane**

2.07.01 **Primer Coat**

It shall consist of polyurethane (P.U.) or any other equivalent material. Primer coat shall be a special blend of moisture curing urethane pre-polymers in solvent. A single coat of this primer shall be applied by brush /spray with airless spray equipment over the prepared bed as an adhesion coat with an application rate of 6-8 sq.m per liter depending on the surface porosity.

The primer shall be allowed to dry for a minimum period of 2 to 4 hours time before the successive finishing coats of P.U. liquid membrane are applied. In any case successive finishing coat shall be applied within 24 hours.

The substrate shall be properly prepared by removing all loose materials by vigorous brushings, fungal growth with proprietary fungicide as recommended. Priming coat shall not be applied to damp substrate.

2.07.02 **Finishing Coats**

The finishing coats shall consist of two successive liquid coatings of high solid content urethane pre-polymers material to form an elastomeric membrane. Application shall be with brush or spray to form an uniform joint less elastomeric membrane. The overall dry film thickness shall be 1.5 mm subject to minimum 750 gm per sq.m per coat application rate.

Each coat shall be allowed to dry for minimum 12 hours before applying the next coat. The surface should be dry and smooth before application.

The coating shall be continued up the parapets/walls for minimum of 150 mm over the finished roof surface or fillet with suitable tucking into the vertical wall surface. It shall be continued into rain water pipes by at least 100 mm.

The final coat of PU liquid when tacky shall be sprinkled with the sand.

For edges, expansion joints and any vulnerable points a layer of polyscrim cloth/fabric are to be embedded between 2 finishing coats.

The entire work shall be carried out under the suspension of approved authorized agency.

2.07.03 **Surface Finish**

Areas of roof treatment shall be provided with wearing course consisting of minimum 25 mm thick PCC 1:11/2:3(using 12.5 mm size aggregate) cast in panel of maximum size of 1.20 m x 1.20 m and reinforced with 0.56 mm diameter galvanized chicken wire mesh and sealing of joints using sealant or elastomeric compound to ensure perfect waterproofing.

When the roof surface is subjected to foot traffic or used as a working area, a cement mortar (1:4) shall be applied over the top most layer of roofing treatment. Over this, a layer of chequered cement concrete flooring tiles conforming to IS: 13801 shall be provided. The tiles shall be laid as per IS 1443.

2.08.00 **Under Deck Insulation**

2.08.01 Insulation material shall be Closed Cell Elastomeric Nitrile Rubber

2.08.02 Density of Material shall be between 40 to 60 Kg/m3

2.08.03 Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/m°K at an average temperature of 0°C

2.08.04 The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990

2.08.05 Material should be FM (Factory Mutual), USA approved.

2.08.06 Water vapour permeability shall not exceed 0.017 Perm inch (2.48 x 10-14 Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor 'μ' value should be minimum 7000.

2.08.07 Under-deck insulation thickness shall be as per HVAC requirement and calculation.

2.08.08 Under-deck insulation shall be provided for all AC areas having roof exposed to sun.

3.00.00 **ACCEPTANCE CRITERIA**

The surface level shall be such as to allow quick draining of rains without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

The Contractor shall give a guarantee in writing for all work executed under this specification supplemented by a separate and unilateral guarantee from the specified agency for the roof water-proofing treatment work. The guarantee shall be for materials and workmanship for a period of minimum 10 years. The mode of execution of the guarantee shall be acceptable to the Owner. Any bad work or any damage to the treatment shall be repaired and made good by the contractor at his own cost.

4.00.00 **I.S. CODES AND STANDARDS**

a)	IS:73	:	Paving Bitumen
b)	IS:702	:	Industrial Bitumen
c)	IS:1203	:	Methods of testing tar and bitumen
d)	IS:1322	:	Bitumen felts for waterproofing and damp proofing
e)	IS:1346	:	Code of Practice for waterproofing of roofs with bitumen felts
f)	IS:3384	:	Bitumen primer for use in waterproofing and damp proofing.
g)	IS:2645	:	Specification for integral water proofing compounds for cement mortar and concrete.
h)	IS:3144	:	Methods of test for mineral wool thermal insulation materials.
i)	IS:4641	:	Expanded polystyrene for thermal insulation purpose.

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SECTION-XXIX

TECHNICAL SPECIFICATION
FOR
WATER SUPPLY

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SECTION-XXIX

TECHNICAL SPECIFICATION FOR WATER SUPPLY

1.00.00 SCOPE

This section includes supply of all materials, labour and incidentals for water supply for residential, business and industrial and other types of buildings. The water supply system of a building or premises covers service pipes and the necessary connecting pipes, fittings, control valves and all appurtenances in or adjacent to the building or premises.

General Requirements

Any damage caused to the building, or to electric, sanitary water supply or other installations etc. therein either due to negligence on the part of the contractor, or due to actual requirements of the work, shall be made good and the building or the installations shall be restored to its original condition by the contractor. Nothing extra shall be paid for it, except where otherwise specified.

All water supply installation work shall be carried out through licensed plumber.

It is most important to ensure that wholesome water supply provided for drinking and culinary purpose is in no way liable to contamination from any less satisfactory water. There shall, therefore, be no cross connection whatsoever between a pipe or fitting for conveying or containing wholesome water and a pipe or fitting for conveying or containing impure water or water liable to contamination or of uncertain quality of water which has been used for any purpose. The provision of reflux or non-return valves or closed and sealed valves shall not be constructed a permissible substitute for complete absence of cross-connection.

Where a supply of wholesome water is required as an alternative or standby to supply of less satisfactory water or is required to be mixed with the latter, it shall be delivered only in to a cistern, and by a pipe or fitting discharging in to the air gap at a height above the top edge of the cistern equal to twice its normal bore, and in no case less than 15 cm.

No piping shall be laid or fixed so as to pass into, through or adjoining any sewer, scour outlet or drain or any manhole connected therewith nor through any ash pit or manure-pit or any material of such that can cause undue deterioration of the pipe.

Where the laying of any pipe through fouled soil or previous material is unavailable, the piping shall be properly protected from contact with such soil or material by being carried through an exterior cast iron tube or by some other suitable means. Any piping or fitting laid or fixed which does not comply with the above requirements, shall be removed and re-laid in conformity with the above requirements.

The design of the pipe work shall be such that there is no possibility of backflow towards the source of supply from any cistern or appliance whether by siphonage or otherwise, and reflux or non-return valves shall not be relied upon to prevent such back flow.

All pipe work shall be so designed, laid or fixed, and maintained so that it remains completely watertight, thereby avoiding wastage of water damage to property and the risk of contamination of the water conveyed.

In designing and planning the layout of the pipe work, due attention shall be given to the maximum rate of discharge, required economy in labour and materials, protection against damage and corrosion, protection from frost, if required, and to avoidance or airlocks, noise transmission and unsightly arrangement.

To reduce frictional losses, piping shall be as smooth as possible inside. Methods of jointing shall be such as to avoid internal roughness and projection at the joints, whether of the jointing materials or otherwise.

Change in diameter and direction shall preferably be gradual rather than abrupt to avoid undue loss of head. No bend or curve in piping shall be made so as to materially reduce or alter the cross-section.

Underground piping shall be laid at such a depth that it is unlikely to be damaged by frost or traffic loads and vibrations. It shall not be laid in ground liable to subsidence, but where such ground cannot be avoided; special precautions shall be taken to avoid damage to the piping. Where piping has to be laid across recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

Where the service pipe is of diameter less than 50mm the stop valves shall be of the screw-down type and shall have loose washer plates to act as non-return valves. Other stop valves in the service line may be of the gate type.

In flats and tenements supplied by a common service pipe a stop valve shall be fixed to control the each branch separately. In large buildings a sufficient number of stop valves shall be fixed on branch pipes, and to control groups of ball valves and draw off taps so as to minimize interruption of the supply during repairs, all such stop valves shall be fixed in accessible positions and properly protected from being tampered with, they may be of the gate type to minimize loss of head by friction.

Water for drinking or for culinary purposes as far as possible shall be on branch pipes connected directly to the service pipe.

Pumps shall not be allowed on the service pipe as they cause a drop of pressure on the suction side thereby affecting the supply to the adjoining properties. In cases where pumping is required, a properly protected storage tank of adequate capacity shall be provided to feed the pump.

Service pipes shall be so designed and constructed as to avoid air-locks, so that all piping and fittings above ground can be completely emptied of water to facilitate repairs. There shall be draining taps or draw-off taps (not under ground) at the lowest points, from which the piping shall rise continuously to draw-off taps, ball valves, cisterns, or vents (where provided at the high points).

Service pipes shall be designed so as to reduce the production and transmission of noise as much as possible. Appliances which create noise shall be installed as far distant as possible from the living rooms of the house. High velocity of water in piping and fittings shall be avoided. Piping shall be confined, as far as possible, to rooms where appliances are fixed, it shall have easy bends, and where quietness is particularly desired, holder bats or claps shall be insulated from the piping by suitable pads.

The rising pipe to the storage cistern, if any, or to any feed cistern shall be taken as directly as possible to the cistern and shall be fixed away from windows or ventilators.

All pipe work shall be planned so that the piping is accessible for inspection, replacement and repair. To avoid its being unsightly, it is usually possible to arrange it in or adjacent to cupboards, recesses, etc. provided there is sufficient space to work on the piping with the usual tools. Piping shall not be buried in walls or solid floors. Where unavoidable, piping may be buried for short distances provided that adequate protection is given against damage and that no joints are buried. If piping is laid in ducts or chases, these shall be roomy enough to facilitate repairs and shall be so constructed as to prevent the entry of vermin. To facilitate removal of pipe casing, floor boards covering piping shall be fixed with screws or bolts.

When it is necessary for a pipe to pass through a wall or floor, a sleeve shall be fixed therein for insertion of the pipe and to allow freedom for expansion, contraction and other movement. Piping laid in wood floors shall, where possible, be parallel with the joints.

Where storage tanks are provided to meet overall requirements of water connection of service pipe with any distributing pipe shall not be permitted except one direct connection for culinary or drinking requirements.

No service pipe shall be connected to any water closet or urinal. All such supplies shall be from flushing cistern which shall have supply from storage tank.

No service or supply pipe shall be connected directly to any hot water system or to any apparatus used for heating other than through a feed cistern thereof.

1.01.00 **Materials**

All materials, fittings, fixtures and appliances shall be of the best quality conforming to relevant Indian Standard and shall be procured from approved manufacturers. Unless specifically allowed by the Engineer, the Contractor shall submit samples of fittings and fixtures which will be retained by him for comparison when bulk supplies are received at the site. Ultimate choice of type, model and manufacturer lies completely with the Engineer.

It shall be the responsibility of the Contractor to procure the materials selected by the Engineer. Hence order is to be placed with the manufacturers in time, so that the materials are available at the site well ahead of their requirement.

The materials brought to the site, shall be stored in a separate secured enclosure away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and items found damaged shall not be retained at the site.

1.02.00 **Pipes and Pipe Fittings**

Under scope of this specification, pipes and pipe fittings may be any or a combination of the following types:

a) Cast Iron

b) Steel: lined, coated with bituminous composition, out coated with cement concrete or mortar or galvanised.

c) Reinforced Concrete

d) Prestressed Concrete

e) Asbestos Cement

f) Lead (Not to be used for potable water)

g) P. V. C.

h) Copper

i) Brass

j) Wrought iron

k) Galvanized Iron- heavy & medium duty pipes- is 1239 & is 4736

l) PP-R Pipes – IS 15801

1.03.00 **Water Tanks**

Water tanks shall be made of PVC, HDPE, MS pressed steel, GI, Concrete masonry. PVC/HDPE/Pressed Steel tanks shall be factory made and from reputed brand with proper test certificates. The capacity of tanks shall be as per drawing design or as per instruction of Engineer-in-Charge.

1.04.00 **Related Works**

All works, like earthwork, masonry, concrete, steelwork, cutting holes, chases, repairs and rectification associated directly with installation of water supply systems shall come under scope of the Contractor unless specifically excluded. These works are not detailed out in this Specification.

1.05.00 **Regulation**

The work which is required to be carried out under the scope of this section, shall be executed by a licensed plumber only (engaged by the Contractor) and he shall obtain all necessary sanctions, permissions, certificates etc. from Municipal and/or other Local Authorities and shall abide by all the rules of such Authorities. The fee paid to the Authorities shall be reimbursed by the Owner.

2.00.00 INSTALLATION

While basic layouts may be available in the drawings provided by the Owner, the details might have to be supplemented by the Contractor for approval of the Engineer.

Special attention shall be given by the Contractor to economy. Symmetry of layout is very important. Fittings meant for operation shall be located and oriented to allow easy reach and operation. Maintenance, repairs and replacements of pipes, fittings and fixtures must be conveniently possible.

2.01.00 Pipe Lines

2.01.01 Laying

In addition to fulfilling the functional requirements all pipelines shall be laid true to line, plumb and level. Any deviation shall need approval of the Engineer. Meticulous care shall be taken to avoid chances of airlock and water hammer.

Pipes shall be laid on continuous unyielding surface or on reliable supports at least one near each joint and spacing as directed by the Engineer. The support must be strong, neat and shall have provisions for securing the pipes in every direction and easy maintenance. Pipes shall be encased or concealed in masonry or concrete if shown on drawing or directed by the Engineer.

2.01.02 Back Flow

The layout of pipe work shall be such that there is no possibility of back flow towards the source of supply from any cistern or appliances, whether by siphonage or otherwise. All pipe works shall be so laid or fixed and maintained as to be and to remain completely water-tight, thereby avoiding waste of water, damage of property and the risk of contamination of the water conveyed.

2.01.03 Contamination

There shall be no cross connection whatsoever between a pipe or fitting for conveying or containing wholesome water and a pipe or fitting for containing impure water or water liable to contamination or of uncertain quality of water which has been used for any purpose.

No piping shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith.

2.01.04 **Underground Pipings**

Underground piping shall be laid at such a depth that it is not likely to be damaged by traffic and other loads and frost, where applicable.

The size and depth of the trench shall be as approved by the Engineer. Back-filling shall be done with selected fine earth, unless otherwise permitted in 150 mm layers and carefully consolidated. Special care shall be taken while filling in the vicinity of the pipe to avoid damage. Before backfilling the laid pipe shall be fully tested and approved.

Where the pipe rests on rock it may be bedded on a layer of fine selected material or concrete to avoid local point support.

The trench shall be so treated by gradient and filling in the area that it does not act as a drainage channel.

2.01.05 **Concealed Piping**

Where desired by the Engineer or shown on the drawings the pipes shall be concealed in masonry or concrete of the structure. The Contractor may co-ordinate with the building Contractor for leaving the chases, openings, conduits as necessary. However, the Contractor will rectify if required the chases, openings and conduits, supplement and make good after laying and testing of the concealed pipelines.

2.01.06 **Jointing of Pipes**

Jointing of pipes shall be completely leak proof and durable. Instruction of the manufacturer shall be followed unless desired otherwise by the Engineer. However, usually recommended practices are stated below for guidance:

a) **Cast Iron**

i) **Spigot and Socket Joints**

Lead joint : The joint is made by first caulking in clean spun yarn upto half depth and filling the reminder by running in molten lead taking care that no dross enters the joint and then thoroughly caulking the lead. The lead need not extend into the joint further than the back of the groove formed in the socket. After completing the joint it shall not be allowed to move. For rectification the joint shall be completely redone.

ii) **Flanged Joints :** Flanged joints shall be made by jointing rings of good quality, smooth and hard compressed fibre board of thickness not less than 1.5 mm and of such width as to fit inside the circle of bolt. Diagonally opposite bolts shall be tightened in pairs and in stages so that degrees of all bolts in a joint are similar. Damaged gaskets shall be replaced.

b) **Steel**

Plain ended steel pipes may be jointed by welding. Screwed and socketed joints shall be carefully tightened. Care shall be taken to remove any burr from the ends of the pipes. Jointing compound, if used, shall be lead free and approved by the Engineer. Once a joint has been screwed up it shall not be backed off unless threads are recleaned and new compound applied.

c) **G I Pipes**

Threads shall be cut with sharp tools, and before jointing all scales shall be removed from pipes by suitable means. The screw / threads of the pipe shall be cleaned out and the joint made by screwing the fittings after treating the threads with approved pipe jointing compound. Once a joint has been screwed up it shall not be backed off unless threads are recleaned and new compound applied.

d) **Asbestos Cement Pipes**

Socket and spigot ended pipes shall be jointed by caulking with tarred gaskets and grouted with 1:3 cement sand mortar.

e) **Lead**

Lead and lead alloy pipes shall be jointed with wiped solder joints.

f) **Concrete**

Concrete pipes may be socket and spigot ended collar or band jointed. Joints shall be effected by caulking with 1:3 cement sand mortar.

g) **P. V. C. / UPVC/ HDPE/PP-R**

Manufacturer's instruction shall be followed. For heating approved equipment with adequate control shall be used.

h) **Tyton Joint**

The manufacturer's instruction shall be strictly followed in making such joints. Tyton joints shall be made by push-on type specification stipulated by the pipe manufacturer. The tools specified by the pipe manufacturer shall be used to secure the jont fully.

2.01.07 **Painting**

Where mentioned in the Schedule, underground steel and cast iron pipes shall be given 2 coats of bituminous paint on the outside after laying, when painting is to be done above ground G.I. pipes shall be given a coat of zinc chromate primer, C.I. and M.S. pipes shall be given one coat of red lead or zinc chromate primer. Top coats shall be minimum 2 coats of best quality paint.

2.02.00 **Storage Tank - Pressed Steel Tank**

Unless otherwise mentioned, water storage tanks shall be pressed steel tanks of nominal size and capacity as mentioned in the Schedule and fabricated with all flanges external, all flanges internal, or bottom flange internal and side flanges external, as shown on drawings or schedule of items. The fabricator shall supply 6 prints of fabrication drawings to the Engineer for prior approval showing thickness of plates, method of jointing the plates, all supports, stays, gussets etc. Pads, cleats etc. required for supporting the tanks shall be supplied by the manufacturer. Inlet, overflow vent pipes, manholes etc. shall be arranged and provided as shown on drawing or mentioned in the schedule. Unless otherwise specified, the outlet pipe shall be 50 mm above the bottom of the tank and there shall be a 150 mm free board at the top of the tank.

All tanks shall be supplied with mosquito-proof covered top with manhole not less than 450 mm diameter. Tanks deeper than 1.00 Metre shall be provided with m.s. internal access ladder adjacent to the manhole. Water level indicator shall be provided if asked for. Two coats of anti-corrosive paint over a suitable primer shall be applied to both internal and external surface of tanks. Such paint if used shall not impart any taste or odour to water and be of lead free composition..

Erection of tanks shall be in accordance with detailed drawings and manufacturer's instructions. The two finishing coats of paint shall be applied to outside after erecting is complete.

2.02.01 **G. I. Water Tank**

G. I. water tanks shall be procured from a reputed manufacturer. The design shall be good enough to withstand the loads safely. Galvanised iron water storage tank shall be made of minimum 2 mm thick galvanised iron sheet. Plain sheets shall be fixed at the corner to angle iron frames by means 6 mm rivets at 40 mm pitch for tanks upto 1000 litres capacity and 8 mm rivets at 35 mm pitch for tanks above 1000 litres capacity. Tanks above 1000 litres shall have 20 mm dia. galvanised / iron stay rods, one fixed to angle framing at top and two in the body of the tank for extra strength. Holes for riveting shall be drilled and not punched. White lead shall be applied to the joints before riveting.

In case it is desired by the Engineer that corners of tank should be welded instead of riveted then the sheets shall be welded to form a tank will not have angle iron frame.

Tanks shall have 400 mm dia. holes at the top with hinged covers. The covers shall be made of galvanised iron sheet with angle iron frame. The cover shall be just loose but close fitting to keep out dust and mosquito and will not be airtight. It shall be complete with lockable arrangement.

Tanks shall be provided with rising main inlets of 40 mm dia. galvanised iron pipe or as shown on Drawing and 25 mm dia. G.I. overflow pipe. The rising main shall be connected to the tank with a ball valve near the top which disconnects the supply when tank is full up to the point of overflowing.

The ball valve permits the entry of water when the tank is empty and disconnects the supply when the tank is full. It consists of a hollow floating ball made of copper, plastic or hand Tubber, 110 mm in diameter, attached to an arm which is so pivoted that the end near the pivot closes the orifice of the main when the ball is raised to the required height of water in the tank and opens the main as soon as the ball drops with the fall of water level as it is drawn off through the distribution pipes. The ball valve shall be fixed to the tank independent of the inlet pipe and set in such a position that the body of the ball valve cannot submerge when the tank is full upto the water line. The ball valve shall be so adjusted as to limit the level of the water line. The level of the water in the tank to 75 mm below the lip of the overflow pipe. Free surface shall be about 150 mm above the maximum water filled level.

2.02.02 **Polythene Water Storage Tanks**

Material

Polythene used for manufacture of tanks and manhole lids may be high density (HDPE), low density (LDPE) or linear low density (LLDPE) and shall conform to IS 10146. Polyethylene shall be compounded with carbon black so as to make the tank resistant to ultra violet rays from the sun. The percentage of carbon black content in polyethylene shall be 2.5 ± 0.5 percent and it shall be uniformly distributed. The materials used for the manufacture of tank, manhole lid and fittings shall be such that they neither contaminated the water nor impart any test, colour, odour or toxity to water.

Manufacture and Finish

The tanks shall be manufactured by rotational moulding process. Each tank and the manhole lid shall be single piece having arrangement for fixing and locking the manhole lid with the tanks. Excess material at the mould parting line and near the top rim shall be neatly cut and finished. The internal and external surface of the tanks shall be smooth, clean and free from hidden internal defects like air bubbles, pit and metallic or other foreign material inclusion. Capacity of the tank, minimum weight of the empty tank (without manhole lid) and the manufacture brand name shall be embossed on the top surface of the tank near manhole.

Shape, Size and Capacity

The tank shall be cylindrical vertical with closed top having a manhole. Diameter and height of the tank of various capacities shall be as per manufacturer's specifications and a clearance of ± 3 percent shall be permitted on these dimensions. Capacity of the tank or up to the bottom of the inlet location whichever is less. Capacity of the tank shall be specified. Extra capacity if any shall be ignored.

Weight and Wall Thickness

The flat base of the tank shall be fully supported over its whole bottom area on a durable rigid flat and level platform sufficiently strong to stand without deflection the weight of the tank when fully filled with water. Depending upon the capacity and the location tanks may be suitably anchored as per the directions of the Engineer-in-Charge. For inlet, outlet and other connections fully threaded GI, HDPE or PVC connections with hexagonal check nuts and washers on either side of the tank wall shall be provided. Holes for threaded connections shall be drilled and not punched. Pipes entering of leaving the tank shall be provided with unions and suitably supported on a firm base to avoid damage to the tank walls.

Manhole Lid

The lid shall rest evenly and fit over the rim of the manhole so as to prevent the ingress of any foreign matter in to the tank. The lid shall be provided with suitable arrangement for locking it with the tank.

The tank and its components shall conform to the local bye-laws for preventions of mosquito menace.

Sl. No.	Capacity (litres)	Minimum Wall Thickness (mm)	Minimum Weight of Empty Tank (kg)
1	2	3	4
1.	200	4.4	7.8
2.	300	4.4	9.0
3.	400	5.5	15.0
4.	500	6.0	18.0
5.	700	7.0	23.5
6.	1000	6.6	33.0
7.	1250	7.0	40.0
8.	1500	7.0	47.0
9.	1700	7.0	54.0
10.	2000	7.0	64.0
11.	2500	8.2	81.0
12.	3000	8.2	96.0
13.	4000	8.8	138.0
14.	5000	10.4	191.0
15.	6000	10.7	209.0
16.	7500	10.7	250.0
17.	10000	11.5	363.0
18.	15000	11.5	550.0
19.	20000	13.2	814.0

Rates

The rate shall include the cost of the tank. Manhole lid, carriage and delivery at the place specified. Hoisting, installation, fittings, platform and anchoring shall be payable separately.

2.02.03 **Tube Wells with Hand Pumps**

Casing Pipe

The casing pipe shall be of M.S. or W.I. of 100 mm dia. And strong enough to stand hammering and vibrations to which it is subjects.

Filter and Brass Strainer

The filter shall consist of a G.I. pipe of the required diameter with 15 mm diameter holes covered with brass strainer both inside and outside. It shall have a driving point riveted or welded to it.

Hand Pump

This shall be of approved quality. It shall be complete with necessary bolt and nuts for jointing to the masonry or concrete base.

2.03.00 **Valve, Cocks, Taps**

All valves, stop cocks, taps etc. shall conform to relevant Indian Standard Specification and shall be of best quality from approved manufacturers. These shall be suitable for working pressures mentioned in the Schedule. Nominal size and material shall be as per schedule.

2.04.00 **Protection**

Open end of each pipe shall be protected during installation by suitable covers or plugs so that the ends, threads, sockets or spigot are not damaged and no foreign material can find its way into the pipe line.

Fittings and fixtures liable to be misused or stolen during the construction phase shall be fitted only before testing and handing over.

3.00.00 **TESTING AND ACCEPTANCE**

3.01.00 **Inspection Before Installation**

All pipes, fittings and appliance shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as rejected and forthwith removed from the site.

3.02.00 **Testing of Mains after Laying**

After laying and jointing, the main shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25 mm inlet with a stop cock, allowed to stand full of water for a few days if time permits, and then tested under pressure. The test pressure shall be 5 Kg/CM^2 or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or in the case of long mains or mains of a large diameter, by a power driven test pump, provided that the pump is not left unattached. In either case due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure

gauges shall be accurate and shall preferably have been recalibrated before the test. The pump having been stopped, the test pressure shall maintain itself without measurable less for at least five minutes. The end of the main shall be closed by fitting a water-tight expanding plug and the plug shall be secured by struts to resist the end thrust of the water pressure in the mains.

3.03.00 **Testing of Service Pipes and Fittings**

The service pipes shall be slowly and carefully charged with water allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under working conditions of pressure and flow. When all draw-off taps are closed, the service pipes shall be absolutely water-tight. All piping, fittings and appliances shall be checked for satisfactory support and protection from damage, corrosion and frost.

4.00.00 **RATES**

Rates shall be unit rates for the complete work as mentioned in the specification unless any particular portion is specifically excluded in the Schedule of Items.

If any material, fittings or fixtures are provided by the Owner f ree, the Contractor shall have to take delivery, keep in safe custody and be responsible till fitted and handed over.

5.00.00 **MEASUREMENT**

For method of measurement regarding works under scope of the specification IS: 1200 (Part-XVI) latest edition shall be followed unless contrary to the following:

5.01.00 **Trenches**

Unless particular items are included in the schedule, no separate measurement shall be made to lead, lift, dewatering, dressing, storing, backfilling, consolidation etc. that may be required in this connection.

5.02.00 **Concrete Masonry**

The measurement shall be on gross area or volume basis as mentioned under the relevant items.

5.03.00 **Soling**

No separate measurement should be made for dressing and ramming the surface. The soling shall be measured on gross area of the work under the item.

5.04.00 **Pipe Works**

No separate measurement shall be made for specials, supports and fixtures, cutting chases, holes and rectification unless specially indicated in the Schedule of Items. If the specials are separately indicated in the Schedule, the measurement for these shall be over and above the measurement of the pipe work as mentioned below :

The pipes of different nominal bores shall be measured separately.

The pipe work shall be measured in length inclusive of sockets, specials, fittings etc. in position.

5.05.00 **Fittings and Fixtures**

Measurement for fittings and fixtures where applicable shall be in number. No separate measurement shall be made for anchors unless they form a separate item in the Schedule.

5.06.00 **Chases, Holes**

If items for cutting and remaking of chases, holes and similar works are included in the Schedule the measurement shall be on gross length, area or volume as appropriate.

5.07.00 **Painting**

Painting pipe works shall be measured on the basis of length for different nominal diameters of the pipes. Painting of steel work may be on the basis of weight or area or otherwise as mentioned against the particular items.

6.00.00 **I.S.CODES**

Important relevant IS Codes for this Specification are listed below :

Latest editions shall always be consulted.

IS:2065	:	Code for Practice for water supply in buildings
IS:1172	:	Code of basic requirements for water supply, drainage and sanitation
IS:1200	:	Laying of water and sewer lines including (Pt.XVI) appcurtnant items.
IS:1239 (Pt. I & II)	:	Specification for Mild Steel Tubes and Mild Steel Tubulars and other wrought steel pipe fittings (10 mm to 15 mm nominal diameter)
IS:1536	:	Specification for Centrifugally cast (Spun) iron pressure pipes for water gas and sewage
IS:1537	:	Specification for vertically cast iron pressure pipes for water, gas and sewage.
IS:3486	:	Specification for Cast iron spigot and socket drain pipes (80 mm to 250 mm nominal diameter)
IS:3589	:	Specification for Electrically welded steel pipe for water, gas and sewage (200 mm to 2000 mm nominal diameter)
IS:784	:	Prestressed concrete pipes
IS:458	:	Concrete pipes (with or without reinforcement)
IS:783	:	Code of Practice for laying of concrete pipes
IS:1592	:	Asbestos cement pressure pipes
IS:1626	:	Asbestos cement pressure pipes, gutters and fittings (Spigot and Socket types)
IS:404	:	Lead pipes
IS:3076	:	Low density polyethylene pipes for potable water supplies
IS:4984	:	High density polythylene pipes for potable water

supplies

IS:2501	:	Copper tubes for general engineering purposes
IS:407	:	Brass tubes for general purposes
IS:1230	:	Cast iron rain water pipes and fittings
IS:804	:	Rectangular pressed steel tanks
IS:4736-1986	:	Hot-dip zinc coatings on steel tubes. (Reaffirmed – 2001)

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TECHNICAL SPECIFICATION FOR DRAINAGE AND SANITATION

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SECTION-XXX

TECHNICAL SPECIFICATION FOR DRAINAGE AND SANITATION

1.00.00 SCOPE

1.01.00 This section covers the layout and construction of drains for roof water, surface water and sewage together with all fittings and fixtures and inclusive of ancillary works, such as connections, manholes and inspection chambers used within the building and from the building to the connection to a public sewer or to treatment work, septic tank and soak pit dispersion trenches.

2.00.00 INSTALLATION

2.00.01 General

All pipe lines, locations of fittings and fixtures, etc. shall be as per drawings or as directed by the Engineer. Correctness of lines, plumb, orientation, symmetry and levels shall be strictly ensured. All items shall be fully secured against movement in any direction and so located as to allow easy maintenance.

All pipe lines, fittings and fixtures shall be installed leak proof. When the works under scope of this specification linked up with works executed by others, the connections shall be such as to prevent any splashing or spilling or emission of foul odour and gases.

2.01.00 Rainwater Down comers & Soil and Drainage Pipes

Rainwater downcomers shall be standard Cast Iron, UPVC, and Asbestos Cement Pipes. In case where specifically desired, M.S. pipes may also be used. M.S. pipes shall be painted outside with two coats of anticorrosive paints under a coat of primer.

Rainwater downcomers shall run along and be secured to walls, columns etc. Where desired by the Engineer these may have to be installed in chases cut in the structure.

All pipes shall be well secured and supported by adequately strong brackets. The brackets may be wrought iron clevis type, split ring type or perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer blocks shall be provided against the vertical surface to which the pipe is fixed.

All bends and junctions shall be supplied with watertight cleanouts.

Roof and floor drains and yard gullies shall be installed, if required, by cutting into the structure and grouted with 1:2:4 cement concrete. All gutters shall be provided with removable gratings.

All horizontal pipes shall have a minimum fall of 1 in 100.

2.01.01 **Unplasticized Polyvinyl Chloride (UPVC) Pipes**

The specification covers requirements for plain and socket end unplasticised polyvinyl chloride (UPVC) pipes with nominal outside diameters 40 mm to 160 mm for use for soil and waste discharge system inside buildings including ventilating and rain water applications. In this specification nominal outside diameter DN of pipes are 40, 50, 63, 75, 90,110,125,140 and 160 mm.

Surface colour of the pipes shall be dark shed of grey. For other details and specifications refer code IS: 13592-1992 (amended to 1995)

Above quality of pipes are divided into two types. Type –A (IS 13592) meant for rain water pipes & Type- B meant for soil pipes.

Colour of Pipe

Surface colour of the pipes shall be dark shade of grey or as specified.

Marking

Each pipe shall be clearly and indelibly marked with the following information at intervals not more than 3 meters.

a) Manufacturer’s name or trade mark.

b) Nominal outside dia of pipe.

c) Type ‘A’

d) Batch number.

Dimensions

Diameter and Wall Thickness : Mean outside diameter, outside diameter at any point and wall thickness for type-A or type-B manufactured plain or with socket shall be as given in Table-1 of IS 13592.

UPVC rain water/ soil pipe shall of the dia, specified in the description of the item and shall be in nominal lengths of 2, 3, 4 or 6 metres either plain or with sliding/grooved socket unless shorter lengths are required at junctions with fittings. Tolerance on specified length shall be + 10mm and – 0 mm.

Fixing and Jointing

Pipes shall be secured to the walls at all joints with PVC Pipes clips by means of 50 x50x50 mm hard wood plugs, screwed with M.S. screws of required length i/e cutting brick work and fixing in cement mortar 1:4 (1 cement : 4 coarse sand). The clips shall be kept about 25 mm clear off finished face of wall, so as to facilitate cleaning of pipes. Pipes shall be fixed perfectly vertical or to the lines as directed. The pipes shall be fitted to fittings with seal ring conforming to IS 5382 allowing 10 mm gap for thermal expansion.

Installation in Wall/ Concrete

The walls/concrete slots should allow for a stress free installation. Pipes and fittings to be inserted in to the slots without a cement base have to be applied first with a thin coat of PVC solvent cement followed by sprinkling of dry sand (medium size). Allow it to dry. The process gives a sound base for cement fixation. This process is repeated while joining PVC material to CI/AC materials.

Fittings

Fittings used shall be of the same make as that of the PVC pipes injection moulded or fabricated by the manufacturer and shall have a minimum wall thickness of 302 mm. The fittings shall be supplied with grooved socketted ends with square grooves and provided with Rubber Gasket conforming to IS 5382. The plain ends of the fittings should be chamfered. The fittings shall be joined with the help of Rubber lubricant. The details of fittings refer IS 13592.

Measurements

The fittings shall be measured by numbers. The pipes shall be measured net when fixed correct to a cm. including or excluding all fittings along its length as stated/described in the BOQ.

2.01.02 **Cement concrete pipes (with and without Reinforcement) (Light Duty, Non-Pressure)**

The pipes shall be with or without reinforcement as required and shall be of class not less than NP2. These shall conform to IS: 458. The reinforced cement concrete pipes shall be manufactured by centrifugal (or spun) process while un-reinforced cement concrete pipes by spun or pressure process. All pipes shall be true to shape, straight, perfectly sound and free from cracks and flaws. The external and internal surface of the pipes shall be smooth and hard. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

Concrete used for the manufacture of reinforced concrete pipes and collars shall not be leaner than 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate). The maximum size of aggregate should not exceed one third of the thickness of the pipe or 20 mm whichever is smaller. The reinforcement in the reinforced concrete pipes shall extend throughout the length of the pipe. The circumferential and longitudinal reinforcements shall be adequate to withstand the specified hydrostatic pressure and further bending stresses due to the weight of water when running full across a span equal to the length of pipe plus three times its own weight.

2.01.03 **Cast Iron (Centrifugally cast) Pipes and Specials**

The spun iron pipes shall conform to IS 1536. The spun iron pipes shall be cast iron cast centrifugally and vary in diameters from 80 mm to 750 mm. These shall be of class LA, class A and class B, as specified. Pipes shall be tested hydrostatically at the pressure specified in the IS Code.

Specials : The special shall conform to IS 1538. The hydraulic test pressure of each class shall be as detailed mentioned in the IS Code.

2.01.04 **Pipes-Galvanised Iron**

The pipes (tubes) shall be galvanized mild steel hot finished seamless (HFS) or welded (ERW) HIRW or HFW screwed and socketted conforming to the requirements to IS 1239 Part – I for medium grade. They shall be of the diameter (nominal bore) specified in the description of the item, the sockets shall be designated by the respective nominal bores of the pipes for which they are intended.

Galvanising shall conform to IS 4736 : The zinc coating shall be uniform adherent, reasonably smooth and free from such imperfections as flux, ash and dross inclusions, bare batches, black spots, pimples, lumping runs, rust stains, bulky white deposits and blisters. The pipes and sockets shall be clearly finished, well galvanized in and out and free from cracks, surface flaws laminations and other defects. All screw threads shall be cleaned and well cut. The ends shall be cut clearly and square with the axis of the tube.

All screwed tubes and sockets shall have pipe threads conforming to the requirements of IS 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

All tubes shall withstand a test pressure of 50 kg/sq.cm without showing defects of any kind.

Fittings : The fittings shall be of mild steel tubular or wrought steel fittings conforming to IS 1239 (Part-2) or as specified. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended.

2.02.00 **Gutters**

The gutters shall be made of G.I. or A.C. All gutters shall be supplied by reputable specialized firms. Each section shall be sufficiently rigid, edges and corners straight and the slopes perfectly uniform. G.I. gutters shall have the edges strengthened by suitable means.

Unless noted otherwise the gutters shall have a minimum fall of 1 in 120. Adequate number of string supports shall be provided so that there is no reflection even when the gutter is full. Each joint must have a support. Unless otherwise specified the supports shall be fabricated M.S. brackets. All junctions shall be thoroughly watertight. The joints may be made by rivetting, bolting or soldering. All joints between successive lengths of gutters shall have on overlap of at least 5 cm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed watertight. Junction with rainwater down comers shall be made fully watertight and secured.

2.03.01 **Gradients**

If not specified the minimum gradients of soil and drainage pipe line shall be as follows :

100 mm nominal dia	:	1 in 35
150 mm nominal dia	:	1 in 65
230 mm nominal dia	:	1 in 120
300 mm nominal dia	:	1 in 200

2.03.02 **Relation with water supply pipe lines**

Unless specifically cleared by the Engineer, under no circumstances shall special drainage and soil pipes be allowed to come close to water supply pipelines.

2.03.03 **Laying**

Each separate pipe shall be individually set for line and for level. Where lengths of sewer or drain pipes are laid in trench, properly painted sight rails shall be fixed across the trench at a height, equal to length of the boning rod to be used, above the required invert level of the drain or sewer at the point where the sight is fixed. More sight rails shall be required at manholes, change of gradient and intermediate positions if the distance for sighting is more than 50 ft. apart. The excavation shall be boned in at least once in every 6 ft. The foot of the boning rod shall be set on a block of wood of the exact, thickness of the wall of the pipe. Each pipe shall be separately and accurately boned between sight rails.

2.03.04 **Support and Protection on Pipelines**

All pipes shall be laid with sockets leading uphill. Preferably the pipe shall rest on solid and even foundations for the full length of the barrel. However, the pipe manufacturer's instruction as approved by the Engineer shall be followed in the matter of support and jointing.

To achieve full and continuous support, concrete for bedding and packing is the best. Where pipes are not bedded on concrete, the floor shall be left slightly high and carefully placed so that the pipe barrels rest on undisturbed ground. If anywhere the excavation has been carried too low packing shall be done in concrete. Where laid on rock or very hard ground which cannot be easily excavated to a smooth surface, the pipes shall be laid on a cradle of fine concrete floor of gravel and crushed stone over laid with concrete or on a well consolidated gravel and crushed stone bed as desired by the Engineer. PVC or similar pipes shall be laid directly on stable soil and packed with selected soil.

The minimum support and protection for glazed stoneware pipes shall be as follows:

a) When cover is less than 2 metre below ground level and where pipes are unavoidably exposed above ground surface, the pipes shall be completely encased or surrounded with concrete.

b) Where pipes are laid on soft soil with the maximum water table laying at the invert of the pipe, the sewer shall be bedded on concrete.

c) Where the pipes have to be laid on soft soil with the maximum water table rising above the invert of the pipe, but below the top of the barrel, the pipe sewer shall be hunched.

d) Where maximum water table is likely to rise above the top of the barrel or wherever the pipe is laid on soft soil the pipe sewers shall be completely encased or surrounded with concrete.

Vitrified clay pipes shall be laid on a bed of 150 mm thick cement concrete (1:3:6) nominal mix by volume.

Cast iron pipes and concrete pipes may be supported on suitable concrete or brick support, where specified. The supports shall be unyielding and strong enough. At least one support shall be located close to ends. Spacing of intermediate supports shall be as decided by the Engineer. Pipes shall be secured to the supports by approved means.

Anchoring of pipes where necessary shall be achieved by suitable concrete encasing designed for the expected thrust.

Laying Of Cement Concrete Pipes : Loading, transporting and unloading of concrete pipes shall be done with care. Handling shall be such as to avoid impact. Gradual unloading by inclined plane or by chain pulley block is recommended. All pipe sections and connections shall be inspected carefully before being laid. Broken or defective pipes or connections shall not be used. Pipes shall be lowered into the trenches carefully. Mechanical appliances may be used. Pipes shall be laid true to line and grade as specified. Laying of pipes shall proceed upgrade of a slope.

If the pipes have spigot and socket joints, the socket ends shall face upstream. In the case of pipes with joints to be made with loose collars, the collars shall be slipped on before the next pipe is laid. Adequate and proper expansion joints shall be provided where directed.

In case where foundation conditions are unusual such as in the proximity of trees or holes, under existing or proposed tracks manholes etc. the pipe shall be encased all-around in 15 cm thick cement concrete 1:5:10 (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size) or compacted sand or gravel.

In cases where the natural foundation is inadequate the pipes shall be laid either in concrete cradle supported on proper foundations or on any other suitably designed structure. If a concrete cradle bedding is used the depth of concrete below the bottom of the pipe shall be at least 1/4th of the internal dia of the pipe subject to the min. of 10 cm and a maximum of 30 cm. The concrete shall extend up to the sides of the pipe at least to a distance of 1/4th of the outside diameter of pipes 300 mm and over a dia. The pipe shall be laid in this concrete bedding before the concrete has set.

2.03.05 **Entry into structures**

For entry of the pipe lines into any building of structure suitable conduits under the structure or sleeves shall be used. The conduits and sleeves shall be such as to allow easy repairs and replacement of the pipes. When openings or chases are required to be made in the structure for entry of pipe lines, locations and sizes shall be marked and checked by the Engineer. After laying of the pipeline the openings and chases shall be mended.

2.03.06 **Ducts**

Where solid, waste and ventilating pipes are accommodated in ducts, access to cleaning areas shall be provided. Connection to drain shall be through a gully with sealed cover to guard against ingress of sewer gas, vermin or backflow.

2.03.07 **Traps and Ventilating Pipes**

Pipes are carrying off the waste from water closets and waste water and overflow water from baths, wash basins, sinks to drains shall be trapped immediately beneath such fixtures. Traps shall have minimum water seal of 50 mm and shall be ventilated whenever such ventilation is necessary to maintain water seal of the trap.

Ventilating pipes shall be carried up vertically from the drain to a height of at least 600 mm above the outer covering of the roof of the building or as shown on drawings. All vertical ventilating, anti-siphonage and similar pipe shall be covered on top with a cowl. The cowl shall be made of C.I. unless desired otherwise by the Engineer.

2.03.08 **Manhole and Inspection Chambers**

The maximum distance between manholes shall be 30 meter unless specially permitted otherwise. In addition, at every change of alignment gradient or diameter there shall be a manhole or inspection chamber. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 metres unless desired otherwise.

Manhole shall be constructed so as to be watertight under test. The bending at the sides shall be carried out in such a manner as to provide no lodgment for any splashing in case of accidental flashing of the chamber. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement, sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow.

Connecting to existing sewer lines shall be through a manhole.

Manholes shall be provided with standard C.I. covers. The covers shall be close fittings so as to prevent gases from coming out. Suitable heavy duty covers shall be used where necessary as decided by the Engineer.

2.03.09 **Cutting of Pipes**

Manufacturer's instructions shall be followed for cutting of pipes where necessary. Suitable and approved tools shall be used for the cutting so as to leave surface clean and square to the axis of the pipe.

2.03.10 **Jointing**

Jointing of laid pipes shall be so planned as to avoid completely any movement or strain to the joints already made. If any joint is suspected to be damaged it shall be opened out and redone.

All joints between pipes, pipes and fittings and manholes shall be gas-tight when above ground and water-tight when underground. Method of jointing shall be as per instructions of the pipe and fittings manufacturer and as approved by the Engineer. However, in the absence of any instruction available from the manufacturer the methods as detailed hereunder shall be used.

a) **Cast Iron Pipes**

Socket and spigot pipes shall be jointed by the cast lead joints. The spigot shall be centered in the socket of the next pipe by tightly caulking in sufficient turns of tarred gasket or hemp yarn to have unfilled half the depth of socket. When the gasket or hemp yarn has been caulked tightly a jointing shall be placed round the barrel and tightened against the face of the socket to prevent airlock. Molten lead shall then be poured in to fill the remainder of the socket and caulked with suitable tools right round the joint to make up for shrinkage of the molten metal on cooling and shall be finished 3 mm behind the socket face.

Joints in cast iron pipes with special jointing arrangements like 'Tyton' joints etc. shall follow the instructions of the manufactures.

In special cases if flanged joints are accepted by the Engineer the joints shall be made leak proof by inserting approved type of rubber gaskets. The bolts shall be secured in stages to avoid uneven strain.

b) **Concrete Pipes**

Care shall be taken to place the collar centrally over the joint.

c) **Glazed Stoneware Pipes**

Tarred gasket or hemp yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be placed into the socket of the pipe previously laid. The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly so as not to fill more than 1/4 of the total depth of the socket. The remainder of the socket shall be filled with a stiff mixture of cement mortar of 1:1 proportion. Then the socket is filled, a fillet shall be formed round the joint with a trowel, forming an angle of 45 deg. with the barrel of the pipe. The newly made joints shall be protected, until set and shall be covered with damp cloth or other suitable materials.

d) **Vitrified clay pipes**

These shall be made from refractory clay mixed with crushed pottery and stone and burnt at a high temperature. These shall be hard, compact and glazed to make them acid resistant and impervious, and shall be obtained from approved manufacturer.

Special care shall be taken in handling these pipes. The pipes shall not be jointed until the earth has been partly refilled over the portion of the pipe between the joint holes. Before laying the second pipe, the socket of the first pipe laid shall be thinly painted all round on the inside with cement slurry (1 part of cement and 2 parts of clean, sharp sand). A ring of rope yarn (closely twisted hemp or jute) dipped in neat cement paste or tar or bitumen, shall be inserted in the socket of pipe and driven home with caulking tools. The rope shall fully encircle the spigot with a slight overlap and shall not occupy more than one-fourth of the total depth of the socket. Where the spigot end of the pipe is made for receiving the gasket, Specification for Building it shall be wrapped with two or three turns of tarred spun, as close to the end as possible, before inserting into the socket. The joint shall then be completely filled with cement mortar (1:1) which shall have very little water and levelled to form a splayed fillet at an angle of 45 degrees with the outside pipe. Special care shall be taken so that any excess mortar etc. left inside the pipe joints is neatly cleaned off immediately after each joint is made. A semi-circular wooden scrapper or a rubber disc to which a long handle is fixed could be used for this purpose.

e) **Lead Pipes**

The joints in lead pipes shall be made as wiped solder joint. The minimum and the maximum length of the wiped solder joints shall be 8 cm. and 9 cm. respectively. The solders shall generally consist of two parts of lead and one part of tin.

f) **Polyethylene Pipes**

The joints shall be thermo-welded or bolted as per manufacturer's instructions.

g) **Jointing Cast Iron Pipes with Stoneware Pipes**

Where any cast iron soil pipe, ventilating pipe or trap is connected with a stoneware or semi-vitrified waste pipe or drain communicating with a sewer, the beaded spigot end of such cast iron soil pipe, waste or ventilating pipe or trap shall be inserted into a socket of such stoneware pipe or drain and the joint made with mortar consisting of one part of cement and one part of clean sharp sand after placing a ratted gasket or hemp yarn soaked in neat cement slurry round the joint and inserted in it by means of a caulking tool.

h) **Jointing Stoneware with Cast Iron Pipes**

Where any water closet pan or earth ware trap connected to such a pan is to be jointed with a cast iron soil pipe, the joint between the stoneware spigot and the cast iron socket shall always be of a flexible nature. Such joint shall be made with a mixture of bitumen and chopped asbestos fiber.

2.04.00 **Trenches and other excavations**

Width of the trench at the bottom shall be such as to provide 200 mm clearance on either side of the pipe for facility of laying and jointing.

Excavated material shall be stacked sufficiently away from the edge of the trench and the side of the spoil bank shall not be allowed to endanger the stability of the excavation. Spoil may be carted away and used for filling the trench behind the work.

Turf, top soil or other surface material shall be set aside, turf being carefully rolled and stacked for use in reinstatement.

All excavation shall be properly timbered, where necessary.

Efficient arrangements for dewatering during excavation and keeping it dry till backfilling shall be made to the satisfaction of the Engineer. Sumps for dewatering shall be located away from the pipe layout.

Where the excavation proceeds through roads necessary permissions shall be secured by the Contractors from the appropriate authorities.

Special care shall be taken not to damage underground services, cables etc. These when exposed shall be kept adequately supported till the trench is backfilled.

The backfilling shall be done only after the pipeline has been tested and approved by the Engineer. Special care shall be taken under and sides of the pipe during hand packing with selected material. At least 300 mm over the pipe shall also be filled with soft earth or sand. Consolidation shall be done in 150 mm layers. The surface water shall be prevented from getting into the filled up trench. Traffic shall not be inconvenienced by heaping up unduly the backfilling material to compensate future settlement. All future settlements shall be made good regularly to minimise inconvenience of traffic where applicable.

2.05.00 **Fixtures**

The Tenderer shall mention in his bid the type and make of the fixtures he intends to use enclosing manufacturer's current catalogues. In the absence of any such agreement, the Engineer shall be at liberty to choose any type and make.

All fixtures and fittings shall be of approved quality and type manufactured by well known manufacturers. All items brought to the site must bear identification marks of the type of the manufacturer. Procurements shall be made well in advance and inspected and approved immediately by the Engineer. All fixtures shall be adequately protected, covered and plugged till handed over.

All fittings, gratings, fasteners, unless specified otherwise, shall be chromium plated. The connecting lead pipes and bends shall weigh at least 3 kg. per 25 mm dia per meter length. Where PVC or similar pipes are allowed the Contractor shall produce the test reports and convince the Engineer about their durability.

Unless specified in the contract the fixtures shall be as specified hereinafter.

2.05.01 **Water closet**

a) **Raised type**

It shall include glazed vitreous china basin with siphon, open front solid plastic seat and plastic cover, low level glazed stoneware flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. Colour of basin, cistern, seat and cover shall be as desired by the Engineer.

b) **Squatting type**

It shall include glazed vitreous china pan with foot rests and high level cast iron flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. The foot rests shall be made of white glazed vitreous china with chequered surface. The flushing cistern shall be painted as desired by the Engineer.

2.05.02 **Urinals**

It shall consist of wall type glazed vitreous china urinals, cast iron automatic flushing cistern complete with supply connections, flush pipe, lead pipes, gratings, traps and all other necessary fittings. Automatic flushing shall be approximately once every five minutes. For a number of urinals located together may be served by one cistern of adequate capacity. All fittings shall be chrome plated.

2.05.03 **Wash basin**

It shall be made of glazed vitreous china. The basin shall be flat back, wall hung by painted cast iron brackets and complete with pattern with hot and cold brass faucets with nylon washers, waste chain, waste washers, lead waste pipes with traps, perforated waste complete with necessary fittings. All fittings including faucets shall be chromium plated.

2.05.04 **Sink**

It shall be made of glazed stoneware. It shall be wall hung by painted cast iron brackets and complete with one brass faucet with nylon washers, waste chain, waste washers, lead waste pipes with traps, perforated waste with necessary fittings. All fittings including faucets shall be chromium plated.

2.05.05 **Bathroom mirror**

It shall be made of the best quality 6 mm thick glass and produced by a reputed mirror manufacturer. It shall be wall mounted with adjustable revolving brackets. The brackets, screws and other fittings shall be chromium plated.

2.05.06 **Glass shelves**

Glass shelves shall consist of 6 mm thick clear glass with guard rails and shall be wall mounted with brackets. All brackets, guard rails and screws shall be chromium plated.

2.05.07 **Towel rail**

Towel rails shall be 20 mm dia chromium plated MS pipes wall mounted with steel brackets. The brackets, screws etc. shall also be chromium plated.

2.05.08 **Soap holder**

It shall be made of chromium plated strong members. The holders shall be wall mounted with chromium plated screws.

2.05.09 **Liquid soap dispenser**

It shall be round and easily revolving with removable threaded nozzle. The body, bracket for wall mounting and screws shall be chromium plated.

2.05.10 **Toilet roll holder**

It shall be made of glazed vitreous china with suitable cover cum cutter. Wall mounting screws shall be chromium plated.

2.05.11 **Installation**

All plumbing fittings and fixtures shall be installed in most workmanlike manner by skilled workers. These shall be perfect in level, plumb, plane, location and symmetry. All items shall be securely anchored to walls and floors. All cuttings in walls and floors shall be made good by the Contractor.

2.06.00 **Septic tank & effluent disposal**

2.06.01 **Septic tank**

Septic tank shall consist of the tank itself with inlet and outlets there from complete with all necessary earthwork and backfilling. The details of septic tank shall be as shown on drawings. This item shall also include ventilating pipe of at least 100 mm dia. Whose top shall be provided with a suitable mosquito proof wire mesh and cowl, Ventilating pipe shall extend to a height of about 2 meter when the septic tank is at least 15 meter away from the nearest building and to a height of 2 meter above the top of building when it is located closer than 15 meter. Ventilating pipes can be connected to the normal soil ventilating system of the building where allowed.

2.06.02 **Effluent Disposal**

The effluent from the septic tank shall be disposed by allowing it into an open channel or a body of water if the concerned authority approves or into a soak pit for absorption by soil or shall be allowed to be absorbed by soil through open jointed SW pipes laid in a trench filled with broken bricks.

2.06.03 **Soak pit**

The soak pit shall be complete as shown on drawing. It shall consist of a 900 mm dia. pit 1000 mm in depth below the invert level of the inlet pipe. The pit shall be lined with stone, brick or concrete blocks set in cement mortar (1:6) and filled with brick bats. Inlet pipe shall be taken down to a depth of 900 mm from the top as an anti-mosquito measure.

2.06.04 **Open joined SW Pipe / dispersion trenches**

Minimum dia. of the SW pipes shall be 150 mm nominal. The trench for laying the pipes shall be minimum 600 x 600 mm pipes. The joints of the pipes shall be left unsealed. The entire length of the pipe within the trench shall be buried in a 250 mm layer gravel or crushed stone of uniform size. On top of gravel/crushed stone layer is a 150 mm bed of well graded coarse aggregate. Ordinary soil is used for filling the top of trench.

2.06.05 **Commissioning septic tank**

After the septic tank has been proved watertight and the sewage system is checked the tank shall be filled with water to its outlet level before the sewage is let into the tank. It shall be seeded with well digested sludge obtained from septic tank or sludge digestion tank. In the absence of digested sludge a small quantity of decaying organic matter such as digested cow-dung may be introduced.

3.00.00 **TESTING AND ACCEPTANCE**

3.01.00 **Inspection before installation**

All pipes, fittings and fixtures shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes shall again be inspected on site before laying by sounding to disclose cracks. All defective items shall be clearly marked and forthwith removed from the site.

3.02.00 **Testing of Pipelines**

Comprehensive tests of all pipe lines shall be made by simulating conditions of use. The method of actual tests shall be decided by the Engineer. All test data shall be recorded and submitted to the Engineer for review and instruction. The Engineer's discretion regarding tolerance shall be final.

General guidance for the tests are given below :

a) **Smoke test**

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be approved gastight by a smoke test conducted under a pressure of 25 mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tar paper or similar material in the combustion chamber of a smoke machine. Chemical smokes are not satisfactory.

b) **Water test**

For pipes other than Cast Iron

Glazed ware and concrete pipes shall be subjected to a test pressure of at least 1.5 m head of water at the highest point of the section under tests. The tolerance figure of two litres per centimeter of diameter per kilometer may be allowed during a period of 10 (ten) minutes. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of the vertical pipe jointed to it so as to provide the required test head or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of test water may due to one or more of the following cases :

a) Absorption by pipes and joints

b) Sweating of pipes or joints

c) Leakage at joints or from defective pipes

d) Trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased and after which the test proper should commence. Any leakage and the defective part of the work shall be cut out and made good.

For cast iron pipes

Cast iron sewers and drains shall be tested as for glazed ware and concrete pipes. The drain plug shall be suitably strutted to prevent their being forced out of the pipe during the test.

c) **For straightness**

i) By inserting at the high end of the sewer or drain a smooth ball of a diameter 13 mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball with roll down the invert of the pipe end emerge at the lower end; and

ii) By means of a mirror at one end of the line and lamp at the other. If the pipe line is straight, the full circle of light may be observed. The mirror will also indicate obstruction in the barrel if the pipe line is not straight.

3.03.00 **Testing Septic Tank**

The septic tank shall be tested for water tightness. It shall be filled up with water and allowed to soak for 24 hours. Then, it shall be topped up and allowed to stand again for 24 hours and loss of level recorded. The fall shall not be more than 15 mm.

3.04.00 **Fixtures etc.**

All fixtures and fittings shall be connected by watertight joints. No dripping shall be accepted.

4.00.00 **RATES**

Rates shall be unit rates for the complete work as detailed out in the Specification unless any particular portion is specifically excluded in the Schedule of Items.

If any material fittings or fixtures are provided by the Owner free, the Contractor shall have to take delivery, keep in safe custody and be responsible till fitted and handed over.

5.00.00 **MEASUREMENT**

For method of measurement regarding work under scope of this Specification IS: 1200 (Part-XVI) shall be followed unless contrary to the following:

5.01.00 **Trenches**

Unless particular items are included in the Schedule, no separate measurement shall be made for lead, lift, dewatering, dressing, storing, backfilling consolidation etc. that may be required in this connection.

5.02.00 **Concrete, masonry**

Unless lumped with other items in the Schedule the measurement shall be on gross area or volume basis as mentioned under relevant items.

5.03.00 **Pipe work**

No separate measurement shall be made for special supports and fixtures, cutting chases, holes and rectification unless specially indicated in the Schedule of Items. If the specials are separately indicated in the Schedule, the measurement for these shall be over and above the measurement, of the pipe work as mentioned below:

The pipes of different nominal bores shall be measured separately. The pipe work shall be measured in length inclusive of sockets specials, fittings etc. in position.

5.04.00 **Fittings and fixtures**

Measurement for fittings and fixtures where applicable shall be in number for the complete item inclusive of anchors, brackets and fasteners required. However, in special cases anchors, brackets and similar items may be measured separately if included as such in the Schedule of Items.

5.05.00 **Chases and holes**

No measurement shall be made for cutting chases, holes etc. and making good for any work within the scope of this specification and shall be inclusive.

5.06.00 **Painting**

All items likely to rust shall be painted with one coat of primer which shall not be measured separately. Where finishing coat of paints are supplied that shall be measured as indicated in the Schedule of Items. Usually, painting of pipes shall be measured in length for each different nominal diameter without giving any extra allowance for specials sockets, etc.

5.07.00 **Septic tank, Soak pit**

Usually it shall be measured in number for the complete septic tank or soak pit as per drawing. All earthwork, backfilling masonry, concrete, manhole, pipes and fittings included. In case, it is intended to pay for individual items the same shall be indicated in the Schedule and measured in number, length, area or volume as appropriate.

6.00.00 **CODES AND STANDARDS**

Some of the important Codes and Standards relevant to this specification shall be followed: Latest editions shall always be consulted.

IS: 1172 - Code of basic requirements for water supply drainage and sanitation.

IS: 1200 - Laying of water and sewer lines including appurtenant (Pt. XVI) items.

IS: 1239 - Mild Steel Tubes and Mild Steel Tubular and other (Pt.I & II) wrought steel pipe fittings.

IS: 1536 - Centrifugally cast (Spun) iron pressure pipes for water gas and sewage.

IS: 1537 - Vertically cast iron pressure pipe for water, gas & sewage.

IS: 3486 - Cast Iron spigot & socket drain pipes.

IS: 1742 - Code of Practice for building drainage.

IS: 5329 - Code of Practice for sanitary pipe work above ground for buildings.

IS: 2470 - Code of Practice for designs and construction of septic tank for small and large installations.

IS: 3076 - Low density polythelene pipes for potable water supplies.

IS: 4984 - High density polythelene pipes for potable water supplies.

IS: 1537 - Vertically cast iron pressure pipes for water, gas and sewage.

IS: 1538 - Cast Iron fittings for pressure pipes for water, gas & sewage.

IS: 1230 - Cast Iron rain water pipes and fittings.

IS: 3889 - Centrifugally cast (spun) iron spigot & socket soil waste and ventilating pipes, fittings and accessories.

IS: 1729 - Sand cast iron spigot & socket soil, waste and ventilating pipes and accessories.

IS: 1626 - Asbestos cement building pipes, gutters and fittings (spigot & socket types).

IS: 458 - Concrete pipes (with and without reinforcement)

IS: 783 - Code of Practice for laying of concrete pipes.

IS: 784 - Prestressed concrete pipes.

IS: 651 - Salt glazed stoneware pipes & fittings.

IS: 4127 - Code of practice for laying of glazed stoneware pipes.

IS: 1726 - Cast Iron manhole covers and frames intended for use in drainage works.

IS: 5961 - Cast Iron gratings for drainage purposes.

IS: 5219 (Part 1) - 'P' & 'S' traps.

IS: 771 - Glazed earthen-ware sanitary appliance.

IS: 772 - General requirements of enamelled cast iron sanitary appliances.

IS: 774 - Flushing cistern for water closets & urinals (valve less siphonic type).

IS: 775 - Cast Iron brackets & supports for wash basins and sinks.

IS: 2548 - Plastic water closet seats & covers.

IS: 2527 - Code of Practice for fixing rain water gutters and down-pipes for roof drainage.

IS: 1703 - Water fittings- copper alloy float valves (horizontal plunger type) - Specification.

IS: 1795 - Specification for pillar taps for water supply purpose.

IS: 2556 (Part-1, Part-2, Part-3, Part-4, Part-5, Part-6, Part-7, Part-14, and Part-15)

- Part-1: General requirements
- Part-2: Specific requirements of wash-down water closets.
- Part-3: Specific squatting pans.
- Part-4: Specific requirements of wash basins.
- Part-5: Specific requirements of laboratory sinks.
- Part-6: Specific requirements of Urinal & Partition plates.
- Part-7: Specific requirements of accessories for sanitary
- Part-14: Specific requirements of integrated squatting pans.
- Part-15: Specific requirements of universal water closets.

IS: 3989 - Specification for centrifugally cast 9spun) iron spigot and Socket soil, waste and ventilating pipes fittings and accessories.

IS: 4827 - Specification for electroplated coating of nickel and chromium on copper and copper alloys.

IS: 4985 - Unplasticised P.V.C pipes for potable water supply-Specifications.

IS: 4127 - Code of Practice for Laying of Glazed Stone Ware Pipes.

IS: 4885 - Specifications for Sewer Bricks.

IS: 12592 - Pre-cast Concrete Manhole Covers and Frames – Specifications.

VOLUME : VII-D

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER (NDCT)

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TECHNICAL SPECIFICATION FOR NATURAL DRAFT COOLING TOWER

1.00.00 INTENT OF SPECIFICATION

1.01.00 This specification is intended to cover supply and installation of One (1) no. of Natural Draft Cooling Tower (NDCT) as detailed hereinafter for 1 x 800 MW Kothagudem Thermal Power Station (KTPS), Stage-VII, Unit-12 for Andhra Pradesh Power Generation Corporation Ltd. (APGENCO) at Kothagudem, Andhra Pradesh.

1.02.00 The scope shall include design, engineering, construction of natural draft reinforced concrete hyperbolic cooling tower including all manufacture, assembly/ pre-assembly, tests at manufacturer's works, shop painting, seaworthy packing, complete with all accessories, auxiliaries as specified hereinafter and as required for safe and trouble free continuous commercial operation.

1.03.00 The scope of this specification also includes but not limited to erection/installation, supervision, including unloading, storage and handling at site, site testing, commissioning, trial run, performance and guarantee tests, training of operating personnel, O&M of the plant till commencement of commercial operation and other erection services to ensure trouble free operation and commissioning of the plant

1.04.00 It is not intended to specify completely herein, all details of design and construction of equipments. However, the equipment shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous commercial operation up to the vendor’s guarantee in a manner acceptable to the purchaser, who will interpret the meaning of drawings and specifications and shall be entitled to reject any work of material which in his judgment is not in full accordance therewith.

1.05.00 The provisions of this technical specification are general in nature and cover broad aspects. Technical specification outlines the minimum requirements. However, it would be absolute responsibility of the bidder to collect, interpret, analyze all necessary information / data for the successful design and construction of the cooling tower. Structural safety and successful operation of the tower shall be the total responsibility of the bidder notwithstanding the approval of the owner.

2.00.00 CODES AND STANDARDS

2.01.00 The design, construction, manufacture, performance, testing and commissioning of the cooling tower as specified hereinafter shall comply with the requirements of all applicable latest Indian/British/American Standards and Codes of Practice. The latest editions of the following standards and publications shall be followed in particular:

2.01.01 BS 4485 Water Cooling Tower (Part 1 thru' 4)

2.01.02 Cooling Tower Institute of USA, Bulletin ATC-105: "Acceptance Test Procedure for Water Cooling Tower."

2.01.03 PTC-23: ASME Performance Test Code for Atmospheric Water Cooling Equipment.

2.01.04 IS: 11504: Criteria for Structural Design of Reinforced Concrete Natural Draught Cooling Towers.

2.01.05 American Society of Testing Materials

2.02.00 The materials of various components such as PVC, plain and reinforced concrete, bars and steel wires for concrete reinforcement etc. shall be in accordance with relevant Indian Standards or else to applicable American Standards.

2.03.00 In case of any contradiction between the aforesaid Standards and stipulations as per this technical specification as specified hereinafter, the stipulations of this technical specification shall prevail.

Also, in case of any contradiction between this technical specification and stipulations of the enclosed "Data Specification Sheets", the stipulations of the Data Specification Sheets will prevail.

3.00.00 GENERAL PERFORMANCE REQUIREMENTS

3.01.00 The cooling tower shall be designed for continuous operation to cool not less than the design flow of water from specified inlet temperature to outlet temperature at a design ambient wet bulb temperature and other design parameters as enumerated in the enclosed Natural Draught Cooling Tower Data Specification Sheets.

3.02.00 The cooling tower shall be designed for continuous operation throughout the year, unless specially stated otherwise in Data Specification Sheet. The guaranteed performance (cold water temperature) shall be achieved at all wind velocities as specified.

3.03.00 The cooling tower shall also give satisfactory performance while handling the specified water during monsoon months, with the range as indicated in Data Specification Sheet.

3.04.00 For arriving at the air properties such as enthalpy, density etc., no correction for altitude shall be considered. All properties shall be taken from the data provided on CTI or BS code corresponding to sea level.

3.05.00 Bidder shall also furnish the following in support of tower design and performance, along with the bid without which the offer is liable for rejection.

3.05.01 Heat balance calculations.

3.05.02 Justification for the outlet air temperature. This could be in the form of operating experience on existing towers or laboratory test on actual fill shape, material and configuration as offered. In the case of laboratory test, Bidder shall indicate correction / scaling factor applied to predict performance of full size tower under field conditions.

3.05.03 Calculations to show the adequacy of tower height to provide the required Draught.

3.05.04 Calculations for tower duty coefficient and performance coefficient.

3.05.05 Sketch showing fill arrangement which should clearly indicate the total depth, horizontal and vertical spacing.

3.06.00 Drift loss of the cooling tower expressed in % of rated capacity shall be limited to as close to zero as possible.

3.07.00 The Bidder shall assume full responsibility in proper design and operating of each and every component of the complete cooling tower as well as the cooling tower as a whole.

4.00.00 **SYSTEM DESCRIPTION**

4.01.00 The natural draught cooling tower will be located inside the plant boundary and will be used for cooling the hot circulating water returning from the condenser and various other heat exchangers. The circulation of water will be maintained by Circulating Water (CW) Pumps and Auxiliary Cooling Water (ACW) pumps located inside C.W. pump house.

4.02.00 The hot circulating water reaching the cooling tower will be raised to the top of the hot water distribution system of the tower. The hot water distribution pipes inside the Tower shall be fitted with spray nozzles to distribute the hot water evenly over the PVC fill located immediately below. The hot water cools by evaporation as it drains through the PVC fill into the cooling tower basin.

4.03.00 The cooled water will be collected in a circular basin located under the cooling tower. The basin shall have a central partition, such that any half of the basin can be cleaned/ repaired while the other half is in use.

4.04.00 Water from the cold water basins will flow through RCC channel to the sump of the C.W. pump house.

4.05.00 The supplier should preferably be in a position to take up maintenance/ overhauling work as and when desired by the Owner during whole life of operation of the plant, on service contract and/or piecemeal basis.

5.00.00 DUTY AND CAPACITY

5.01.00 Cooling tower shall be capable of cooling the total quantity of hot condensate circulating water and auxiliary cooling water, through the specified 'Range' at the design wet bulb temperature and other parameters as per Data sheet. This cooling shall be possible even with the maximum or calm wind conditions. The Cooling tower shall be designed for continuous operation throughout the year.

5.02.00 The basin wall curb level shall be minimum 500 mm above the finished grade floor. The grade level surrounding the cooling tower shall provide for effective storm water drainage away from the tower. Depth of basin from well top shall be suitable for 6 minute storage of rated capacity excluding free board of 300 mm and not less than minimum one (1) metre. Basin slope towards cooling sump shall be 1 in 120.

5.03.00 The bidder shall review the analysis of water in circulation. All materials and components furnished under this specification shall be suitable for continuous and reliable operation of the tower with the water in circulation. Special care must be taken to select and use materials and components, which will not corrode, leach or be subject to organic and inorganic deposits or destructive action leading to subsequent failure or erosion by water droplets or be source of electrolytic corrosion being set-up between components. Any materials or components, found inadequate for the service during the first 12 months, after commissioning will have to be replaced at site with suitable material of construction in all towers without any additional cost to the Owner at a time when unit is under shut down.

5.04.00 Re-cooled water from tower basin will be conveyed through a concrete channel to the circulating water sump for recirculation. Hot water will be delivered to the tower through distributing headers. Re-cooled water from tower shall be thoroughly mixed to ensure temperature equalization prior to entering the channel leading to the pumps.

6.00.00 SCOPE OF SUPPLY AND WORKS

The following Equipment shall be supplied under this specification.

6.01.00 General

- Thermal, mechanical and structural design of cooling tower including all appurtenant civil works.
- Drift eliminators
- Supply at site of all materials and equipment required for construction.
- Construction of cooling tower including all work and services connected herewith.
- Construction of cold water basin, cold water outlet channel/ duct and basin de-sludge arrangement.
- Hot water distribution piping/ducting along with spray nozzle system.
- Supply, shop testing of components and erection of all mechanical equipment, PVC fill, Spray nozzles, etc.
- Complete lightning protection system, aviation obstruction lighting system, earthing including the necessary power distribution arrangement as per technical specification for “Electrical Equipment and Accessories, Vol.V-A & Vol.V-B”.

6.02.00 Detailed Scope of Civil Works

- Excavation and backfilling for columns foundation and substructure below cold water basin level.
- R.C. foundation raft & Cold water Basin, R.C. Shell, R.C. support framework for fill support.
- Hot water distribution duct.

  Painting of concrete surfaces shall be as per Cl. 9.09.00 of volume - VII D.
- Providing and installation of access doors in the shell of cooling tower including the necessary fittings and appliances on Tower Shell. The access doors shall be of heavy duty MS doors duly painted with 3 coats of epoxy paints.

- Main access RC staircase outside the tower up to Hot water Duct top, internal RC walkways and platforms all with necessary galvanized MS pipe handrails.

- Cold water channel outlet into gravity tunnel.

- De-sludging arrangement for each compartment of cold water basin.

- Provision of permanent access ladder up to top of tower manufactured in galvanized mild steel with adequate back-guards and landing platforms. The ladder shall comply with all applicable regulations.

- Provision of peripheral drainage around cooling tower as per Cl. 9.11.00 of volume - VII D

- Necessary site clearing and grading all round the tower in accordance with specifications and drawings.

- Water fill test of cold water basin, cold water outlet channel and tunnel.

- Hydro test of Hot water Duct.

- Supply and erection of all base plates, foundation plates, anchor bolts, sleeves, nuts, fasteners, embedded parts and any other likewise material required for all electrical and mechanical equipment and accessories to complete the work.

- Rock anchors will not be considered for foundations in any case.

- Preparation and supply of all working drawings required for the work:

- Piling, excavation, dewatering, shoring and shuttering, backfilling around under ground structures and disposal of surplus soil outside the plant boundary / to the designated dump yard.

- Any other works not mentioned herein, but sufficiently implied and are necessary for completion and proper functioning of the cooling tower.

6.03.00 **Detailed scope of Mechanical works**

- Hot water distributions spray system of reliable & efficient design, along with its supporting arrangement.

- Hot water duct/pipe work along with supports and anchors.

- Gear operated with chain pulley arrangement isolation valves on hot water inlet piping before hot water distribution system to achieve basin maintenance.

- Painting both inside and outside surfaces of steel pipes with three coats of rust and corrosion resisting paint including thorough cleaning of the surfaces.

- Tower PVC fill, drift eliminators including all required supporting structure and accessories, etc. as necessary.

- Screens along with guides embedded in concrete at each of the cold water outlet channels from the cold water basin.

- Sluice gate with mechanical jack arrangement and guides in each of the cold water outlet channel connection from the cold water basin.

- Manually operated chain pulley blocks, together with the monorails and supporting frames for the handling of screen and gates.

- Cold water outlet duct/tunnel.

- Knife-edge gate valve/sluice valve in each de-sludge connection and also De-sludge piping up to the disposal point at local storm water drain channels.

- Tower Fill Hot water By-Pass Nozzle connections on Hot water duct/ piping for system lines flushing during commissioning.

- Instrument tapping provisions on hot water duct/piping and cold water duct/piping for carrying out flow and temperature measurement during PG test.

6.04.00 **Detailed Scope of Electrical Works**

Refer Volume V-B, Section-XV, Technical Specification for Chimney and Natural Draft Cooling Tower- Electrical works.

6.05.00 Any additional equipment, material, services which are not specifically mentioned here, but are required to make the plant/systems in the scope of the Bidder complete in every respect in accordance with the technical specification and for safe operation and guaranteed performance, shall be deemed to be covered under the scope of this specification.

6.06.00 All accessories and hardwares.

6.07.00 One set of special tools and tackles.

6.08.00 All relevant drawings, data and O&M manuals.

6.09.00 The scope of this specification also includes erection, installation, site testing, commissioning, trial run, performance and guarantee tests, training of operating personnel, O&M of the plant till commencement of commercial operation and other erection services to ensure trouble free operation and commissioning of the Equipment/System.

7.00.00 DESIGN AND CONSTRUCTION

7.01.00 Hot Water Distribution System

7.01.01 The distribution system shall be designed for flexible and satisfactory operation at all reasonable loads.

7.01.02 The hot water distribution shall be suitable for handling an additional 20% flow over the design circulating water flow. The hot water distribution shall be done by two headers, each covering half of cooling tower area so that it can be operated at 50% capacity.

7.01.03 The hot water distribution piping and valves shall be designed for a working pressure as calculated by the Bidder.

7.01.04 The spray system can be either upward or downward maintaining water spray even with shutdown flows.

7.01.05 The sprayers shall be arranged in a uniform pattern with proper distance to produce 10% to 20% overlapping of the individual sprays. This arrangement shall provide extremely even water distribution with uniformly sized droplets entering the fill. The spray overlapping required avoiding dry pockets in the fill due to variations expected in water head availability in main hot water duct.

7.01.06 The spray nozzle shall be reliable and effective in breaking the hot water jet into a spray pattern of uniformly sized droplets. It should be proven and tested design to provide maintenance free service for minimum 3 years.

7.01.07 The fixing arrangement of spray nozzles to hot water distribution header shall be of flanged joint type. Screwed joint shall be avoided as they are likely to get loosened due to flow induced vibrations.

7.01.08 The distribution of water shall be in Ducts / troughs of approved material. The entire water distribution system shall be self-draining and non-clogging type.

7.01.09 The distribution troughs/pipes shall be independently supported from the structures and shall be easily removable. Provision shall also be made for easy flushing or cleaning of all troughs / pipes.

7.01.10 The structural design of the water distribution system shall also consider the following loadings, combined as appropriate.

a) Self weight.

b) Hydraulic pressure during normal operations, including pressure surges.

c) Hydraulic pressures due to mal-operation of tower or supply pumps.

7.01.11 Seismic loading on the water distribution system shall also be considered.

7.01.12 The water distribution system shall be provided with adequate pressure surge relief facilities to prevent pressure loadings 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 pressure level to be considered shall not be less than 1.5 times the design pressure.

7.01.13 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, outlet water temperature and ambient temperature.

7.01.14 If open basin system of distribution is provided, the basin shall be provided with removable type covers made of pre-cast concrete.

7.01.15 Splash boxes in cross flow tower shall be provided at the discharge of each distribution valve to minimize splashing and to facilitate even distribution of water.

7.01.16 The nozzles shall be spaced to give even distribution of water over the entire space occupied by top row of fills.

7.01.17 The nozzles and splash plates shall be made of High Density Polyethylene or approved equal.

7.01.18 The pipes & valves etc. used shall be designed and arranged to take care of the possible thermal stress due to temperature variation. The pipes & fittings shall have extra heavy thickness.

7.01.19 Ready accessibility to the different parts like isolation valves etc. shall be provided and as required necessary platform/walkway and ladder shall be provided for this purpose.

7.02.00 **Louver and Casing**

7.02.01 Louvers shall be designed for air entry to the tower with low velocity for minimum pressure drop and less chance of recirculation of moist air. To eliminate splash out, louvers shall slope to shed water inwards.

7.02.02 The louvers and casing may be made of concrete. Concrete casing wall shall be supported from the basin through reinforced concrete. Hinged access door with platforms shall be provided for entry into the tower at suitable locations.

7.03.00 **Fill**

7.03.01 Cooling tower fill shall be made PVC, V-bar type of approved make.

7.03.02 Minimum weight of fill should be 100 Kg/sqm.

7.03.03 The Bidder shall enclose with his proposal a write-up on the method of replacement of damaged/deteriorated fills during the life of cooling tower. Also Bidder's experience with pre-stressed concrete fills shall be clearly furnished in proposal. Bidder shall also indicate whether these are to be manufactured at shop or at site.

7.03.04 The PVC fill if offered shall be durable and fire retardant quality. The Bidder shall furnish details of PVC fill along with his offer indicating fire retardant properties, ageing effect, vibration caused by water and wind effects. Frequency of replacement of PVC fills and the method of such replacement shall also be mentioned with above details. The PVC fills shall be of proven quality and the make and its properties shall be subject to Purchaser's approval. The Bidder shall furnish with his proposal, a sample of the fill material to be used for the specified cooling tower.

7.03.05 Design and facing of the fills shall be such as to expose high air/water surface with minimum air pressure drop. Air velocity through the fills shall be uniform.

7.04.00 **Fill Supports**

7.04.01 Splash bar type fills shall be supported on the grids at frequent intervals, preferably not exceeding 450 mm, to minimize sag, possibility of dislodgement, and damage to fill materials as a consequence of induced vibration in the fill.

7.04.02 For film type filling, the sheet like fills consisting of multiple vertical surfaces shall be tied with filling support bars by stainless steel or nylon wires. Suitable spacers shall be used to maintain verticality of the sheets.

7.04.03 The fill and the support system shall be sufficiently strong to withstand the

water loading when the flow path is 30% chocked.

7.05.00 **Drift Eliminators**

7.05.01 Zig-Zag path type Multi pass Drift eliminators (minimum two pass) shall be provided so as to limit the drift loss to that specified earlier or as in the Data Specification Sheet.

7.05.02 In case the tower is provided with pre-stressed concrete or PVC fill, drift eliminators may be made up of PVC.

7.05.03 The eliminator frame shall be of rugged construction and shall be firmly secured to arrest vibration.

7.06.00 **Access**

7.06.01 Staircases shall be provided external to the cooling tower along with stairways, landings, walkways, handrails and access doors. Minimum 2 Nos. staircase 1000 mm wide and minimum landing width of 1000 mm at locations as necessary to give safe and convenient access to the top and the interior parts of the tower.

7.06.02 Suitable arrangement for supporting walkways inside the cooling tower shall be made and such arrangement shall be independent of the fill material.

7.06.03 Whether specifically mentioned in the Data Specification Sheet or not, steel components and fittings used in walkways, handrails shall be hot dip galvanized after fabrication.

7.07.00 **Cooling Tower Basin & Outlet Sumps**

7.07.01 The hot water distribution basin and cold water outlet channel of the cooling towers shall be designed by considering a minimum of 10% margin over the design cooling tower flow.

7.07.02 Cooling tower basin, shall be supplied/constructed along with all civil parts, base plates, anchor bolts, nuts, and other accessories, pipe sleeves, inserts, etc. and as required to complete the work in all respects.

7.07.03 The work shall include excavation/back-filling as necessary, all concrete/steel work, cold water outlet sump & sludge pit for each basin, water-proofing and all other works.

7.07.04 The basin shall be partitioned into two individual chambers such that one section can be taken out for maintenance /de-sludging while the other section is in operation.

7.07.05 Sludge pit with isolating valves, and spool pipe shall be provided for individual

basin chambers for connection to drainage pipe.

7.07.06 For each basin chamber, there shall be a cold water outlet sump. In the connection between basin chamber and cold water sump there shall be screen and sluice gate/Butterfly valve.

7.07.07 Each basin chamber shall have overflow arrangement at sludge pit end.

7.07.08 Basin slope towards cooling sump shall be 1 in 120.

7.08.00 **Screens & Isolating Devices in Cold Water Outlet Sumps, Valves and Pipes in Sludge Pits and Accessories**

7.08.01 Screens shall be out of 8 gauge 25 mm clear opening SS wire netting welded to frame of structural steel section/flats. Framework shall be hot dip galvanized and provided with primer and bituminous painting. Two numbers of screens shall be supplied per tower. Lifting lugs or eye bolts shall be provided on top of the screen frame for ease of handling.

7.08.02 For handling screens, one set of monorail with supporting structure and chain pulley hoist complete with lifting chain and push type trolley for mounting the hoist shall be furnished, if asked for in the Data Specification Sheets. The chain pulley hoist shall be manually operated and shall conform to IS: 3832, Class-2.

7.08.03 Sluice gates or Butterfly valves in cold water outlet sumps shall be provided as mentioned in Data Specification Sheet. Sluice gates shall be as per appropriate class of IS: 3042. Butterfly valves shall conform to AWWA C-504 (latest revision).

All mild steel parts shall be galvanized or painted with epoxy enamel primer & paint. The sluice gate may be rectangular or circular as per preference of the Bidder.

The sluice gates/Butterfly valves shall be complete with head-stock for manual operation. The head-stock shall have pillar, base plate and hand wheel made up of cast iron. The head-stock shall have rising/non-rising spindle with position indicator.

7.08.04 The flow area through each gate/valve and screen shall be such as to maintain a flow velocity through them within 1.2 M/sec during the rated flow from cooling tower, with the minimum water level in the cold water basin.

7.08.05 The isolating valves in sludge pits shall conform to appropriate class of IS: 780. Each valve shall be complete with pedestal type manual operator, with rising/non-rising spindle and valve position indicator.

7.08.06 The pipe spools, to be embedded in sludge pit for piping connection, shall be

C.I. pipe as per IS: 1536, Class-LA, unless otherwise mentioned elsewhere.

7.09.00 **Hardware**

All nails and fastening bolts, nuts & washers used in the cooling tower stainless steel, if not specified in the Data Specification Sheet.

8.00.00 **CIVIL AND ALLIED WORKS**

8.01.00 The civil design and construction of the cooling tower shall be in accordance with the following technical specifications and the Data Specification Sheets enclosed with this specification –

a) Earthwork in Excavation and Backfilling.

b) Cement Concrete (Plain and Reinforced).

c) Masonry and Allied work.

d) Finish to Masonry and Concrete.

e) Metal doors, windows, ventilators, louvers etc.

f) Roof water proofing, insulation and allied work.

g) Painting, white washing, polishing etc.

h) Sheet work in roof and siding.

8.02.00 The technical specifications are of general nature. Only those portions of the specifications which relate to the various works required to be done as per the technical requirements as specified in the tender document need to be considered.

8.03.00 The Cooling Tower shell, ring beams, diagonal columns at base supporting the ring beam below shell, cold water basin, fill support frame work, hot water distribution duct, cold water channel, louver etc. shall be cast-in-situ RCC construction.

9.00.00 **CIVIL DESIGN BASIS**

9.01.00 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.

9.01.01 **Dead Load**

For assessing the self weight of the structure, the specific weight of the concrete shall be taken as 2500 kg/m^3. 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 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. In addition, live load on the supporting structure due to maintenance activities related to fills /ducts/distribution system shall be considered.

9.01.02 **Wind Load**

The wind pressure on the tower 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 load 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 would be the responsibility of the contractor to collect necessary meteorological data duly vetted from the recognized govt. agencies/institutions. After collection of necessary meteorological data, most critical wind speed, wind pressure distribution and other necessary parameter shall be determined by the bidder and get the same vetted by the above agency/appropriate agency(s). Then with the help of physical model tests in a

wind tunnel, offering appropriate aerodynamic similitude, the contractor shall obtain the most critical forces, stresses etc. with cooling tower at various levels and locations. Such model test shall also include all adjacent topographical features, buildings, and other structures which are likely to influence the wind load pattern on the tower significantly. 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 contractor shall have requisite experience and should have successfully carried out tests in the past for at least one cooling tower of similar capacity. The model tests shall be duly witnessed and approved by the Owner/consultant. 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. Under the theoretical method, the circumferential net wind pressure distribution and wind pressure coefficient (p1) for the tower shell (without meridional ribs) shall be obtained from the “Criteria for structural design of Reinforced concrete Nature Draft Cooling Towers IS: 11504-1985.

The above circumferential wind pressure coefficient (p1) shall be increased by multiplying it by 1.43 to account for turbulence in the incident wind and load intensification due to turbulence induced by the adjacent cooling tower or the other structures of significant dimensions. Therefore, the actual design circumferential net wind pressure coefficient (p) shall be computed as p=1.43(p1), where (p1) is the wind pressure coefficient as per IS: 11504-1985.Enhancement factor 1.43 is considered to take the interference effect of adjacent structures of significant dimensions into account.10% increment shall be considered for imperfection in construction as per IS:11504.This factor shall be increased further by 10% during foundation design in absence of model test results. If the model is for C/L of shell, wind load shall be appropriately augmented to cater to the increase in diameter of the shell(O.D).

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) shall include 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 net design 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” and as given below.

The wind pressure at a given height [P(z)] shall be computed as per the stipulations of IS: 875 (Part 3)-1987. For computing the design wind pressure at a given height the basic wind speed (Vb) shall be taken as Vb=50m/sec at 10.0 meters height above mean ground level. For computing design wind

speed (Vz) at a height z, the risk co-efficient K1=1.08 shall be considered. For coefficient K2, Terrain category 4 and class 'C' as per table 2 of IS: 875 (Part-3) – 1987 (Latest) shall be considered. Coefficient K3 shall be determined by taking into account nearby plant site and other features of the station & topography. The wind direction for design purposes shall be the one which would induce the worst load conditions. However, coefficient K3 shall not be less than one under any circumstances. The wind pressure at a given height shall be computed theoretically in accordance to the IS Codal position given as under:

$Pz = 0.6\ Vz2\ \ N/m^2$

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)-1987. 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)-1987.

Design of the tower shall satisfy quasi-static method & GEF method. 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 & dynamic effects.

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 of 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.

9.01.03 **Earthquake Forces**

The seismic analysis shall be carried out in accordance with IS:1893 (all latest parts) 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: 456-2000 Clause 6.2.3.1 with an Age Factor of 1.0. 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 reference where the same has been successfully implemented.

9.01.04 **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 12.0^{o}C to 50^{o}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-axi-symmetric 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 also be designed for one sided solar radiation effect. Nevertheless an effective temperature difference of at least 25^{0} C across the shell thickness constant over the height and follow 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.

9.01.05 **Construction 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.

a) Barrowing of concrete

b) Scaffolding and formwork

c) Loads produced by anchoring devices of climbing scaffolds.

d) Hoist fixings

e) Storage of materials on scaffolding

f) Temporary access

g) Tower crane fixings

h) Works temporarily omitted for access purposes.

Any other load such as foundation settlement, etc.

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 unfavourable load combination.

9.01.06 **Load Combinations**

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

a) DL + WL + SL

b) DL + Se L

c) DL + TL

d) DL + WL + TL + SL

e) DL + Se L + TL + SL

f) 1.0 DL + 1.5 WL

g) 0.9 DL +1.5 WL

h) 0.9 DL-1.5WL

Where,

DL = Dead Load
WL = Wind Load
SL = Settlement Load
Se L = 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.

9.01.07 **Permissible Stresses**

For load combination (a) to (e) working stress method shall be done without considering 33% increase in permissible stresses in concrete and reinforcement.

For the load case (f) to (h) the shell of cooling towers shall be checked by limit state method as per IS: 456. The stress in the reinforcement steel shall not exceed 87% of the specific characteristic strength of reinforcement steel and the compressive stress in the concrete shall not exceed 45% of the specified 28 days cube strength of the concrete as per IS: 456.

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.

Permissible stress for steel structures shall be as per IS: 800 based on working stresses.

9.02.00 **Tower Design Consideration**

9.02.01 **General**

- 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 un-cracked, homogenous and isotropic. The design geometric profile, thickness variation and support conditions of shell shall be considered in the structural analysis.

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

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

- 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.

- Boundary conditions shall be realistic and based on actual configuration. The magnitude of the calculated displacements should be within limits of the applied theory.

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

9.02.02 **Size and Shape**

- The base diameter, air intake opening height, tower height and throat diameter shall be determined by thermal design consideration by the contractor 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.

9.02.03 **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.

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 10^{o} plan angle and of not more than 0.05 of the shell height.

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 from BS: 4485 Part-4:1996.

- Buckling of Cooling Tower shell be checked as per Finite Element Analysis using software such as NISA 2, Ansys etc. The factor of safety for snap through buckling shall be more than 5. This requires non linear analysis including simulation of opening in the model. Alternatively, bifurcation buckling factor can be calculated using linear eigen value analysis with modulus of elasticity E=0.8Ec, to account for cracked section, with factor of safety more than 7.

- 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/BS 4485.

- 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. **Opening 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 corner as close as possible. The total cross-sectional area in cm2 of this reinforcement shall be 0.5d, at each corner 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**

The thickness of the shell shall ~~not~~ be minimum 300 mm or more as per design.

E. **Minimum Reinforcement in Shell Spacing and Placement**

- The reinforcement used shall be cold worked steel high strength deformed bars of grade Fe 415/500 conforming to IS: 1786 – latest. All reinforcement steel shall be corrosion resistant steel/HCRM. 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 meridional and circumferential directions.

- Minimum bar diameter shall be 10 mm in transverse direction and 12 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. At least two S-hooks in each square metre area of shell surface shall be provided. The hooks shall be of minimum 8 mm diameter bars.

- The concrete cover shall be 50 mm minimum. However, the clear cover shall not be less than 1.5 times diameter of bars. 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 300 mm.

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

c) Shell buckling and strength shall be checked as per clause-9.02.03 B above without considering the effect of ribs.

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

e) Bidder shall furnish an authorized English translation of the VGB-BTR KUCHLTURMEN GERMAN SPECIFICATIONS (Latest) during detailed engineering stage.

9.02.04 **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 superstructure considering various load combinations as specified in this document.

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 times 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.

d) The minimum size of raker column section shall be 1200 mm diameter or more as per design

e) The size of pedestals shall be such that it will have minimum 200 mm clear projection from the raker column.

9.02.05 **Crack Width Control**

Under working stress method the maximum crack width of tower shell, lintels, raker columns, cold water basin and fill support structure shall be controlled up to 0.1 mm on basis of formulas as per IS:456-2000 and relevant British codes.

Fill support structures and Drift Eliminators shall be designed as per the load combinations specified in this document. Appropriate Live Loads and imposed loads shall also be considered in addition. The design shall confirm to limit state method as per IS: 456. For fill support structure, the design shall be done considering the weight of fills, falling water, plugging/scaling load and the live load due to the maintenance activities.

9.02.06 **Pre-stressed Concrete Members**

Design, construction and workmanship of pre-stressed concrete, members shall be in accordance with IS: 1343 (Latest revision). Steel wire for pre-stressing shall conform to IS: 1785 (Part 1) (latest edition) or IS: 6003 (latest edition). Crack width control shall be limited to 0.1 mm.

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 corrosive resistant. Concrete and grout used shall be sulphate resistant.

The bidder shall furnish a write-up for the method to be used for pre-stressed concrete structures.

9.02.07 **Liquid Retaining Structures**

a) The cold water basin including sludge pits, cold water channels, shall be designed as per IS: 456 (latest) with crack width control of 0.1 mm for outer face of the wall and inside face of the wall shall be designed as per IS 3370.

The structures shall be designed for the following conditions:

i) Water filled inside up to maximum level and no earth outside.

ii) Earth pressure with surcharge load of 2.5 t/m^2, as applicable, and with/without ground water table at 1.0m below finished ground level outside and no water inside.

b) The basin and associated structures shall be checked against uplift for basin empty condition. Stability shall be checked during construction stage as well as maintenance stage. The factor of safety shall be as per IS: 3370.

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

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

e) Basin floor slab shall be designed to rest on piles or raft/mat foundation including fill-pack support structures. The stiffness of the subsoil shall be taken into account. The founding level of the raft/mat shall be either on virgin ground level or shall be placed at higher level only after scooping out filled up soil up to virgin ground and then filling

back with well compacted sand (80% of relative density) up to the founding level of the raft/mat. The bidder shall ascertain the safe bearing capacity of the stratum at the founding level and may adopt the same subject to Owner's approval.

f) 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. The effect of provision of flap valves/pressure release valves shall not be considered in the design of CW basin. In the space underneath the basin floor slab a layer of at least 100 mm thick PCC of mix 1:3:6 shall be provided.

g) All reinforcements used shall be corrosion resistant steel/HCRM.

h) The basin floor shall be cast in alternate bays in chequered pattern with sides not exceeding 4.5 meter

i) No pressure relieve valve to be used at basin floor.

9.02.08 **Water Distribution System**

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

a) Self weight, other imposed loads and live load.

b) Hydraulic pressures during normal operations including pressure surges.

c) 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. For the structural design the pressure level to be considered shall not be less than 1.5 times the design pressure.

- 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.

- The design shall be carried out based on uncracked section as per IS: 3370 under normal operating conditions. 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 use 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.

- Hot water distribution basin/trough/channel at top shall be covered by removable precast concrete slab to prevent direct exposure from sunlight. Corners of pre-cast concrete slabs shall be protected by angles. Lifting lugs shall also be provided for handling of concrete slabs.

- Basin channel wall shall be designed for a minimum surcharge load of 25 KN/Sqm. Paving shall be provided all round cold water basin.

9.02.09 **Platforms, Walkways, Stairways, Staircases, Internal Grillage etc.**

These shall be designed as per working stress method IS: 456-2000 and IS: 800. The crack width in all RCC structures shall be limited to 0.1 mm. A minimum live load of 500 kq/sqm 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.

9.02.10 **Steel Structures**

All structural steel members shall conform to IS: 2062 (GR-A). 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 anticorrosive system.

9.02.11 **Slide Gates and Screens**

Slide Gates and Screens, as per IS: 5620 conforming to IS: 2062 Gr. A, shall be designed for worst combination of operating and maintenance condition. All steel components shall be coated with anti-corrosive paint system. However, all guides of slide gates and screens shall be of stainless steel of Grade AISI 316L.

9.03.00 **Foundations**

Data specification sheet and Soil Report (By EPC Contractor) shall be referred to for selecting allowable bearing pressure to be considered in designing the foundation and in selecting depth of foundation. Cooling tower foundation is to be designed as strip foundation considering appropriate modulus of subgrade reaction. However, the bidder has to select suitable type of foundation compatible with the soil strata and calculated settlement of structure and foundation system. The bidder shall have to furnish conceptual design indicating type of foundation, general arrangement drawing for super structure, basin, pipe supports, pits, founding level etc. including settlement criteria complete with a design basis report with the offer.

The design of the cooling tower foundation structures shall be based on IS: 456 as per working stress method for worst load combination as per clause 9.01.06 In case of load combination DL + 1.5 WL, the limit state method as per IS: 456 shall be adopted.

Foundation shall be checked for safety against overturning, sliding and uplift. The minimum factors of safety for overturning, sliding and hydrostatic uplift shall be 1.5, 1.5 and 1.25 respectively.

While checking stability of the structures, neglect favourably acting loads from water fill, soil cover beyond the edge of the foundation. Ground water table shall be considered at 1.0m below Plant Finished Grade Level for design of foundations and all underground structures.

Minimum grade of concrete shall be M25 for foundation resting over 100mm thick PCC (1:3:6) layer. Clear cover shall not be less than 50mm.

Pile foundation if adopted shall be designed in accordance with IS: 2911(Part-I / Sec-I, II and III).

Generally net tension should be avoided in the foundations/piles for the shell support foundation unless specifically permitted by the Owner.

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.

The foundation structures will be subjected to following loading and extreme load combination case shall be considered for design.

1. Most critical forces transferred from superstructure for the various load combinations.

2. Uplift forces

3. Loading due to foundation settlement

4. Concentrated local loading from column nodes

5. Thermally induced local loading where supply culverts pass through the foundation structures without structural isolation.

6. Surcharge of 2.5 t/sq.m.

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

9.04.00 **Fill Support Structures and Other Structures**

The self weight of the pack support structures shall be based on the weight of the packing including weight of standing, running and dripping water, other operation and plugging/chocking (debris/scaling) loads, etc. in accordance with manufacturer's data. In addition, a live load of 100 kg/m2 shall also be considered for the design of supporting structures.

For other structures like walkways, platforms, etc. a live load of 500 kg/sq.m shall be considered. Hand railings shall be designed for horizontal load of 60 kg/m2.

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

Design of RCC members shall be based on IS: 456:2000 with limiting crack width of 0.1 mm.

The cold water basin slab/raft shall form the common foundation for the pack support structures. The foundation shall be designed for the most critical forces transferred from CW basin & fill supporting structures including loads introduced by constructional equipments and crane deployed for fill supporting structure or shell erection.

9.05.00 **Requirements for Concrete and Reinforcement**

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

Ordinary Portland cement Grade 53 complying with IS:12269 shall be used in concrete works for all structures and foundations. For PCC, paving and plinth protection works, OPC Grade 43 shall be used.

Fine and coarse aggregate to be used in cement shall comply with IS-383.

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 conform to severe exposure category as per Table 3 of IS: 456 except noted specifically otherwise.

Plain mild steel reinforcing bar shall conform to IS: 432 grade I quality and high yield strength deform bars (TMT) shall conform to IS: 1786 (Fe-500).

All reinforcements used in RCC structure shall be corrosion resistant. 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.

The minimum grade of concrete of structural components of cooling towers shall be as follows in accordance with IS: 456.

a)	Shell and Raker Columns	:	M-30 grade
b)	Pre-cast pre-stressed elements	:	M-30 grade
c)	All other RCC concrete	:	M-30 grade
d)	PCC encasement concrete except piles	:	M-25 grade
e)	Piles (with OPC/PPC/PFC)	:	M-30 grade
f)	Tower foundation	:	M-30 grade
g)	Mud mat/lean concrete PCC	:	M-10 grade

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. In particular limestone aggregates shall never be used. The maximum size of coarse aggregate shall not be larger than 1/8th narrowest dimension between reinforcement bars not more than 20 mm.

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

The water cement ratio by weight shall be 0.45 maximum including free moisture in the aggregates, and slump should be suitably decided to provide good quality concrete work.

9.06.00 **Admixtures**

Admixtures may be permitted to be used in accordance with relevant IS codes to modify the rate of hardening or setting, to improve workability or as an aid to control concrete quality and protection to reinforcement bars against corrosion. The Owner reserves the right to direct the contractor to conduct laboratory tests or use test data, or other satisfactory reference before granting approval. The cost of all tests conducted shall be borne by the contractor. The admixture shall be used in strict accordance with the manufacturer's directions and/or as directed by the Owner. No extra payment will be made to the contractor on account of using admixtures.

Particular attention must be given to concrete placement because of the thin wall section and the presence of reinforcing steel. Consolidation of concrete shall be by vibration. Removal of air and water at the form surface shall be by vibration and rodding. Particular attention shall be paid to accurately shape the corners at all openings.

Point of discharge of the concrete in to the forms be 1500 mm max. above the concrete surface. Concrete shall be deposited in approximately level layers not greater than 400 mm deep unless permitted otherwise.

Concrete in the cooling tower shell in each lift shall be so laid that the no. of vertical or inclined construction joints are minimized to the extent possible. Horizontal construction joints shall be maintained at uniform spacing throughout the height of the cooling tower as per the directions of the Owner.

Special attention shall be paid to proper curing of vertical faces of the cooling tower shell so that these do not remain dry. All thin walled structural members shall be protected by means of curing agents. It is recommended to use a curing agent for the cooling tower shell providing additional protection like a single transparent cooling with a material based on vinyl mixed polymer. Inside face of the shell should be protected by a second pigmented coating of the same base material. Any other method of curing, if permitted by the Owner may be used.

Sampling and testing of concrete shall be carried out as stated in Technical Specification elsewhere and as per relevant Indian Standard Codes. However, following minimum tests shall be carried out, irrespective of whatever stated otherwise:

Test of compressive strength

Columns – 1 Set of 3 cubes per column

Shell-2 sets of 3 cubes per climbing section

9.07.00 **Cover to Reinforcement**

Unless indicated otherwise the clear concrete cover for reinforcement shall be as per IS Codes.

The correct cover shall be maintained by cement mortar spacers/cubes or other approved means, reinforcement for footing/pile caps, grade beam, and slabs on sub-grade shall be supported on pre-cast concrete cover block as approved by Engineer-in-charge. The use of pebbles or stones as cover blocks shall not be permitted.

The 28 days crushing strength of cement mortar cubes/pre-cast concrete cover blocks shall be at least equal to the specified strength of concrete in which the cubes / blocks are embedded.

The minimum clear distance between reinforcing bars shall be in accordance with IS:456 (latest edition) or as specified elsewhere in this specification.

All lapping of reinforcement bars in the cooling tower shell shall be by lapping as per relevant codal provisions. Prior approval of the Owner shall be taken for deciding the method of lapping the reinforcement bars in the shell.

9.08.00 **Checking of shell geometry**

The form work for shell shall be capable of adjusting to shell profile and thickness accurately, and rigidly braced to prevent deflection or movement during concreting.

The form work shall be rigid, shape preserving , tight fitting and easy to construct so as to ensure smooth concrete surfaces, no geometrical discontinuities and achieve a high degree of dimensional accuracy.

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 lift.

The shell shall be constructed within the dimensional tolerances as stipulated in clause 7.3 of IS: 11504. If the permissible dimensional tolerance are exceeded, the Owner 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 Owner 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 Owner, for approval, before construction will be permitted to proceed.

If in the opinion of the Owner the calculations show that the integrity of the shell could be threatened, the Contractor will be required to submit to the Owner 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 programme 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 1m of height. Any such adjustment shall be made with full knowledge and consent of the Owner.

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 Owner prior to commencing the next shell pour.

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

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.

All piling work shall be carried out by specialist subcontractor approved by the Owner. Initial pile load test shall be carried out for at least 3 sets of piles for direct compression and lateral load.

Since the effective action of the piles will depend on the adopted method of construction, the contractor shall guarantee that the piles, as constructed by the sub-contractor, shall effectively transmit the maximum loads which can be imposed on the foundation soil and corresponding maximum deflections.

9.09.00 **General Requirements**

a) The basin slab 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 I) (Latest edition). 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.

b) PVC water stops shall be provided at all construction/ expansion joints of water retaining structures. 230 mm (min) wide and 10 mm (min) thick approved quality PVC water stop with central bulb shall be used where expansion joints are envisaged.

c) The basin floor of each compartment shall be provided with a slope of not less than 1 in 120 towards sump for dewatering. 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 sluice gates (rising spindle type) conforming to IS: 3042 or sluice valves shall be provided in the drain chamber or any other arrangement specified elsewhere in the tender document. Suitable operating platform with access ladders for operating the gates or valves and pipes, shall be provided in the drain box.

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

e) 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.

f) Fill will be of film type supported on RCC beam. Film fill should be characterized by reduced air pressure losses, and shall not susceptible to clogging. Design and facing of the film fill shall be such as to expose high air/water surface with minimum air pressure drop.

g) The sluice gates shall be structural steel with anti-corrosive coating specified elsewhere. Number of sluice gates and removable screen shall be two (2) per tower. Proper rubber seal shall be provided so as to avoid any leakage of water. The rubber seal provided for the sluice gates be tested in accordance with the relevant Indian Standard Code. Sluice gates shall be checked for water tightness and smooth operation in dry and wet conditions. Suitable facilities, as approved by the Owner, shall be provided for handling of sluice gates and screens.

h) Lean concrete below foundations, cold water basin, other liquid retaining structures and all underground structures, unless noted otherwise shall be at least 100 mm thick.

i) The R.C.C. structure of the Cooling Tower shall be painted on the

exterior surface with two (2) coats of water proof cement paint of approved make and colour .

The interior surface of the Cooling Tower structure and the interior face of the Cooling Tower Basin, fill supporting beams, columns and bracings, raker columns etc. which are in contact with water / moisture shall be painted with one coat of primer and two coats water proof bituminous paint conforming to IS:3384 and IS:9862 respectively.

j) Unless noted otherwise all concrete surface which are in contact with the earth shall be applied with anticorrosive coat system.

k) 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.

l) The tower shall be provided with two numbers external RC 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 stair shall have risers not exceeding 125 mm and treads 250 mm minimum. Anti-skid nosing at each step shall be provided.

m) Minimum size of all doors shall be 2100 mm high (clear) and 1200 mm wide (clear). The door shall be of steel with anti-corrosive coating of polyurethane as specified elsewhere. However, FRP material or equivalent may also be used subject to approval of the Owner. The door shall be air tight when closed.

n) The hand railing on both sides of the staircase shall be galvanized with three rails of 32 mm NB pipes conforming to medium class as per IS:1239, and posts conforming to medium class as per IS:1239 of 32 mm dia galvanized pipes spaced not more than 1.2 m centers. The top hand rail shall be at 1000 mm above the steps with an intermediate member at 550 mm height. The posts and runners shall be welded construction with round corners. Complete hand rail shall be applied with anticorrosive coating system as specified elsewhere. All galvanization works shall have 610 gm/sqm of deposit.

o) Approved walkways and platforms shall be provided inside the tower at distribution pipe level. These walkways and platforms shall provide safe and clear access to all sprayers and all distribution pipes. The clear width of walkway shall be 1.5m and clear head room shall not be less than 2 m. Radial gaps of 12 mm wide shall be provided at intervals in the walkways for discontinuity.

A reinforced concrete platform of 1500 mm clear width shall be provided around the tower valves. Other walkways shall be at least 600 mm wide with 50 mm (minimum) safety kerbs along each edge. 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.

p) Hot double dip galvanized handrails as described above shall be provided on all sides where there is a risk of falling through the fill.

q) Reinforced concrete platforms 1.2 m clear width all around the tower circumference shall be provided on the tower for fixing of aviation warning light at levels specified elsewhere. 12 mm wide radial gaps shall be provided in the platform at suitable intervals for discontinuity. Adequate MS embedment shall be provided in each side of platform to facilitate maintenance of tower shell.

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 as per IS: 3696.

r) MS rung ladders shall be hot dip galvanized ladder shall be 600 mm wide fabricated out of 60 mm x 10 mm flats with 20 mm dia. rungs at 300 mm centers. Stays shall be provided at every 2.25 m intervals connecting the ladder with the concrete shell. Upto throat level these ladders shall be on the exterior surface of the cooling tower and shall be continued along the inside surface of the tower up to the top of the tower.

Galvanised MS Safety cage shall be provided for all ladders and shall be fabricated out of 5 nos. verticals of 50 mm x 6 mm flats with 50 mm x 6 mm flat straps at 800mm centers.

A RCC landing of size not less than 750 mm x 1500 mm, with galvanized handrails and galvanized steel door to be provided at the throat for interchange. Intermediate landings of reinforced concrete of size not less than 750 mm x 1500 mm shall be provided at every 8 to 10 m height of the ladder.

Some of these 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. The ladder leading to the top platform shall have approach from ground via the RCC staircase.

s) In order to provide approach for maintenance of shell (inside & outside faces), all platforms shall have 20 mm wide radial openings in the platform floor at locations approved by Owner. Adequate numbers of 75 mm internal diameter puddle flanged C.I. pipes shall be embedded in this platform for passing ropes during maintenance of tower shell.

t) All exposed structural steel work used in cooling towers shall be hot double dip galvanized unless it is coated with a separate anti-corrosive coating system. 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.Galvanization shall be followed by the application of an etching primer and anticorrosive hibuild epoxy coating system of DFT 260 microns. 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.

u) Mix proportion in Cement-sand mortar for brick masonry work shall be 1:6 for 250 mm thick brickwork and cement-sand mortar (1:6) shall be used for 125 mm and 75 mm thick brickwork.Thickness of 1:6 cement-sand plaster on brick masonry shall be 18 mm for outside, 12 mm for inside and thickness of 1:4 cement-sand plaster shall be 6 mm for ceiling.

v) Materials for precast concrete components including joint fixing, lifting hooks and other exposed steel components shall conform to technical specification and other points mention in the document.

9.10.00 Grating

Steel gratings, where required, shall be fabricated out of steel flats with minimum thickness of 6 mm. Thickness of fabricated grating shall be 32 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 up to 100 mm above the walkway surface. All steel gratings shall be galvanized and applied with anticorrosive coating specified elsewhere.

9.11.00 Paving

The finished ground level shall be paved for 3.0m width all round the outer edge of the cold water basin. The paving shall consist of 150 thick RCC slab of M-20 grade over soling. The minimum reinforcement shall be 10 mm dia spaced 150 mm center to center both ways top and bottom. The RCC slab shall be overlaid 100 mm thick M-10 PCC mat and 300 mm well compacted

sand layer. All around peripheral RCC drain leading to drain chamber shall be suitably provided.

9.12.00 **Fittings and fixtures**

a) Complete system of Lightning protection, Aviation warning lights and Access ladder to be provided as per Clause 7.5 of IS 11504 (latest).

10.00.00 **ELECTRICAL ITEMS**

Refer Volume- V-B, Section-XV.

11.00.00 **TESTING AND INSPECTION**

11.01.00 **Test at Manufacture's work**

11.01.01 The manufacturer shall conduct all tests required to ensure that the equipment furnished shall conform to the requirements of this specification and shall be in compliance with requirements of applicable codes and standards.

11.01.02 The particulars of the proposed tests and the procedures for the tests shall be submitted to the Purchaser/Consultant for approval before conducting the tests.

11.01.03 Inspection shall be conducted by the manufacturer to establish and maintain quality of workmanship, to ensure mechanical accuracy of components, compliance with drawings, identity & acceptability of all material, part and equipment. Where specified, all such inspections shall be conducted in presence of Purchaser's representatives.

11.01.04 The Bidder shall submit to the Purchaser/Consultant at the initiation of the contract, the detailed bar chart showing the manufacturing program and indicating the period when Purchaser or his authorized inspecting agency are required at the shop for inspection and/or testing. Also, the manufacturer shall intimate the Purchaser 3 to 4 weeks in advance of such tests. The Purchaser/Consultant shall be given full access to all tests and inspection.

11.01.05 All materials used for cooling tower construction shall be of tested quality. Materials shall be tested as per the relevant standards or codes and test certificates shall be made available to the Purchaser/Consultant.

11.01.06 Where stage inspection is specified, all material test certificates shall be correlated and verified with the actual material used for construction before starting fabrication by Purchaser's inspector who shall stamp the material. In case mill test certificates for the material are not available, the supplier shall

carry out physical and chemical tests at his own cost from a testing agency, approved by the Purchaser, as per the requirements of specified material standard. The samples for physical and chemical testing shall be drawn up in presence of Purchaser's inspector who shall also witness the testing.

11.01.07 Hydrostatic testing for hot water distribution piping shall be at a pressure of 200% of design pressure after fabrication at shop.

11.01.08 Butterfly valves shall be tested as per the stipulations of AWWA C- 504, latest edition.

11.02.00 **Tests at Site**

11.02.01 After completion of construction, erection and commissioning of the cooling tower, performance test of the cooling tower shall be carried out as specified in Data Specification Sheet in accordance with Cooling Tower Institute Bulletin No. ATC-105 "Acceptance Test Procedure for Water Cooling Tower" or ASME (USA) performance test code PTC: 23 or other equivalent mutually agreed method. The details of the proposed test procedure shall be submitted by the supplier sufficiently in advance of the commencement of test for the review and approval of the Purchaser.

11.02.02 Necessary correction curves required for correcting the test results for any difference between test and guaranteed design conditions shall be furnished by the supplier for approval along with the proposed test procedure.

11.02.03 All testing and calibrating instruments required for site performance tests shall be arranged by the cooling tower supplier without any extra cost.

12.00.00 **PERFORMANCE GUARANTEES**

12.01.00 Each equipment shall be guaranteed to meet the performance requirements as specified. If during the performance testing of the tower, the actual cooling water temperature obtained is higher than the guaranteed cooling water temperature (obtained from the performance curve) corresponding to the flow, wet bulb temperature, relative humidity and cooling range prevailing during the test, the contractor shall satisfactorily rectify all defects within scheduled time period.

12.02.00 After the tests conducted at the Manufacturer's works in accordance with this specification, rectification of any defect observed shall be satisfactorily done without charging any extra cost to the Owner.

12.03.00 The performance test shall be carried out at site as specified and all defects shall be satisfactorily rectified within scheduled time period. No extra cost shall be charged to the Owner for such rectification. After rectification, retesting will be done by Bidder without any extra cost to Owner till

satisfactory performance is achieved.

12.04.00 The bidder shall guarantee that the cooling towers offered shall meet the ratings and performance requirements stipulated in this specification. The bidder shall also furnish a declaration for certain guaranteed parameters like "Fulfillment of cold water temperature" which shall attract levees of liquidated damages for shortfall in performance. In case the contractor does not fulfill the guaranteed parameters, purchaser may undertake to rectify the system/equipment and expenditure incurred along with any other incidentals shall be recovered from the contractor.

13.00.00 **DRAWINGS/DOCUMENTS, DATA & INFORMATION TO BE FURNISHED BY THE BIDDER ALONG WITH THE TECHNICAL OFFER**

13.01.00 The Bidder shall furnish along with his proposal following specific drawings/documents/data as asked for in this section.

13.01.01 General arrangement drawing for cooling tower, incorporating all relevant dimensions, material of construction of different parts, limits of scope of supply of piping, limits of civil works included, basin details indicating overflow and de-sludging arrangement, arrangement of staircase, ladders, platforms, lightning protection system, Aviation obstruction lightning system of cooling tower etc.

13.01.02 Predicted performance curves, showing wet bulb Vs. cold water temperatures for design cooling range, 85% cooling range and 115% cooling range. Such curves shall be furnished for 85%, 100%, 115% flow. In case more than one operating point is specified, all above details/curves are to be furnished corresponding to all additional operating points also.

13.01.03 Cooling Tower Manufacturer's detailed literature including drawing and diagram for :

a) Tower fills with supporting arrangement.

b) Drift eliminator.

c) Complete distribution system including regulating type water distribution valves, distribution basin/pipes, orifices/ nozzles, etc.

13.01.04 Electrical power distribution scheme.

13.01.05 A detailed experience list about supply of similar plant by the Bidder/ Manufacturer and his collaborator.

13.01.06 A comprehensive write-up or Brochure on the details of manufacturing and testing facilities in the shop of Manufacturer.

13.01.07 All other relevant data and drawings as asked for in the specification and as

required.

13.01.08 A sample of the fill material to be used for the specified cooling tower.

13.01.09 Bidder's proposal covering chemical treatment of cooling water to minimize biological fouling, scaling and corrosion as well as for containing concentration factor.

14.00.00 **DRAWINGS/DOCUMENT, DATA, AND MANUAL TO BE FURNISHED AFTER AWARD OF CONTRACT**

14.01.00 Final version of all drawings/data/informations asked for in clause 13.00.00 above.

14.02.00 The following drawings shall be submitted within a reasonable time after placement of order :

14.02.01 General arrangement of the cooling tower, indicating all principal dimensions, extent of platforms, walkways, handrails, stairs, doors, illumination, arrangement of cooling tower structure and limits of supply and erection of piping, electrical and civil works.

14.02.02 Arrangement drawing of the cold water sumps and sludge pits for the cooling tower, incorporating also arrangements of screens, sluice gates, butterfly valves, gate valves, piping, and monorail chain pulley block installation, etc.

14.02.03 Performance curves as described in Clause 12.01.02.

14.02.04 Following drawings on mechanical equipment, their drives and accessories:

i) Fabrication and piping erection drawing.

ii) Outline and sectional drawings of valves of each category indicating also material of construction.

iii) Drawing on fill, drift eliminator and its support systems and fastening arrangement complete with data on material of construction.

iv) Drawing on splash boxes, nozzles in hot water basin, with data on material of construction.

v) Drawings on screens & gates with material of construction.

14.02.05 Electrical Drawings and Data as specified in Volume- V-B, Section-XV.

14.02.06 Detail technical particulars of equipment and materials under the scope of this specification.

14.02.07 **Drawings, Data and Calculation on Civil works**

i) Design calculations for strength and suitability showing justification for size of members chosen for all structural components of the cooling tower inclusive of pre-stressed concrete fill where applicable.

ii) Load drawings setting out clearly and concisely the various loads taken into consideration for design.

iii) Civil drawings for cold water basin, connecting channels, partitions, louvers, end walls, longitudinal beams, hot water distribution basin, its covering, staircase, platforms, cable trenches, etc. all complete.

iv) Bar bending details for all reinforced concrete structures.

v) Insert details, anchor bolt details.

vi) Final painting schedule.

vii) Other drawings & data as necessary.

14.03.00 The Documents to be submitted before dispatch of Equipment for approval

14.03.01 Material Test Certificate for mechanical equipment.

14.03.02 Certificates on treatment done on timber components.

14.03.03 Test certificates on each electrical equipment, cables and accessories.

14.03.04 **Instruction Manuals**

i) The Instruction Manuals shall present the following basic categories of information in practical, complete and comprehensive manner prepared for use by operating and/or maintenance personnel :

- Instruction for initial installation of mechanical and electrical equipment.
- Instructions for operation, control, monitoring and protection.
- Instruction for maintenance, overhaul and replacement of parts etc.
- Recommended inspection points & periods of inspection.
- Lubrication Chart.
- Ordering information for all replaceable parts, etc.

- Write-up, leaflet/catalogue etc. covering equipment features.

ii) The information shall be organized in a logical and orderly sequence. A general description of the equipment including significant technical characteristics is required to familiarize operating and maintenance personnel with the equipment.

iii) Necessary drawings and/or other illustrations shall be included or copies of appropriate certified drawings shall be bound in the manual. Test, adjustment and calibration information, as appropriate, shall be included and shall be identified to the specific equipment. Safety and other warning notices and installation, maintenance and operating cautions shall be emphasized.

iv) A parts list shall be included showing part nomenclature, manufacturer's part number and/or other information necessary for accurate identification and ordering of replacement parts.

v) Instruction and part list shall be legible and prepared on good quality paper.

vi) The Instruction Manual shall be securely bound in durable folder.

vii) If a standard manual is furnished covering more than the specific equipment purchased, the applicable model (or other identification) number, part number and other information for the specific equipment purchased shall be clearly identified.

viii) The Instruction Manual shall include list of all special tools and tackle furnished with complete drawing and instruction for use of such tools and tackle.

ANNEXURE-A

DATASHEET FOR NATURAL DRAFT COOLING TOWER

1.0 General Information

Type of Cooling Tower	:	Natural Draft, Hyperbolic
No. of Cooling Towers Required	:	One
Location	:	Outdoor
Duty	:	Continuous

2.0 Design Working Conditions

Hot water inlet temperature	:	42.0^{o}C
Design Ambient wet bulb temperature (WBT)	:	28^{o}C
Design Ambient temp. for electrical equipment	:	50^{o}C
Design Ambient Relative Humidity (RH)	:	44.96%
Whether inlet air wet bulb temperature to be corrected considering re-circulation as per CTI bulletin PFM-116	:	Yes
Design CT inlet wet bulb temperature	:	By Bidder
Basin Holding Capacity	:	6 mins of design CT capacity
Design Wind speed	:	As per site data

3.0 Performance Requirement

Rated Cooling Water flow	:	By Bidder
Cooling range	:	10.5°C
Approach to ambient wet bulb temperature	:	5.0°C
Maximum permissible drift loss	:	0.002%

Design pressure for hot water distribution system	:	By Bidder
Operating range to be established by cooling tower characteristics curves and performance curves	:	As per Clause no. 5.03.00

4.0 **Special Features**

Type of Tower design. (Bidder to justify his offer)	:	Counter-flow / Cross-flow
Type of fill	:	PVC Splash (V-bar type of approved make)
Whether fills are removable type	:	Yes

5.0 **Material of Construction**

Cold water basin, outlet channel/sump & sludge pit	:	R.C.C.
Casing & superstructure	:	R.C.C.
Basin diagonal partition, if any	:	R.C.C.
Staircase	:	R.C.C./HDG Steel
Hot water distribution piping		
• Inside Tower	:	HDG Steel/PVC
• Outside Tower	:	MS pipes with PVC/FRP Wrap on outside.
Hot water distribution nozzles Equal	:	Polypropylene/Approved
Fills	:	PVC with minimum spacing of 20 mm
Fill Support	:	R.C.C./HDG Steel
Louvers	:	R.C.C.

Drift eliminator	:	PVC
Hot water piping	:	IS: 3589
Butterfly valve for hot water distribution system/cold water outlet channel	:	
• Body	:	CI as per IS-210, FG-260
• Disc	:	- do -
• Shaft and spindle	:	SS304 as per ASTM A-479
• Shaft bearing	:	Leaded bronze, self lubricated (BS-1400, LB-2)
• Seat ring	:	ASTM A-479, Type 304
• Gland packing	:	Impregnated Teflon
• Seal	:	Nitrile Rubber, Shore Hardness 50-60 Deg.
• Bolts & Nuts (in contact with water)	:	Stainless Steel Sludge pit isolation valves:
• Body	:	CI IS-210, FG-260
• Spindle & Trim	:	Stainless Steel.
• Sludge outlet pipe	:	CI IS-1536, LA
• Screen	:	Anodised Aluminium
• Guide for screen	:	CI IS-210, FG-260
• Bolts, nuts & other hardware	:	Stainless Steel

6.0 **Inspection And Testing**

Quality surveillance by	:	Manufacturer/Purchaser
Material testing and identification	:	Required
Stage inspection to be witnessed by Purchaser	:	Yes

Hydrostatic test for piping & valves required	:	Yes
Hydrostatic test to be witnessed by Purchaser	:	Yes
Field performance test of individual items and the cooling tower as a whole required	:	Yes
Field performance test to be done by Contractor	:	Manufacturer/EPC
All tests on the Butterfly valves at manufacturer's works to be witnessed by Purchaser	:	Yes
All testing instruments by supplier	:	Yes
Commissioning at site by Contractor	:	Manufacturer/EPC

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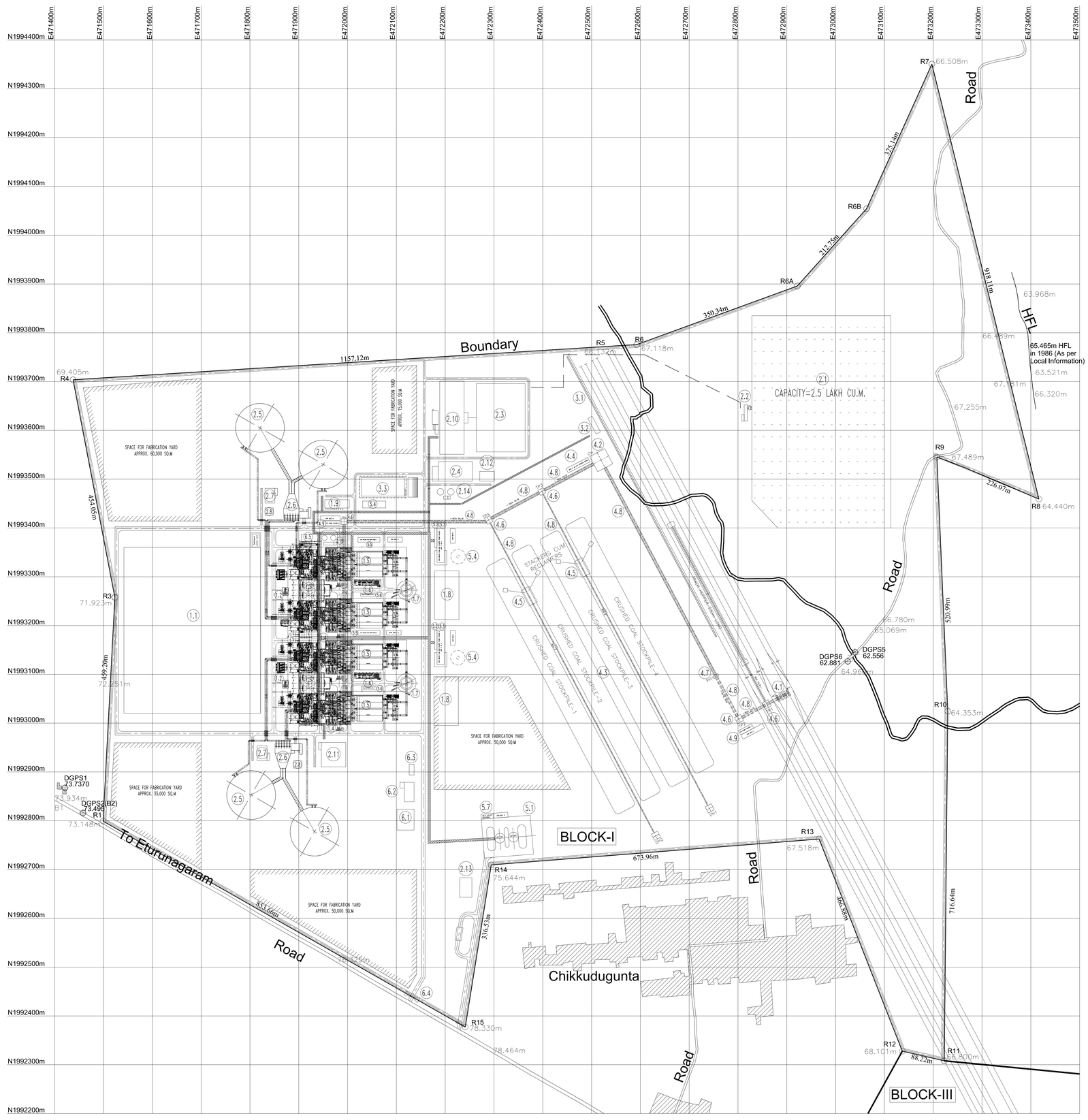
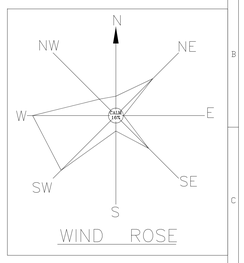


TABLE	
FACILITY	DESCRIPTION OF FACILITIES
1.0	MAIN PLANT AREA
1.1	SWITCH YARD
1.2	TRANSFORMER YARD
1.3	TURBINE BUILDING
1.4	BOILER
1.5	ESP
1.6	ESP CONTROL ROOM
1.7	CHIMNEY
1.8	SPACE FOR FGD
1.9	IA & SA COMPRESSOR HOUSE
2.0	WATER SYSTEM
2.1	RAW WATER RESERVOIR
2.2	RAW WATER PUMP HOUSE
2.3	PT PLANT
2.4	DM PLANT
2.5	NDCT
2.6	CW PUMP AREA
2.7	CW CHLORINATION PLANT FOR CW SYSTEM
2.8	CW TREATMENT PLANT FOR CW SYSTEM
2.9	DELETED
2.10	CLARIFIED WATER STORAGE TANK & PUMP HOUSE
2.11	EFFLUENT TREATMENT PLANT
2.12	CHEMICAL LAB
2.13	SEWAGE TREATMENT PLANT
2.14	DM TANKS & DM TRANSFER PUMPS
2.15	CONDENSATE STORAGE TANKS AND CONDENSER MAKE UP & BOILER FILL PUMPS
3.0	FUEL OIL SYSTEM
3.1	FUEL OIL UNLOADING TRENCH
3.2	FUEL OIL UNLOADING AND PRESSURISING PUMP HOUSE
3.3	FUEL OIL STORAGE TANK AREA
3.4	FUEL OIL FORWARDING PUMP HOUSE
4.0	COAL HANDLING PLANT
4.1	WAGON TIPPLER
4.2	CRUSHER HOUSE
4.3	CRUSHED COAL STOCKPILE
4.4	CHP CONTROL ROOM
4.5	STACKER RECLAIMER
4.6	TRANSFER POINT (TP)
4.7	PENT HOUSE (PH)
4.8	COAL BELT CONVEYOR
4.9	DUST SUPPRESSION PUMP HOUSE
5.0	ASH HANDLING PLANT
5.1	FLY ASH SILOS
5.2	ASH SLURRY PIMP HOUSE
5.3	ASH WATER PUMP HOUSE
5.4	AHP CLARIFIER
5.5	AHP VACUUM CUM COMPRESSOR HOUSE
5.6	AHP VACUUM PUMP HOUSE – ADDED
5.7	SILO UTILITY BUILDING
6.0	NON – PLANT BUILDING
6.1	ADMN. BUILDING
6.2	CANTEEN
6.3	FIRE STATION
6.4	MAIN GATE
6.5	SERVICE BUILDING
6.6	DELETED



LEGENDS:

- Area Boundary
- Road
- River, Stream
- DGPS Point with MSL Level in Metres — DGPS-5 62.556
- Village
- Pipe/Cable Rack

NOTES:–

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ASH DYKE LOCATION CONSIDERED IN BLOCK–II AS PER DESEIN PLOT PLAN 111–29–0200 R1 DT. 31.12.14 RECD. VIDE MAIL DTD. 09.01.15.

FOR TENDER PURPOSE ONLY

REV	DATE	ALTD	CHD	APPD
P01	15.01.15	RK	LKJ	SPV

1. WIND ROSE, ROADS & SPACES FOR FABRICATION YARD MARKED.
2. FACILITIES 2.7, 2.8, 5.2, 5.3 & 5.4 RELOCATED.
3. FACILITY 2.9 & 6.6 DELETED.
4. NDCTs LOCATIONS AND CW CHANNELS & CW PIPES ROUTING MODIFIED.
5. DG BLDG, SWITCHGEAR & CENTRAL CUBICLE ROOM RELOCATED.
6. RW RESERVOIR CAPACITY UPDATED.

CUSTOMER	TELANGANA STATE POWER GENERATION CO. LTD.
CUSTOMER'S CONSULTANT	DESEIN CONSULTING ENGINEERS NEW DELHI
JOB No.	K27
STATUS	PROPOSAL
DISTRIBUTION	
TO	
No.OF†	

4X270 MW MANUGURU TPP

BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NEW DELHI

DEPT		NAME	SIGN	DATE
M	CODE	DRN RK		25.09.2014
		DESN RK		25.09.2014
		CHD LKJ		25.09.2014
		APPD SPV		25.09.2014

TITLE: PLOT PLAN

MPL	C	MSE	I	MAX	E	DEPT.	SCALE 1:3000	DRAWING No. PE–DG–K27–100–M001
						SIGN		
						DATE		SHEET 1 OF 1 REV P01

SIZE–A0

COMPUTER FILE NAME: K27-100-M001_P01.DWG